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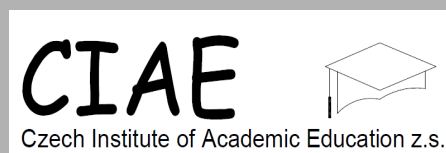
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Engineering, Transport, IT and Artificial Intelligence

**Management, Economics, Business and Marketing
(IAC-MEBM)**

Public Sector Supply Chain Management Maturity as a Driver of sustainable SMEs in South Africa

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Abstract

Mounting evidence suggests that the failure of SMEs in many developing countries could be attributed in part to inefficient public supply chain management. This study explored the degree of public sector supply chain management maturity in South Africa, using the case of SMEs in a district municipality. It investigated the potential that the public sector SCM has for the growth and sustainability of SMEs. The study used a qualitative case study approach involving 13 supply chain role players drawn from the Ehlanzeni District Municipality in Mpumalanga Province. Data were collected using online semi-structured interviews. The findings show how three themes, namely supply chain governance framework, degree of supply chain maturity, and SCM reforms, can be harnessed to promote the creation of SMEs and support their growth and success in municipal areas.

Keywords: Supply chain management, supply chain management maturity, public sector

1. INTRODUCTION

At the heart of government policy in South Africa is a determination to ensure the continued existence of Small and Medium Enterprises (SMEs). The drive to improve the sustainability of SMEs appears to have gained widespread recognition since South Africa's democratic transition in 1994. Since SMEs are primarily concentrated in specific areas, their growth depends on local economic development (LED) initiatives spearheaded by local governments/municipalities (Mukwarami, Mukwarami & Tengeh, 2020). Furthermore, entrepreneurial development in local governments encourages emerging companies to expand alongside larger businesses through sub-contracts on large-scale municipal infrastructure projects (Madzivhandila & Musara, 2020). As a result, SMEs play an essential role in addressing municipal procurement objectives through improved supplier diversity. Additionally, sustainable SMEs can provide spillover effects on social issues such as inclusion, poverty alleviation, and equitable access to opportunities (Wiid & Cant, 2021). However, despite their considerable socio-economic impact, SMEs have a significantly lower involvement rate and success in gaining public contracts than larger firms (Akenroye et al., 2020). According to Saastamoinen, Reijonen, and Tammi (2020), SMEs that can collaborate with the public sector and understand the complexities of the procurement process are more likely to succeed in tenders. Therefore, support for supply chain management (SCM) in the public sector is critical to the success of SMEs.

Within the public sector in South Africa, SCM is viewed as an integral part of governance that seeks to introduce internationally accepted best practices whilst addressing secondary procurement-related strategic objectives (Department of National Treasury, 2003). According to Liu et al. (2020), public sector SCM differs from private

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* Corresponding author.

procurement because it is subject to regulations and has stronger policy compliance requirements. Because SMEs account for a bigger proportion of the economy's enterprises, several governments have attempted to address this potential bias and ensure that SMEs can participate in public tenders through policy initiatives (Hoekman & Taş, 2022). However, overly complicated public procurement procedures increase transaction costs and may reduce competition (Nemec, Grega & Orviska, 2020).

This study aims to explore the degree of maturity of the public sector SCM in South Africa, with the intent of casting a broader spotlight on the potential of such activities in driving the success of SMEs. In simple terms, SCM maturity is the ability of a supply chain to consistently generate superior business results (Groschopf, Dobrovnik & Herneth 2021). Supply chains constantly evolve, so the level at which a supply chain operates can determine whether it has matured to the extent of developing the expected performance capabilities. Likewise, public sector supply chains, including those in which municipalities operate, are not exempt from maturity models to determine their performance. As South Africa contends with the triple threat of high unemployment, poverty, and inequality levels, it also spends more than R938 billion a year on procuring goods, services and works as reported by the Department of National Treasury (2018). Furthermore, the report reveals that local government accounts for R381 billion of the total annual procurement spend. These figures demonstrate the considerable purchasing power of the government and the possibility for public spending to be used to achieve South Africa's broader socio-economic goals.

Considering such astronomical levels of spend, it is surprising to note that there are still relatively few research papers allowing municipal officers to understand where their organisations are in terms of SCM maturity and what must occur for their supply chain to mature. Accordingly, the study investigated the current SCM practices and their degree of maturity, using the case of the Ehlanzeni District Municipality (EDM) in the Mpumalanga province of South Africa. The central research question addressed in this article reads as follows: 'To what extent does public sector SCM maturity drive the sustainability of SMEs in the local sphere of government?'.

2. THEORY

This section presents brief insights on SMEs as well as public sector supply chain maturity and its effect on the sustainability of SMEs.

2.1. The overview of SMEs in South Africa

The South African government recognises SMEs' viability as a central economic development subject. However, SMEs in South Africa face numerous challenges, which are well-documented in the literature and have long been a source of concern for the government. These include a lack of managerial competency and skills deficiencies in financial and operational understanding, insufficient technological capacity, and broader access to capital (Wolmarans & Meintjes, 2015; Ntiamoah & Kwamega, 2016; Sitharam & Hoque, 2016; Olarewaju & Msomi, 2021). Furthermore, because of external constraints that influence the growth of new SMEs in South Africa, critical factors such as competition in the market, crime and corruption, bureaucracy and burdensome regulations (Ntiamoah & Kwamega, 2016; Mantzaris, 2017; Nieuwenhuizen, 2019) continue to hinder the growth and sustainability of SMEs in South Africa. As a result, SMEs in South Africa have one of the worst sustainability rates, as more than 70% fail during the first two years of operation, and 90% within 10 years (Mohammadi, Zamani & Mokhles, 2019).

2.2. Public sector supply chain management maturity

The volatility of socio-economic needs and fragility of SMEs at the local government level point to an ever-increasing need for flexible and responsive supply chains that require integration with suppliers (Sabet, Yazdani & De Leeuw, 2017). As a result, public sector SCM has moved from a cost focus to a customer focus and, more recently, to a transformational focus centred around achieving socio-economic goals. In addition, processes have transformed from a clerical activity to an initiative-taking, strategic, and value-adding business function, according to Van Pouckea and Matthyssensa (2012). The concept of process evolution from an initial state to a more advanced state is known as maturity (Bvuchete, Grobbelaar & Van Eeden, 2018). SCM maturity assumes that procedures and processes are implemented in multiple evolutionary and successive stages (Fischer et al., 2016).

With targeted procurement for goods, works, and services flowing from SMME suppliers, SCM maturity deliberations at the local government level have become imperative. According to Versendaal et al. (2011), the

maturity process provides parameters to assess stages that define the evolutionary path of improvements over time. Therefore, SCM maturity is grounded in process maturity and predicated on acknowledging that processes have clearly defined stages that can be managed, measured, and controlled (Söderberg & Bengtsson, 2010). The goal of SCM maturity is to balance four factors: efficiency, effectiveness, pertinence, and discernment (Potage, 2017). For this reason, Netland and Alfnes (2011) suggest that the maturity of the supply chain must be assessed to develop a cohesive operations strategy that includes customers and suppliers and is aligned with the overall business strategy. Therefore, on this basis, Santos et al. (2020) conceded that SCM maturity can produce a more comprehensive vision (both internally and externally) and thus improve benchmarking initiatives. Therefore, continuous monitoring of the maturity levels of its supply chain operations can help the municipality enhance the performance of its SCM processes. According to Cheshmberah and Beheshtikia (2020), various levels (dimensions) for maturity measurement are advanced in SCM maturity. Figure 1 depicts a schema for a five-level SCM maturity measurement architecture that the public sector can adopt.
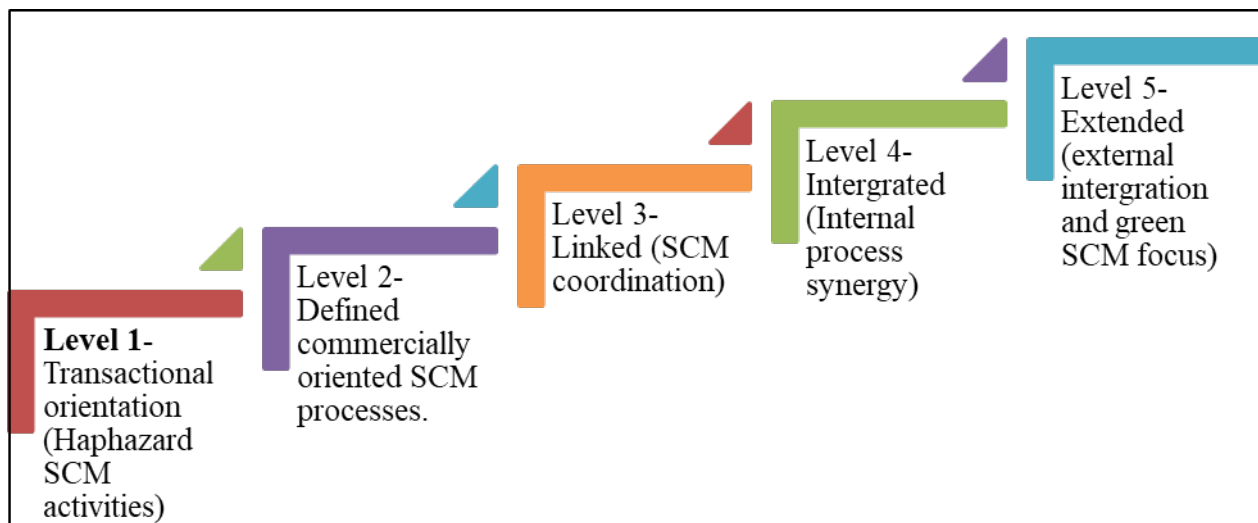
Figure 1: Five-level SCM maturity measurement architecture

Municipalities must recognise the significance of process maturity for SCM to transition from a conventional functional activity to a strategic Business Process Management (BPM) oriented system, necessitating a significant shift in corporate culture. To attain excellence in public sector SCM, processes should progress through the stages of maturity mentioned in Figure 1. Accordingly, maturity as a metric for assessing the capabilities of an organisation concerning SCM capabilities has grown in popularity in recent years. Typically, SCM maturity is based on process maturity, which refers to the evolutionary path of improving business processes (Mallya, 2022).

There is a positive and significant relationship between maturity and supply chain performance, as well as some relationships between SCM maturity and financial performance (Söderberg & Bengtsson, 2010). Retegi and Igartua (2018) observed that adopting a supply chain maturity model could effectively implement a supplier improvement program. Haraburda (2017) posits that maintaining a mature supply chain is critical to an organisation's success, necessitating the development of a structured diagnostic tool to determine its maturity level.

3. METHOD

The qualitative approach was identified as the optimal method for this study using the case study research design. Since the concept of SCM maturity in the public sector is not a widely researched topic in South Africa, an exploratory qualitative research design was used for this study, allowing for the discovery of in-depth and high-quality responses throughout the research study (Khan, 2014). Participants in this study consisted of 13 SCM role players, such as general SCM staff and management, drawn from the Ehlanzeni Municipality in Mpumalanga Province. The purposive sampling technique was used to select participants. Purposive sampling identifies and selects people with knowledge and experience with the problem under investigation (Palinkas et al., 2015). As such, only individuals most likely to yield appropriate and valuable information were selected. The profile of participants is presented in Table 1.

Table 1. Participant Profiles

Code	Position occupied	Gender	Years of experience	Role	Position
P01	SCM Manager	M	9 Years	SCM	Management
P02	LED Manager	M	5 Years	LED	Management
P03	Bid Manager	M	10 Years	SCM	Management
P04	SCM Clerk	F	5 Years	SCM	Support
P05	Acquisition Accountant	F	13 Years	SCM	Specialist
P06	Demand Accountant	M	20 Years	SCM	Specialist
P07	SCM Officer	F	6 Years	SCM	Specialist
P08	Compliance Officer	M	3 Years	SCM	Specialist
P09	SCM Officer	F	10 Years	SCM	Specialist
P10	Deputy Director SCM	M	3 Years	SCM	Management
P11	LED Officer	M	5 Years	LED	Specialist
P12	Procurement Officer	F	10 Years	SCM	Specialist
P13	SCM Specialist	F	7 Years	SCM	Specialist
n=13; M, male; F, female.					

The primary data for this study were gathered through semi-structured in-depth interviews held and recorded on the Microsoft Teams platform. Since semi-structured interviews are open-ended in disposition, creativity and flexibility in the questions were permitted, and participants could speak freely about the subject matter. Prior to the interviews, participants were alerted to the aim and the general objectives of the study. All interviews were conducted in English and lasted between 30 and 45 minutes.

In preparation for analysis, the voice recordings from the in-depth interviews were automatically transcribed by the Microsoft Teams AI function into text format, allowing for a complete and accurate transcript of the dialogue. A thematic analysis process was then followed to analyse the data.

Various ethical considerations, such as informed consent, voluntary participation, protection from victimisation and confidentiality, were followed throughout the study.

Trustworthiness

Efforts were made to ensure the study met the trustworthiness standard expected in qualitative research. Credibility was attained through a meticulous description of the data analysis and verification of data sources obtained from participants from whom data were gathered. Audit trails were applied to ensure the confirmability of the findings, whereby participants checked the correctness and completeness of interview transcripts to ensure that they accurately reflected their inputs. To convey transferability, a rich account of descriptive data was provided, such as the context in which the research was conducted. To achieve dependability, the research process was rational (with clear research questions), identifiable, and well-documented (Nowell et al., 2017).

4. FINDINGS

4.1. Themes emerging in the study

Three key themes emerged from the analysis of the empirical data. The themes and their operational definitions are presented in Table 3. The individual themes and empirical evidence to support these themes are discussed in the next section.

Table 3. Themes and operational definitions

Theme	Description	Operational Definitions
1.	Supply chain governance framework	This refers to the set of policies, guidelines, and standard operating procedures that coordinate the authority and power dynamics determining how efficiently and effectively financial, material, and human resources are disbursed within the chain.
2.	Degree of supply chain maturity	This measures how resilient, stable, and consistent an organisation's supply chain is throughout all stages of operation.

| **3.** | SCM reforms | This refers to a set of legislation, regulations, policies and procedures in SCM. |

Theme 1: Supply chain management governance framework

The SCM governance framework emerged as the first theme of the study. It was identified as the golden thread that provides accountability and good governance parameters in public sector SCM. The participants expressed their knowledge of how the legal instruments that support the entire SCM process, and their related interests, are filtered down into SCM operations. Their understanding of this theme can be attributed to policies, guidelines and operational strategies. The participants acknowledged the existence of an approved SCM policy that complies with the framework. The daily operations of SCM were viewed as critically dependent on the necessity of having a policy and understanding its impact on the procurement process. Additionally, there was general agreement on how they understood SCM's legal context. The following excerpt from a director supports these views:

"We do have an SCM policy, which caters to the key processes we deal with regarding our day-to-day responsibilities. But remember the SCM policy, which comes about through the regulations. But the policy is in place. It is implemented. It is working. It is effective for us." [P01]

The analysis revealed the existence of an approved SCM policy that complies with the regulatory framework, implying that government policies act as a catalyst for efficient governance across the public sector. Attitudinal changes are needed to ensure that role players demonstrate prudence in following SCM-related regulations and policies, which impact the sustainability of SMEs in the area.

Theme 2: The degree of supply chain management maturity

The degree of supply chain maturity emerged as the second theme of the study. Many participants had difficulty comprehending the concept of supply chain maturity, and their understanding was centred around three categories: SCM policies and practices, procurement process decision-making process, and supplier performance monitoring. A crucial factor in determining the degree of supply chain maturity is the comprehension of SCM policies and procedures, which served as the cornerstone for the second theme. The municipality's general SCM policies and how they impact the procurement process are well understood. As a result, it may be inferred that the various SCM role actors consistently synchronise their activities. This analysis of the snippet from participant one [P01], who expressed a consolidated view, reveals that these beliefs are mirrored across the responses:

"Our processes have matured. All officials within SCM. Yes. They know exactly what to do for the various stages of our procurement thresholds because, remember, we are still bound by what the regulations say. Yes. So, I can attest to the fact that our processes have matured. I do not have to be here for one of the SCM officers to do a procurement, which goes up to R200,000. I am talking about the policy now. They understand what the policy says. Mine is just to come and then review the documentation in almost 95% of the instances. The documentation follows the processes. So, the processes have matured, and remember I said to you that one must get a clean audit, which means their processes must be solid. Yes. Yes. Not by design, but by implementation. So we were quite comfortable on that one. We are at level five." [P01]

Furthermore, participants are aware of their impact on the SCM process and how their actions contribute to the sustainability of SMEs. More arguments were made in favour:

"There are several options to choose from and most decisions concerning SMME empowerment are based on facts and if proper decisions and research are made, big decisions are made, it means, uh, eh, we can eradicate up to 90% of challenges faced by SMEs." [P05]

As stated in the findings, supply chain maturity is a rather distinctive and challenging concept to comprehend. A recurring theme that seemed to resonate with all participants was the existence of integration, coordination, and standardisation of the procurement processes. These integrated processes, systems, and procedures that are

standardised and implemented throughout a public supply chain result in greater efficiency and are tailored to address the challenges facing SMEs in the municipality.

Theme 3: Supply Chain Management Reforms

The third theme derived from the empirical data is SCM systems and processes reforms. Participants felt that current SCM reforms are practical and efficient. Furthermore, the policy appears to represent SCM reforms, according to most participants. The following excerpt, which most participants share, demonstrates how some of these reforms have been implemented by the municipality and to what extent:

"Yes, the contractor incubation programme, which focuses on developing construction SMEs, is implemented through procurement activities. This went as far as being approved by the council, and it will also be included in the SCM policy in terms of how the process is going to be in terms of its implementation, so that it gives the, you know, upcoming companies or SMEs a boost in terms of their activities." [P03]

Sections 112 of the Municipal Financial Management Act 56 of 2003 (MFMA) and 217 of the Constitution contain provisions relating to SCM reform processes. Implementing procurement reforms in the public sector has been difficult because of cultural, political, socio-economic, ethical, and environmental systems and structures (Basheka, 2021). Different ideas about what constitutes SCM reforms have been revealed according to the analysis of this study. As a result, on the one hand, the analysis showed a significant number of participants who could not explain these reforms well. It was unaware of what needed to be done. Although SCM reforms have made some commendable progress, the systems for implementing procurement practices in the public sector are not as reliable as those used in other, more established fields, such as finance (Matebese-Notshulwana, 2021). If SCM reforms are correctly implemented, the governance structures will be strengthened, leading to dialogue and interventions to improve the sustainability of SMEs in the municipality.

5. CONCLUSIONS

This study aimed to explore the degree of maturity of the public sector SCM to cast a broader spotlight on the potential that public sector SCM possesses to drive the sustainability of SMEs. Three themes were highlighted by analysing the qualitative data collected from various role players in the municipality. The study found that three factors, (1) Supply chain management governance framework, (2) degree of SCM maturity, and (3) SCM reforms, are essential pillars that require attention in the bid to improve the success of SMEs in the municipal area considered in the study. Specifically, the study concludes that strengthening regulatory policy awareness and improving implementation can lead municipalities to develop interventions to bolster SMEs' success. Second, the study concludes that mature municipal supply chains catalyse improved SME performance. Third, since SCM continuously evolves, reforms linked to SME operations in a municipal area are essential, ensuring that reviews are tailored to spur further establishment, growth, and the flourishing of small businesses.

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Motivations of Women Bazaar Curators in Egypt

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Abstract

Bazaars/street markets have been central to the economic, social, and cultural life of Middle Eastern cities for centuries. In the 20th century, the rise of industrialization and modernization brought substantial transformations drawing crowds away from them. Many bazaars have adapted to this new reality by turning into tourist attractions offering souvenirs and inducing a nostalgic sense for the past. In Egypt, over the past decade, the bazaar concept has undergone a reinvention with new directions. In addition to the traditional concept, a new form has emerged with women entrepreneurs organizing seasonal and/or monthly "bazaars" to bring together other fellow entrepreneurs (mostly women) to showcase and sell their products, which include fashion items, food, artisanal crafts, among other things. These women bazaar curators also offer training and consulting services aiming to help local entrepreneurs overcome barriers to market entry. These bazaars target upper-middle-class consumers (mainly women) and are held in posh areas in Greater Cairo. They are very popular and represent great women success stories. This research explores the motivations behind women curating these bazaars through the lenses of Innovation, Opportunity, Social Network, and psychological traits theories, providing a comprehensive understanding of the driving forces of these initiatives. We conducted one-to-one in-depth semi-structured interviews with three of the most prominent bazaar curators. The results were analysed and presented through a case study approach, employing thematic analysis. Preliminary findings reveal that women bazaar curators identified potential market gaps (opportunity) and designed creative solutions (innovation). They relied on their networks (network approach to entrepreneurship) and personal attributes (psychological traits) and empowered other local entrepreneurs.

Keywords: bazaars, Egypt, empowerment, entrepreneurs, innovation theory

1. INTRODUCTION

Street markets, bazaars, and craft fairs have existed for centuries, especially in the Middle East (Hjalager & Kwiatkowski, 2017). Street Markets refer to markets held in streets, often informal and involving various vendors (Thorne-Murphy, 2022). Bazaars were defined by Chen et al. (2022) as "a market that is characterized by offering a range of products and services, demonstrating individual vendors' specialized products and the needs of local residents. This may range from traditional products and local production to imports and essentials." Craft fairs focus on the sale of handmade crafts and artisanal products (Thorne-Murphy, 2022). Such vibrant marketplaces, often referred to as souks, are characterized by an array of shops and stalls with a numerous amount of goods for sale. They are economic

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and social hubs, where small-scale business owners, artisans, and the self-employed engage in business activities without the need for formal contracts (Timothy, 2018).

Bazaar, from the Persian word bāzār, "place of prices," has been a fixture of city life for thousands of years. Its origins go back to ancient Mesopotamia, where streets were reserved for specific crafts like copper-smithing as early as 2000 BCE (Markham, 1998). These early markets became increasingly organized commercial districts with the rise of Persian, Greek, and Roman civilizations, and later flourished under Islamic rule, becoming the centre of cities' economic, social, and religious activities (Goswami et al., 2022).

By the 4th century CE, the bazaars were well deep-rooted in the Middle East, strategically located along major trade roads such as the Silk Road and the Spice Route. The routes connected cities from China to the Mediterranean, not only for the trading of commodities but for the exchange of ideas, tongues, and cultures (Markham, 1998). Accounts by 19th-century travellers depict bazaars as mazes of narrow, poorly lit alleys crowded with life, colour, and perfume where one could buy anything from spices and silks to such commodities as meat and vegetables (Diraneyya, 2023). Every city specialized in a specific article, whether Salé's beautiful mattings, Fez's saddlery embroidery, or Muscat's perfumes (Wood, 2020).

In Islamic societies, bazaars were deliberately incorporated into urban design. They were generally placed near mosques, madrasas, and caravanserais and formed the centre of the city. They not only functioned as trade centers but also as forums of social interaction, religious debates, and culture (Goswami et al., 2022).

Historically, bazaars were both permanent and itinerant. In rural and desert settings, they were sometimes seasonal or temporary, tied to religious events like Ramadan or Hajj (Diraneyya, 2023). In addition to economic exchange, bazaars also produced trust, social cohesion, and collective identity within society (Deboulet et al., 2008; Ghasemi et al., 2021). Their architectural characteristics—covered alleys, interior courtyards, and separate zoning by product—reflected both climate and culture of the place (Major & Tannous, 2020).

Bazaars have provided essential goods and services at affordable prices to the economically disadvantaged (Deboulet et al., 2008). They are not just shopping centres but sites where cultures and traditions are fostered through locally based craft and art, where they also strengthen relationships, develop trust, and form a sense of belonging among the buyers and merchants (Deboulet et al., 2008; Ghasemi et al., 2021). The layout of the markets is generally reflective of the native weather and culture, offering a new shopping experience in covered passages, courtyards, and complex designs (Major & Tannous, 2020). They are different in content, some handling specific items like textiles, spices, jewellery, or crafts, while others have a wide range of goods (Chen et al., 2022). They also have their season of appearance in harmony with religious festivals, harvests, or events, further adding to their festive nature.

The Grand Bazaar of Istanbul, for instance, reflects the organic development of districts over time and the ideal expression of a complex adaptive system (Wohl, 2015). Cases like Marrakech's souks, Muscat's Souq Mutrah, and Doha's Souq Waqif highlight the bazaars' rich heritage and diverse products. Cairo's Khan Al-Khalili, prominent for its touristy vibe, sells souvenirs, spices, and genuine Egyptian handicrafts (Radwan & Jones, 2015). These markets ring with ancient trade routes and the exchange of goods across distant plots, and they are enduring symbols of trade and commerce.

While some bazaars like Istanbul's Grand Bazaar or Cairo's Khan Al-Khalili survived and even prospered as tourist destinations (Wood, 2020), their intrinsic economic role was undermined by the emergence of industrialization and department stores in the 19th and 20th centuries. Modern retail chains offered more variety and convenience, diverting consumer traffic from traditional bazaars (Diraneyya, 2023). Yet, most bazaars were able to survive by rebranding themselves, emphasizing heritage look and nostalgic atmosphere to attract tourists and middle-class buyers.

In Egypt, this reinvention has recently taken a new direction. The last decade has seen the emergence of premium lifestyle bazaars for upper-middle-class customers in localities like New Cairo and Sheikh Zayed. They are recurring weekend events featuring curated ranges of local brands and specialty items, filling gaps in the market abandoned by mass merchants. They leverage social media platforms like Facebook (FB) and Instagram to sell and promote their offerings; old behaviors coupled with new technology.

In the dynamic bazaar and souk ecosystems, women have traditionally been at the forefront, using entrepreneurial spirit and contributing significantly to the local economies. Egyptian women, for instance, possess extensive experience in entrepreneurship that dates back as far as ancient Egypt, where they exemplified such traits as opportunity spotting, creativity, and risk-taking (AlSadaty, 2020; Onay, 2017). Despite social limitations, women have broken conventional norms and entered into numerous businesses, usually taking over those industries.

In Egypt, entrepreneurial traits were also evident in women like Tsenhor, who managed mortuary businesses and achieved economic autonomy c. 550 BCE (Van Heel, 2014). The early 20th century was characterized by increased dynamism, with women engaging in business and cultural production. Pioneers like Fatma al-Youssef, Aziza Amir,

and Hidiya Afifi Barakat broke new grounds in publishing, film, and education, challenging gender conventions and altering social opportunity structures (Fakhreldin et al., 2021; Fertat, 2016; Cormack, 2021).

These cases, as varying in their size and objectives, all share these same features of innovation, risk-taking and creating new social and economic opportunities (Knight, 1921). These are the key features of entrepreneurship, and it demonstrates the significant contribution these women have made to their communities and to Egyptian society.

Women in societies worldwide have used bazaars and souks as platforms to sell their craftsmanship, market their products, and become economically independent (Dinar, 2020). Beyond any gender inequality, entrepreneurship is still clearly influenced by what is socially desired and acceptable, and despite cultural, patriarchal, and religious interfaces which are mostly traditional inclinations, women keep finding means of creating agency and prospects (Bastian et al., 2019). Women possess entrepreneurial attributes in nature such as innovation, patience, industry, and management skills, which they apply to other business areas (Rawal, 2024). Empowerment and identification of women entrepreneurship within bazaars and souks play a crucial role in promoting economic growth and improving gender equality in these active marketplaces (Džananović & Tandir, 2020).

Despite the announced low labour force participation rate of women in Egypt (18% in 2023; Assaad & Krafft, 2024) and the well-recognized importance of women's employment and empowerment for economic development (Mahmoud, 2025; Omran & Bilan, 2022), the recent proliferation of women bazaar curation, along with women and youth bazaar vendors remain underexplored. To the best of our knowledge no prior research has investigated this phenomenon, which merits study as it has become a structural trend, with multiple bazaars occurring concurrently almost every weekend throughout the year. Moreover, this trend could have critical implications for women and youth entrepreneurship and informal economic participation. The aim of this study is thus to examine these motivations through the lens of four entrepreneurial theories: innovation, opportunity-based, social network, and psychological traits theories.

Given the novelty of this topic, this study adopts an exploratory approach, focusing exclusively on the pioneers of this trend rather than the broader groups of recent entrants, who may have different motivations. This limitation of our scope ensures depth of insight into the early drivers of this phenomenon. We conducted one-to-one, in-depth semi-structured interviews with three of the most prominent women bazaar curators. We approached three others, but unfortunately the interviews did not materialize due to their limited availability, especially since two of them are well-known TV hosts. We analysed the data using thematic analysis within a case study framework.

The remainder of this study is organized as follows: Section 2 introduces the theoretical framework. Section 3 explains the methodology used. Section 4 presents the narrative profiles of the three bazaar curators. Section 5 discusses the results of the thematic analysis. Section 6 concludes the study.

2. THEORETICAL BACKGROUND

Entrepreneurship is a complex and multifaceted concept that has been studied by diverse scholars, leading to the evolution of various entrepreneurship theories. This study examines four theories that are believed to be the most relevant in finding answers to our research question: the motivations behind women bazaar curation.

1.1. Innovation Theory

Schumpeter's Innovation Theory (1934) positions the entrepreneur as the main agent of economic transformation. Entrepreneurs through the introduction of "new combinations" — novel products, innovative production methods, new markets, new sources of supply, and pioneering organizational structures — disrupt existing equilibria and generate new economic growth opportunities. This dynamic "creative destruction" process creates value-capturing prospects.

Value creation is a core concept and a central outcome in Schumpeter's Innovation Theory. Entrepreneurs create value through the "new combinations." The creative destruction process increases productivity and economic growth which creates significant value for society. Entrepreneurs also gain competitive advantages and temporary monopoly status, which is a form of value creation since this allows them to enjoy market dominance and increase their profits. These innovations also create value for consumers as the new and enhanced products satisfy their needs more proficiently. Furthermore, entrepreneurs create value through the efficient utilization of resources to generate any particular innovation.

In addition to economic value, innovations can create environmental and social values. Contemporary scholars extend Schumpeter's framework beyond technological or industrial innovation to encompass cultural, experiential,

and institutional novelty. Prahalad and Ramaswamy (2003) emphasized value co-creation between companies and consumers through collaborative processes, while Jones and Corner (2010) highlighted experiential markets in which symbolic and emotional values often outweigh functional utility. Giones and Brem (2017) further demonstrated how digital transformation enables micro-entrepreneurs to innovate not only in product design but also in distribution, branding, and customer engagement.

In bazaar's historically rooted, culturally embedded marketplaces, innovation does not necessarily manifest through radical technological breakthroughs but through the reimagining of space, experience, and exchange. Bazaar curators function as Schumpeterian entrepreneurs by fusing heritage (local crafts, culinary traditions, folk music) with contemporary consumer expectations (aesthetic presentation, digital accessibility, sustainability narratives). Many bazaars now operate as hybrid ecosystems, where social media is leveraged for curation, promotion, and community-building—thereby democratizing access for vendors who might otherwise be excluded from formal retail channels, particularly women and youth entrepreneurs.

Thus, innovation in bazaars reflects recombinant creativity: the blending of tradition and modernity, locality and globality, commerce and culture.

1.2. Opportunity-Based Theory

Drucker (1985) argued that entrepreneurs do not necessarily initiate change but rather recognize and capitalize on opportunities brought about by changes in consumer behaviour, market conditions, and technology. Kirzner (1979) emphasized the importance of entrepreneurial alertness (Kirznerian alertness), which is the cognitive ability of an entrepreneurs to notice opportunities/perceive market disequilibria—gaps between supply and demand, mismatches in consumer preferences, or inefficiencies in distribution—and to act upon them before others do. Kirznerian alertness is not about deliberate search for opportunities, but rather about being spontaneously open and aware of arising possibilities that emerge from change and being able to put it all together. Alert entrepreneurs can earn profits simply by being among the earliest to exploit novel opportunities. Shane and Venkataraman (2000) highlighted the importance of opportunity recognition in entrepreneurship research. They defined entrepreneurship as the process of discovering, evaluating, and exploiting opportunities that exist independently of the entrepreneur but that are recognized and acted upon through alertness and resource mobilization. Shane (2003) stressed the role of resourcefulness whereby successful entrepreneurs mobilize and combine resources to mitigate limitations instead of waiting until resources are abundant or conditions are ideal. He also distinguished opportunity-driven entrepreneurs from necessity-driven ones who are compelled by survival. The former proactively seek growth and innovation and are characterized by their sensitivity to emerging trends, willingness to experiment, and ability to connect disparate market signals into coherent value propositions.

In the bazaar context, curators function as opportunity entrepreneurs by identifying latent consumer demand for authenticity, locality, and experiential engagement—trends increasingly at odds with global retail homogenization (Holt, 2002). The experiential turn in consumption (Pine & Gilmore, 1999) positions bazaars as competitive alternatives to conventional shopping, offering not just goods but curated experiences such as live performances, artisan demonstrations, workshops, and gastronomic storytelling.

Moreover, bazaar curators serve as intermediaries between small-scale producers and consumers seeking meaning beyond utility, thus constructing platforms where products that struggle in mass retail (due to branding, scale, or distribution barriers) find niche markets and loyal audiences.

Opportunity recognition in bazaars unfolds across several dimensions: (1) identifying unmet or underserved consumer needs (e.g., ethically sourced goods, cultural authenticity, immersive experiences), (2) enabling marginalized entrepreneurs, particularly women and youth, to overcome barriers in formal markets, (3) demonstrating Kirznerian alertness by interpreting cultural, technological, and policy shifts as entrepreneurial openings, and (4) mobilizing social, financial, and symbolic capital flexibly to adapt to changing environments.

Curators thus operate not as mere event managers, but as market-makers constructing entrepreneurial ecosystems.

1.3. Social Network Theory

Social Network Theory conceptualizes entrepreneurship as a relationally embedded process, wherein outcomes depend on the function, quality, and structure of ties (Granovetter, 1973; Burt, 2005). "Weak ties" – acquaintances rather than close friends – facilitate access to novel information and opportunities, while brokerage across structural holes enables entrepreneurs to connect otherwise disconnected groups, generating competitive advantage. Social

networks are thus fundamental to entrepreneurial success. Entrepreneurs leverage their networks to access critical resources such as information, funding, and various kinds of support, reduce uncertainty, and advance innovation (Riaz et al., 2024). The size and diversity of an entrepreneur's network are crucial to entrepreneurial performance and creativity as they expand access to resources and reduce asymmetric information (Leyden et al., 2014). Frequency of interaction within networks or networks proactiveness is also important to entrepreneurial success as they strengthen ties, enhance the flow of information, and amplify resource recombination (Wu et al., 2025). The strength of the network ties also plays a significant role in supporting entrepreneurs through fostering trust and enabling resource sharing (Peng et al., 2022). Entrepreneurs who enjoy central positions and good reputations and are influential within their networks benefit more and perform better (Leyden et al., 2014; Pittz et al., 2021).

In bazaars, networks serve both motivational and instrumental roles. Family, friends, and professional ties provide emotional encouragement alongside tangible resources such as seed funding, marketing assistance, and logistical support. Success is further tied to curators' ability to mobilize trust, reciprocity, and social capital within local communities. Participation in associations, guilds, or digital creator networks expands access to mentors, collaborators, and customers. Thus, bazaars function not only as marketplaces but as nodes within entrepreneurial ecosystems sustained by relational ties.

1.4. Psychological Traits Theory

The psychological traits theory posits that certain enduring psychological characteristics distinguish entrepreneurs from non-entrepreneurs and predict entrepreneurial intention, persistence, and performance. McClelland (1961) emphasized the need for achievement, while subsequent research has highlighted traits such as internal locus of control, risk-taking propensity, self-efficacy, and resilience (Rauch & Frese, 2007; Vizcaino et al., 2021; Zhao & Seibert, 2006).

Contemporary scholarship underscores dynamic interactions between traits and context. Morris et al. (2019) argue that traits shape how entrepreneurs perceive opportunities, mobilize resources, and respond to uncertainty. Shepherd et al. (2015) highlight cognitive and emotional traits—such as optimism and tolerance for ambiguity—in sustaining effort through setbacks. Others emphasized the need for autonomy/independence and self-confidence (Zarnadze et al. 2022), leadership (Sukirno et al., 2020), persistence/perseverance (Al Mamun et al., 2018), and Zidan (2023) found that wealth-valuation was the most prominent entrepreneurial trait in the Egyptian context,

Meta-analyses confirm trait validity. Thai and Mai (2024) found consistent associations between innovativeness, creativity, proactiveness, and internal locus of control with entrepreneurial outcomes. Critics argue that trait approaches risk underplaying institutional constraints (Dedekuma & Akpor-Robaro, 2015), yet their explanatory power remains robust when integrated with contextual moderators.

Bazaar curators work within uncertain, resource-constrained environments requiring resilience, proactiveness, and adaptability. Proactiveness helps anticipate market or logistical challenges, resilience supports persistence amid financial or operational shocks, and tolerance for ambiguity enables experimentation with new formats. Leadership and interpersonal skills are especially critical for managing diverse vendors, resolving conflicts, and cultivating collaboration.

Crucially, traits moderate environmental constraints: high self-efficacy buffers against limited capital or institutional support, while low persistence may exacerbate regulatory barriers. Traits thus function as both enablers and moderators of entrepreneurial success.

3. METHODOLOGY

Scholars utilize case studies in research to offer an "in-depth, multi-faceted understanding" of an event, issue, or phenomenon in its natural context (Crowe et al., 2011), especially that researchers have been becoming increasingly concerned about the shortcomings of quantitative methods and their inability to provide thorough explanations to behavioural and social issues (Tomski, 2017). This study is an *exploratory* study that uses an *intrinsic* and *collective* structure, driven by an *interpretative* epistemology, and employs a qualitative approach. *Exploratory* since the phenomenon under scrutiny – women bazaar curation – has proliferated in Egypt over the past few years and yet is understudied, if not entirely unexamined. *Intrinsic* because the objective is to "learn about a unique phenomenon" where "the case is selected [for] its own merits…. not because it is representative of other cases." *Collective* since it involves "studying multiple cases simultaneously…in an attempt to generate a …broader appreciation of a particular issue" (Stake, 1995), in this case three of the most popular and pioneer women bazaar curators. *Interpretative* because

this study is "trying to understand individual and shared social meanings," through thick descriptions and thematic analysis of three in-depth semi-structured interviews for the purpose of exploring motivations behind women bazaar curation in Egypt.

Just a few years ago, women rarely curated bazaars in Egypt. Today, bazaars have proliferated to the extent that they have become an almost every-weekend event throughout the year. To select the interviewees, we relied on Instagram – the primary platform for bazaar marketing – along with our own observations as bazaar goers and word-of-mouth recommendations. We targeted women curators with more than 100,000 Instagram followers, which resulted in six potential participants. We contacted all six, but only three interviews materialized; two of the non-participants are famous TV show hosts.

Two interviews were conducted online and one in person, all recorded with prior consent. The interviews were conducted primarily in Arabic with some English, reflecting common communication style among educated Egyptians. Transcriptions were translated into English using an AI tool and thoroughly revised by the research team. Participants were informed about the objective of the study and signed consent forms. They were asked whether they would prefer using pseudonyms for themselves or their bazaars, but all opted to use their real names and business names. Ethical approval for the interview questions was obtained from the university ethics committee before data collections began.

4. THE NARRATIVES PROFILE

4.1 Lydia Akram and L.A Market

Lydia Akram, a 35-year-old Egyptian entrepreneur, holds a bachelor's degree in Logistics and has long been passionate about event organization. As a university student, she led an informal charity group and organized major Orphans Day events. According to Lydia, her Logistics degree taught her planning, management, and coordination, which complemented her practical experience, enabling her to connect theory with her passion.

Married at 21, Lydia stayed home for three years after her first child, then briefly worked at a school realizing the rigid schedule was not compatible with her family life. The idea for a bazaar emerged during a casual coffee meeting with a friend who managed a fashion FB group for modest elegance. Drawing on their charity experience and the nascent emergence of online modest fashion, they organized their first bazaar in April 2018 with 40 local brands. Lydia leveraged her social network, learned industry practices, and soon formalized her business by registering L.A Market, which now has over 297K Instagram followers.

Lydia identified a gap: existing bazaars focused on charity or crafts, while she envisioned a market dedicated to modest fashion made in Egypt. L.A Market features only locally produced goods (even if the raw materials are imported)—clothing, accessories, skincare certified by the Ministry of Health, home décor, and food—supported by local sponsors. Despite scepticism toward Egyptian-made products, Lydia championed quality over mass production, helping shift public perception. Today, local brands are a source of pride. Her vision emphasizes community, quality, and meaningful impact. Lydia rejects superficial imitation and enforces strict quality standards, including on-site checks for stitching, fabric quality, design, and presentation. Each season, L.A Market admits 20–30 new brands while removing underperforming ones. Integrity in execution remains a core principle guiding her operations.

Integrity and "doing the right thing" have guided Lydia from the start, a principle she believes paid off. She refused to operate informally despite friends' advice. A year after launching her bazaar, the Tax Authority contacted her, asking her to encourage local brands—many of which were online—to register officially for a symbolic fee. Lydia explained that the government was not seeking revenue but wanted to assess whether Egypt's textile and apparel sector was growing and had real potential.

Initially, Lydia's bazaars were held in mall courtyards for easy access to parking, restrooms, and prayer areas. Later, she was approached by Cairo International Convention Centre (CICC), Egypt's premier exhibition venue, and offered space. Today, L.A Market is curated there almost monthly, expanding from 40 brands to 700–800 annually, with 2,500 more on the waiting list. In addition to L.A Market, Lydia has opened a concept store in one of New Cairo's largest lifestyle malls to showcase local products year-round, and she plans to expand into exports.

Vendor selection at L.A Market is merit-based, with gender playing no role. Vendors are evaluated individually for originality, design quality, visual presentation, uniqueness, word of mouth, and client feedback—rather than social media following. Lydia takes pride in success stories, such as two male vendors who began with only two bag designs and now own showrooms and export their products. Lydia maintains a dedicated WhatsApp group, "From L.A Market," to share updates and resources such as consultants and workshops. Vendors join primarily for exposure and

visibility. Financial arrangements involve a fixed fee covering booth setup, logistics, and social media promotion; Lydia does not take a percentage of sales. She avoids interfering with pricing but offers advice when requested. After each bazaar, she provides feedback on aesthetics and interpersonal engagement.

L.A Market primarily attracts upper-middle-class households (segments A and B), excluding the very top tier who prefer imported goods. Customers return for exclusivity, as most products are not available in malls and many are unique to L.A Market. The experience emphasizes meeting designers, ordering custom pieces, and discovering new collections rather than simple transactions. To enhance convenience, Lydia incorporates children's play areas, food and beverage stations, and avoids loud entertainment to maintain a refined atmosphere.

Lydia leads the business alongside two silent partners but retains ultimate decision-making authority while encouraging team input. She values collaborative discussion and often defers to the majority view when convinced. L.A Market faces ongoing challenges, including inflation, employee retention, and growing competition among vendors. However, boycotts, organized as a stance against countries and products perceived as unsupportive of Gaza's rights, have significantly increased L.A Market's relevance, resulting in a significant increase in applicants, customers, and sales. Before October 7th, 2023, sales averaged EGP 3–4 million; by May 2025, they had risen to EGP 15 million. Despite her demanding schedule, Lydia remains committed to mentoring aspiring bazaar founders.

4.2 Dina Essam and HBShop

Dina Essam, 35 years old and a mother of two, also holds a bachelor's degree in Logistics. Her employment ended when her company refused to renew her contract after she disclosed her pregnancy, prompting her to pursue entrepreneurship.

In 2019, Dina created a FB group, *Hijab Bloggers*, which quickly grew to over 200,000 members. The group aimed to challenge stereotypes that veiled women are unfashionable or belong to a lower social class. It evolved into a community-driven marketplace where women shared outfits, sources, and eventually sold their own modest collections—revealing strong demand without a structured platform.

This insight led to on-ground bazaars in carefully selected venues where local brands could be experienced firsthand. Initially, the goal was not profit but promoting a message of authenticity and empowerment. Dina modelled clothes herself without makeup or photo editing to build trust, reinforcing her social mission of supporting women designers and promoting locally made, high-quality fashion over mass-produced alternatives.

When COVID-19 struck, Dina launched a website to host brands and started an Instagram page. In 2021, she opened a physical concept store, HBShop, which achieved five times the daily revenue of the website on its first day. Today, Dina curates two to four HBShop bazaars annually, strategically scheduling them at Eid nights when couriers stop delivering and other bazaars do not operate. These events attract large crowds and have become commercial benchmarks, with participating brands reporting record sales.

Venue selection is based on accessibility, parking, seasonality, and market gaps. Dina favours the front yard of a particular mall for its strong footfall and supportive management but shifts indoors during summer to avoid heat. She views mall shops as complementary rather than competitive, as her bazaars offer curated, homegrown modest fashion unavailable in standard stores.

Vendor sourcing began within her FB community and expanded through a multi-channel digital ecosystem, including Instagram, TikTok, WhatsApp, SMS, mothers' groups, influencers, and word of mouth. Around 100 active brands form the vendor pool, with 80 selected for each bazaar and a 70% overlap. Selection criteria prioritize visual coherence, brand identity, seasonal relevance, and professional presentation rather than social media metrics. Dina has accepted brands with minimal followers for strong branding and rejected long-established ones for poor content. Financial arrangements involve a fixed participation fee without sales commission, reducing risk for small entrepreneurs. Dina does not interfere with pricing but ensures market balance. She provides vendors with consumer-driven insights, such as unmet product demands, to help them adapt.

Dina prioritizes social mission over profit, empowering women-led enterprises—particularly those without retail presence—by offering visibility, practical experience, and direct customer access. Her platform supports home-based tailors, designers, and small-scale vendors, creating a tight-knit ecosystem.

Dina leads a team of 24, holding most ownership while sharing 10% with her two sisters. Her husband, an e-commerce business owner, helped build the website; one sister designed branding; and her children modelled clothes. Family support and flexible structures enabled her to balance business and motherhood. Dina faced many operational challenges including navigating complex tax and registration frameworks, which led her to hire a lawyer and accountant to ensure compliance. After the Gaza-related boycott movement, vendor applications surged. While

competitors raised prices dramatically, HBShop maintained affordability, strengthening customer loyalty. Beyond clothing, Dina mentors women starting non-competing businesses, reflecting her broader commitment to supporting female entrepreneurs.

4.3 Rania Atef and I Make This

Rania Atef holds a bachelor's degree in statistics with a minor in economics and a master's degree in social research methods and statistics from the London School of Economics. Although she never formally studied entrepreneurship, she relied on self-learning to acquire the necessary skills. Rania previously worked in development projects with UNICEF and the Ministry of Family and Population before moving to London with her diplomat husband, where she pursued photography as a freelancer.

During a trip to Cairo in late 2019, Rania sought to market her photography services and discovered that small businesses relied on inefficient methods such as posting on FB and asking friends to share. Larger FB groups either rejected her posts or charged high fees. Recognizing the need for a platform where small businesses could showcase products and engage customers, Rania and her friends launched a private FB group, *I Make This*, in December 2019. The group grew rapidly, reaching 100,000 members within a month, fostering collaboration and sales among participants.

Encouraged by this success, Rania and her brother studied the Etsy model and launched an e-commerce platform under the same name, alongside plans for on-ground events. The first bazaar was scheduled for March 2020 but was canceled due to COVID-19 lockdowns. The inaugural event eventually took place in October 2020 in a residential compound and attracted such a large crowd that authorities intervened to close it early, though vendors reported record sales.

Participation in *I Make This* requires businesses to be women-led or have women as primary decision-makers. Men are allowed only if part of a family business. Joining the website is mandatory before participating in bazaars, which serve primarily as marketing tools. Rania sometimes uses the bazaar to evaluate new sellers. But they cannot join the second bazaar before joining the website.

Vendor selection emphasizes uniqueness and quality. She does not brand herself as "support local" platform as she does not want purchases out of sympathy. Products are often priced higher than imported alternatives due to their originality. Starting in 2024, Rania introduced a subscription fee for the website in addition to the 10% commission on sales, along with a separate bazaar participation fee. Fees are waived for creative underprivileged makers. Rania shared her disappointment about the inability to include makers from other governorates even though could be extremely talented because they are unable to logistically handle the online orders. Occasionally, Rania partners with NGOs to support women lacking technical skills, provided logistics are managed by the NGO.

Rania does not interfere in the vendors setting their own prices, but quality control is strict: products with three repeated returns are removed, and makers with consistent complaints or who copy each other are excluded. Refunds and exchanges are mandatory. Rania provides real-time feedback during bazaars, shares sales data, and offers training on customer interaction and social media posting. In collaboration with the National Bank of Egypt, she launched a capacity-building program to teach financial literacy and business skills.

Sponsors frequently approach Rania to host bazaars at their venues, aligning with their marketing goals. While bazaars generate profit, the website remains less lucrative. Customers are primarily upper-middle-class, seeking unique, non-repetitive items. They tend to be older and more selective, favoring high-quality products over impulse purchases.

The Gaza-related boycott temporarily boosted demand for Palestinian-themed products, though this trend later subsided. Rania expressed frustration over delays in launching the website during the initial FB surge, which limited outreach as algorithmic visibility declined over time. Despite reaching 100,000 members in one month, the group now has 197,000 after five years. Instagram has become the primary growth channel, while the website still requires development. Rania's long-term vision is to position *I Make This* as the Etsy of the Middle East—a leading e-commerce platform for handmade and creative goods.

Rania views her venture as a social enterprise rather than a charity, aiming for mutual benefit: her success depends on enabling other women to succeed. She acknowledges the challenges of entrepreneurship, emphasizing that being one's own boss demands constant work and sacrifices, despite the rewarding sense of achievement.

The following section presents a thematic analysis of the in-depth interviews and links the emerging themes to the theoretical framework.

5. DISCUSSION AND REFLECTIONS

5.1 Serendipitous entrepreneurship

None of the three women initially planned to become an entrepreneur. Their ventures emerged as a mix of personal circumstances, Kirznerian alertness, social networks, and psychological traits. Lydia felt demotivated after staying home for three years following childbirth and disliked the rigidity of a traditional full-time job. Dina's shift was triggered when her multinational employer refused to renew her contract upon learning she was pregnant. Rania transitioned to freelance photography after leaving her development work to join her husband on a diplomatic assignment in London.

Their Kirznerian alertness, combined with their informal networks played a critical role in allowing them to recognize the opportunities and mobilize rapidly. Lydia recalled, "I was having coffee with a friend who had a small FB group… *"Let's do something together!"* *"I called up friends… I posted asking for venue suggestions, reached out to bazaar organizers… and we pulled it off."* Similarly, Dina explained, *"it all started with a FB group called "Hijab bloggers" …it grew to over 200K members…girls posted photos of their outfits…. soon… the group [turned] into a grassroots marketplace."* She added *"I saw other groups like Rahet Bali ["Peace of Mind" group for mums] organizing bazaars… and I decided to try it."* As for Rania, she shared, *"I asked my friends with small businesses how they promote their products… the posts were either rejected, or they asked for a high fee… I told my friends: What if we created our own group?... the group was private and invite-only… one month later, we hit 100K members… we didn't plan to become a business – it grew organically… every single opportunity came from the community – we never reached out to anyone."*

The three women's needs, coupled with their skills, creativity and proactivity traits lead to their entrepreneurial ventures. Lydia was a master in event organization: *"I'd long been organizing Orphans Days and school fun days – and my degree in Logistics helped me connect the dots… give me any event and I'll plan it for you."* Dina described her modest fashion initiative as *"a form of emotional escape and purpose"* during postpartum. Rania highlighted her self-learning approach: *"I've always had a scientific approach to learning… I taught myself everything we need along the way."*

5.2 Bazaars as a byproduct

For all three women, bazaar curation is not their ultimate goal. Instead, bazaars serve as tactical steps-crucial for testing demand, creating visibility, and paving the way toward higher ambitions. Rania emphasizes this clearly: *"I never describe myself as someone who does events… [being] on-ground is a marketing tool to promote the website."* She adds, *"we are the Egyptian Etsy"* and *"our mission is to become the Etsy of the Middle East."* Similarly, Dina operates a website and has launched a physical retail concept store, with plans to expand into other governorates. She highlighted the showroom's success: *"It made five times the website's daily revenue on its first day,"* signalling a broader vision that extends far beyond individual bazaar events. Nevertheless, she continues to host HBShop bazaars two to four times a year because, as she explains, *"bazaar attendees want variety and discovery. Showroom visitors come for a more curated, calm experience. Each attracts diverse types of customers."* She further notes, *"Bazaars attract exploratory shoppers; stores bring more focused buyers."* As for Lydia, she also launched a retail concept store as well, yet her bazaar has grown into a major monthly event in New Cairo or Sheikh Zayed: *"L.A Market moved to CICC, which sets us completely apart from all the other bazaars happening around Egypt."* In Schumpeterian terms, the three women are innovative strategic thinkers. They introduced "new combinations," disrupted the existing equilibria, and created economic and social values for local producers and consumers with both forward and backward linkages, as well as to themselves.

5.3 Social mission and identity reframing

The three women share a common social objective, albeit with minor variations: they all aim to encourage local production that is creative, authentic and of high quality. For Dina and Lydia, modest fashion lies at the heart of this social mission. Dina explained, *"Hijabis were stereotyped as lacking taste, but I knew fashionable veiled women so I wanted to prove modest and elegance can coexist."* This commitment does not compromise quality. As she noted, she *"champion[s] local designers – when their quality is high,"* and her HBShop retail store features limited imported designs suitable for veiled women. Lydia echoed this vision: *"I saw an opportunity to create a market 100% focused on modest fashion… featuring 100% local brands and sponsors."* She refuses to display in her L.A Market bazaar or

her Pop Kult concept store any items that are not locally produced – even if the raw materials are imported. Rania, on the other hand, takes a different stance: *"we do not brand ourselves as a "support local" platform. I do not want purchases out of sympathy. We are not cheap. [We are expensive] because we offer something unique."* She adds: *"Our customers are mostly upper-middle class. They like funky, one-of-a-kind pieces."* While Dina and Lydia are not explicit about the gender of their vendors – though mostly women – Rania insists *"a woman must be a central part of it… if I earn 10, ten women must earn 10."* This Schumpeterian economic value creation fosters equitable growth while simultaneously promotes social value creation rooted in local pride, authenticity, and women empowerment. It reflects optimism and resilience, as the process unfolds along a long trajectory of continuous learning.

5.4 Social networks leveraging and community growth

The social networks of the three women played a pivotal role in the growth of their communities and businesses. The dense and size of their trusted networks, combined with their centrality and strong reputations, enabled them to reach both vendors and customers. Dina noted that *"hijab bloggers grew to over 200K members … the largest modest fashion community in Egypt,"* and when promoting her HBShop bazaar, she emphasized that *"word of mouth in mommy groups are incredibly effective."* Lydia explained that to launch her first bazaar, she *"tapped into different communities – like Korba religious gatherings asking who sells scarves abayas, dresses"* and today *"work[s] with 700-800 brands yearly… and ha[s] about 2500 brands on our waiting list."* Rania's invite only FB group *"hit 100K"* in a just one month. Moreover, she shared that *"banks and sponsors reached out to us – every opportunity came from the community."*

5.5 Autonomy and Control

The three curators value autonomy and prefer making their own business decisions to preserve agency, while still listening to their teams when necessary. Dina explained *"I hold the majority ownership, with 10% shared between my sisters… one sister designed the branding and visuals."* Lydia shared that she has *"two silent partners…but… [she is] the main decision maker."* She added *"if I send an idea, I am 100% sure about, and nine of them disagree, I go with their input…my team mean everything to me."* Rania, meanwhile, has no official partners on paper, and although her brother *"invested in I Make This when it was first launched, he is not involved in management."*

For all three, autonomy is closely tied to integrity and long-term legitimacy. Dina registered HBShop and hired a lawyer and an accountant, following her father's advice to *"keep things legal."* Lydia also registered L.A Market from the start and was even approached by the Tax Authority *"asking [her] to encourage local brands to formalize."* Similarly, Rania's I Make This is also registered, and while she has been approached for partnerships by authorities, she admits being cautious, saying she is afraid to *"accept partnerships that [might] not align with [her] mission and vision."* The emphasis on autonomy aligns with psychological trait theories, which highlight entrepreneurs' inherent need for independence—a view supported by scholars such as Zarnadze et al. (2022).

5.6 Resilience and Adaptability

The three curators encountered hurdles along the way, yet they demonstrated flexibility, adaptability, and a strong tolerance for ambiguity, along with persistence, and resilience. Dina affirmed, *"when COVID hit… I launched the website… to host the brands we worked with [in the bazaars]. I also started the Instagram page."* Similarly, Lydia and Rania persevered during the pandemic. Rania noted that the *"actual first bazaar happened in October 2020, when things opened up a bit."* She also highlighted the demanding nature of entrepreneurship: *"I have been doing this full-time for five years now. And I have not taken a single day off."* Lydia also expressed the numerous obstacles that she faces, such as *"constant inflation that affects rent, production and the overall pricing,"* along with *"staffing, setup delays, 3D designs that do not come out as expected…. And the biggest challenge… the drama between women vendors."* This shows that once again psychological traits such as persistence, resilience, and tolerance for ambiguity remain critical for entrepreneurial success, as emphasized by scholars including Al Mamun et al. (2018), Rauch & Frese (2007), Shepherd et al. (2015), Vizcaino et al. (2021), and Zhao & Seibert (2006).

5.7 Leadership as community stewardship

Leadership is multifaceted. For the three curators, it involves not only safeguarding trust and product integrity but also mentoring vendors and raising standards across the local production ecosystem. Regarding product integrity,

Lydia asserted *"we do not accept people who just copy designs or do things carelessly… we drop the ones who do not meet our standards… we do quality control reports, field visits to inspect stitching, fabric quality, and presentation."* Similarly, Rania confirmed *"if someone copies original work, they are blacklisted…. Also, we do enforce quality control: if three clients return the same product, we remove it [from the website], If a maker consistently receives complaints we remove them. Refunds and exchanges are mandatory – we do not accept the "no refund" policies."* For Dina, authenticity is central: *"originality and honesty… I modelled the clothes myself – no filter, no makeup… this helped build trust."*

Beyond quality, the three curators actively support their vendors through mentoring and capacity building. Dina shared, *"I mentored someone launching a kids' product store… and I am happy to support any non-competing business."* Rania partnered with the National Bank of Egypt to create *"a whole program of capacity building… teaching financial literacy and business skills."* She also provides social media training, explaining, *"I train them specifically on how to write a post on I Make This,"* and gives on-the-ground advice *"on their product display."* Lydia maintains a WhatsApp group with her vendors where she *"share[s] updates all year and also share[s] useful resources like good business consultants and workshops."* Leadership is a crucial trait for successful entrepreneurship as argued by many scholars including Sukirno et al. (2020).

5.8 *Calculated risks*

The three curators each took significant risks in their entrepreneurial journeys. Rania's introduction of a subscription fee in 2024 was a calculated risk: *"It was a way to filter for commitment,"* though it initially sparked backlash - *"Now, you want to profit from us?"*—yet proved crucial for the platform's health. Lydia's decision to move L.A Market to CICC was another bold move. She recalled, *"I was like, 'No way!' That is like going to the desert… but then we studied it… this decision opened up massive opportunities."* Similarly, Dina acknowledged that opening the HBShop concept store was a major risk. Risk-taking propensity is a critical entrepreneurial trait (Rauch & Frese, 2007; Zhao & Seibert, 2006), and each of the three curators demonstrated the ability to take calculated risks—an essential ingredient for entrepreneurial success and growth.

6. CONCLUSION

Employing four entrepreneurial theories—Schumpeter's innovation theory, opportunity-based theory, social network theory, and psychological traits theory—this study explored the motivations behind women bazaar curation in the Egyptian context. Findings reveal that the three curators demonstrated Kirznerian alertness, resourcefulness, and leveraged their social networks to introduce "new combinations" that disrupted existing equilibria, driving both economic and social value creation. Their psychological traits—such as autonomy, resilience, adaptability, tolerance for ambiguity, persistence, leadership, and risk-taking propensity—enabled them to make strategic decisions and sustain growth. Collectively, these factors underscore how entrepreneurial success in this context is shaped by innovation, opportunity recognition, strong social capital, and enduring personal traits.

Acknowledgements

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An Analytic Study of Stakeholders' Perceptions on Environmental Responsibility and Natural-Based Tourism in Adriatic Coastal Zone of Albania

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Abstract

The Adriatic coastal zone of Albania represents one of the country's most dynamic areas for tourism development, where natural resources, cultural values, and economic interests intersect. This study investigates stakeholder perceptions of natural-based tourism, focusing on the quality of tourist destinations, the negative impacts of tourism, and the responsibility for ensuring sustainable practices. A structured questionnaire was administered to 72 stakeholders representing diverse professional backgrounds, including public institutions, civil society, businesses, educational institutions, and NGOs. Data analysis was conducted using SPSS, including 11 variables related to environmental factors, perceived quality indicators, awareness of potential environmental impacts, and responsibility in managing tourism sustainably. The reliability coefficient (Cronbach's Alpha = 0.702) confirmed acceptable internal consistency of the included variables.

Findings indicate the highest representation from tourism businesses (25%), local public institutions (20%), and educational institutions (17%). The most cited reasons for visiting the Adriatic coast were coastal tourism (23%), ecotourism (21.3%), gastronomic tourism (14.5%), and cultural tourism (14.5%). Spearman correlations revealed significant positive relationships between several variables, such as air quality and environmental cleanliness (ρ = .578), and between perceptions of tourism's negative impacts on biodiversity, natural environment, and water pollution (ρ = .846; ρ = .781). Study suggested improvements to the destination included well-scheduled public transport, expanded recreational activities, and greater environmental cleanliness.

This study provides valuable insights for policymakers, destination managers, and local communities, highlighting the importance of integrating stakeholder perspectives in developing sustainable, natural-based tourism along the Albanian Adriatic coast.

Keywords: Adriatic coast of Albania, natural-based tourism, stakeholders, environmental impacts, Spearman's rho correlation

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1. INTRODUCTION

The Albanian Adriatic coastal zone presents one of the most dynamic areas of tourism development, shaped by the interplay of distinctive natural coastal features, a favorable Mediterranean climate, and a rich natural and cultural heritage. While the area attracts a wide range of visitors for seaside, cultural, and gastronomic tourism, there is an increasing interest in nature-based and ecotourism activities, reflecting a global trend toward sustainable and environmentally conscious travel. This dynamism is further influenced by policy frameworks that facilitate market-oriented growth and by substantial infrastructure investments, although these processes also pose challenges in terms of sustainability and balanced territorial management. Ministry of Tourism and Environment (MTE, 2019: 3) states that "Data year after year prove the rise of tourism as one of the sectors that bring the most revenue to the state budget, entrepreneurial and family budget, with a direct contribution to the GDP of 8.5% and an indirect value added of 26.2%", showing an important indicator to economy of Albania. Meanwhile, in 2023, Albania ranked 4th globally for the highest increase in the percentage of international tourist arrivals, marking a 56% growth compared to 2019, which highlights the country's growing appeal as an emerging travel destination and the rapid development of its tourism sector (MTE, 2024, pg.6)

Ecotourism, as a form of natural-based tourism, offers the dual advantage of supporting local economic development while promoting environmental conservation. Looking at the Albanian Adriatic coast, Dhimitri et al, (2025: 1946) confirms that seaside tourism remains the dominant reason for visits (23.6%), underscoring the importance of coastal attractions. Cultural tourism (16.8%) and gastronomic tourism (13.5%) follow, highlighting Albania's historical and culinary appeal. Ecotourism (12.6%) also holds a significant presence, pointing to an interest in nature-based activities. These trends suggest that tourism strategies need to integrate both the demand for recreational experiences and the necessity of preserving natural ecosystems. Environmentally sustainable investments in the ecotourism sector produce vital benefits to local communities and provide an important and viable alternative investments with positive perspectives not only in lines of business as tourism but also conserves biodiversity. However, the negative and/or positive impacts needs to be watched and reassembled with time and space; can be achieved through the development of new and innovative eco-engineering management systems with a special focal point of ecotourism Vs ecological sustainability based on natural biological spheres that exist in accordance to soil-water-climate (Lushaj, et. al, 2012).

However, the tourism industry can also be viewed as a destructive force, associated with negative externalities such as the loss of natural landscapes, water pollution, biodiversity loss, environmental and cultural degradation. These problems are more likely to be exacerbated where there is a lack of well-designed planning and effective management of tourism development (Brokaj, 2014). Stakeholders' perceptions are therefore essential to identify priorities, responsibilities, and strategies for sustainable tourism (Pulaj & Agaraj, 2024; Liça, Gashi & Qosja, 2024). Research shows that environmental sustainability, accessibility, hospitality, and service quality are key factors shaping destination competitiveness and visitor satisfaction (Dhimitri, 2025; Mbrica et al., 2023). Stakeholder perspectives highlight that in the Albanian Adriatic coast, destination quality is significantly influenced by environmental sustainability and hospitality, while tourism product quality is shaped by accessibility and service infrastructure. These findings emphasize the importance of collaborating and integrating environmental, regulatory, and service-based improvements to create a more competitive and attractive tourism destination (Dhimitri, 2025: 1950).

This study aims to understand how stakeholders perceive nature-based tourism and their sense of responsibility toward sustainable management of the Albanian Adriatic coast. The study emphasizes stakeholders' assessments of air quality and environmental cleanliness in the tourist destinations, as well as their perceptions of tourism's negative impacts on flora and fauna, the natural environment, water pollution, and destination overcrowding. It also seeks to explore stakeholders' sense of responsibility toward environmental protection, biodiversity conservation, and the minimization of the exploitation of unique local resources. By emphasizing ecotourism and integrating environmental awareness with tourism development, the research highlights the importance of policymakers, destination managers, and local communities promoting sustainable practices that balance economic growth with conservation alongside the Adriatic Coast in Albania.

2. STUDY AREA AND LITERATURE REVIEW

The coastline of Albania is washed by the Adriatic Sea and the Ionian Sea, both of which are part of the Mediterranean basin. The total length of Albania's coastline is about 472 kilometers, including the coastal areas of the lagoons (ASHSH, Kabo, 2009: 2538). The two seas are separated by an imaginary line extending from Cape Gjuhëz on the Albanian coast to Cape Otranto on the Italian coast. The area covered by this study represents the southeastern Albanian section of the Adriatic Sea. From a geomorphological point of view, this area is predominantly low-lying, characterized by sandy beaches, dunes, and lagoons, except for several rocky capes composed of marl or sandstone, as well as deltas (Rodon, Bishti i Palles or Palit, Treport, and Lagi), which are elevated, featuring marine cliffs and active coastal erosion (ASHSH, Pano & Kabo, 2008: 10-11). This coastline is continuously shaped by marine processes and by the depositional activity of rivers (Qiriazi, 2019: 110). Different sections of the coastline are influenced by either the erosive or accumulated activity of the sea, which exposes tourism infrastructure and affects the overall quality of the tourist destination. Numerous beaches such as Velipoja, Shëngjin, Tale, Lalëzi, Durrës, Kavaja, Seman, and Vjosa, along with marine bays like those of Shëngjin, Lalëzi, Durrës, Karavasta, and Vlorë, as well as the warm summer waters (around 22°C), and lagoons such as Viluni, Kune-Vain, Patoku, Karavasta, and Narta, together represent powerful natural resources that support tourism, its diversity, and the related tourism industry.

The Western Lowland is the geographical region of the country that lies along the Albanian Adriatic coast and is characterized by a predominantly flat relief, with the presence of low hills featuring gentle, asymmetric slopes. Lowland relief is the result of the activity of rivers that cross the territory, from the Buna River in the north to the Vjosa River in the south. Such terrain increases the ease and speed of access to tourist destinations along the Adriatic coastline.

The climatic features of the coastal area near the Adriatic belong to those of a lowland Mediterranean climate, with a strong maritime influence. According to Koppen's climate classification with additional modifications by Geiger and Pohl (1953), the territory of Albania belongs to the category Csa (C – moist climates with mild winters, s - dry summers, a - summers long and hot with classification criteria: warmest month > 22ºC with more than 4 months > 10ºC (Holden, 2012). According to Hydrometeorological Institute (1980) the amount of precipitation varies from 1000 mm around Myzeqe to 2000 mm in the northern part of the Western Lowland. Tourist destinations are exposed to these climatic conditions, including extreme phenomena such as intense rainfall that can cause flooding in river-adjacent areas, or the effects of heatwaves, a phenomenon often referred to as a "silent killer."

Thus, Porja & Dhimitri (2022), in their study, emphasized that during the period 2015–2019, eight heatwave episodes occurred over five years, an average of approximately 1.6 episodes per year, totaling 121 days meeting heatwave criteria. Meanwhile, during the period 1980–2014, there were 37 episodes over 35 years, about 1.1 episodes per year, with a total of 356 heatwave days.

Extreme temperature events in the Albanian Adriatic coastal zone demand particular attention due to their impacts on both the natural environment and local communities. These periods often overlap with high tourist activity, highlighting the need for tourism stakeholders to adopt measures that ensure visitor satisfaction while minimizing environmental pressures.

The region is rich in natural and protected areas that serve as key resources for ecotourism. Notable examples include Divjake-Karavasta National Park (recorded the highest number of visitors in the country in March 2025, representing 29% of all visitors, MTE, 2025), Vjosa River National Park, and Karaburun-Sazan Marine National Park, as II Category of IUCN. According to the Council of Ministers Decision (VKM) No. 303, dated May 10, 2019, the study area also contains numerous well-preserved natural monuments across municipalities: Vlorë (18), Durrës (4), Divjaka (9), Fier (4), Kavaja (7), and Lezha (10). Also, there are "Kune–Vain–Tale–Patok–Fushëkuqe–Ishëm" Managed Nature Reserves, "Shkodër Lake" Managed Nature Reserve, IV Category of IUCN. "Pishë Poro – Nartë" is a Protected Landscape, Category V (IUCN), "The Buna River – Velipojë" as well. In this area, there are also two Ramsar sites: the Karavasta Lagoon–Pisha e Divjakës, designated by Decision of the Council of Ministers No. 413, dated 22.08.1994, with a surface area of 20,000 ha, and the Shkodra Lake–Buna River, designated by Decision of the Council of Ministers No. 683, dated 02.11.2005, with a surface area of 49,562 ha (AKM, 2023: 86). Various studies,

(Braholli & Dhimitri, 2022:11; Braholli & Menkshi, 2021; Dhimitri, Sinani & Todi, 2015) for Adriatic coast touristic destinations, highlight the need for scientific knowledge and interpretation in preparing professional guides, local communities, pre-university students, (Zdrava & Dhimitri, 2025), within the framework of ecotourism through geoeducation.

These protected sites offer opportunities for sustainable tourism development, combining recreational experiences with environmental conservation and education, and are essential for promoting natural-based tourism along the Albanian Adriatic coast. Ecotourism emphasizes responsible travel to natural areas that conserves the environment, supports local communities, and promotes awareness of ecosystems. In coastal regions like the Albanian Adriatic, it leverages protected landscapes, national parks, and natural monuments to offer sustainable experiences that combine recreation with environmental stewardship. Ecotourism is an ideal form of sustainable tourism because it is claimed to minimize negative impacts on the environment and increase economic prosperity by increasing the benefits of the tourism sector. However, ecotourism has challenges in its development. Ecotourism is a type of tourism whose development could be faster, and the results are also slow because ecotourism is non-mass tourism, so stakeholders often pay little attention (Khusaini, et.al., 2024).

Local communities, tourism businesses, public institutions, and NGOs play a key role in ecotourism by ensuring sustainable planning, protecting natural resources, and raising visitor awareness. Their involvement helps balance tourism development with environmental and cultural preservation, ensuring long-term benefits for both nature and local populations. To enhance development of local community's vis-a-vis conservation of resources both natural and cultural, an alternative benign approach to tourism, generally known as ecotourism, is widely advocated as a comprehensive tool (Chan, & Bhatta, 2013). As ecotourism grows, responsible management becomes essential to ensure long-term benefits for both the environment and local populations. Successful ecotourism depends on the active participation and cooperation of stakeholders, including tourists, local communities, tourism operators, government agencies. Meanwhile, the government views the environment as both a valuable ecosystem and an economic resource, committing to its protection for present and future generations. Initiatives include afforestation, erosion control, and air quality monitoring. These measures support ecotourism by preserving protected areas and integrating conservation into sustainable tourism planning, benefiting both visitors and local communities (MTE, 2025)

Ecotourism along the Albanian Adriatic coast provides sustainable tourism opportunities while minimizing environmental degradation, including impacts on air, water, flora, fauna, and noise levels. These elements are part of the environmental indicators considered during the environmental assessment of a geographical area (AKM, 2023: 27–28), including tourist destinations. They may represent indicators of state, pressures, responses, driving forces, or impacts, based on the DPSIR (Driving forces–Pressures–State–Impacts–Responses) methodology. The success of ecotourism initiatives largely depends on active responsibility of key stakeholders including local communities, tourism operators, and government agencies whose perspectives and engagement are valuable for protecting natural resources and ensuring long-term ecological and social benefits.

Fig. 1. Tourist Destinations in Adriatic Coast of Albania. (Authors' editing; Source: Google Earth Pro)

3. METHODOLOGY

The study adopted a quantitative research design, employing an online survey specifically developed to capture stakeholders' perceptions of tourism destinations along the Albania Adriatic coast. Data was analyzed using descriptive statistics and Spearman's rank correlation to examine the relationships among variables related to ecotourism. The dataset forms part of a broader empirical database; however, for the purpose of this analysis, a subset focusing on stakeholders' perceptions of ecotourism was extracted. From the initial 186 respondents, 72 participants (approximately 38.7%) provided valid responses explicitly addressing aspects of ecotourism.
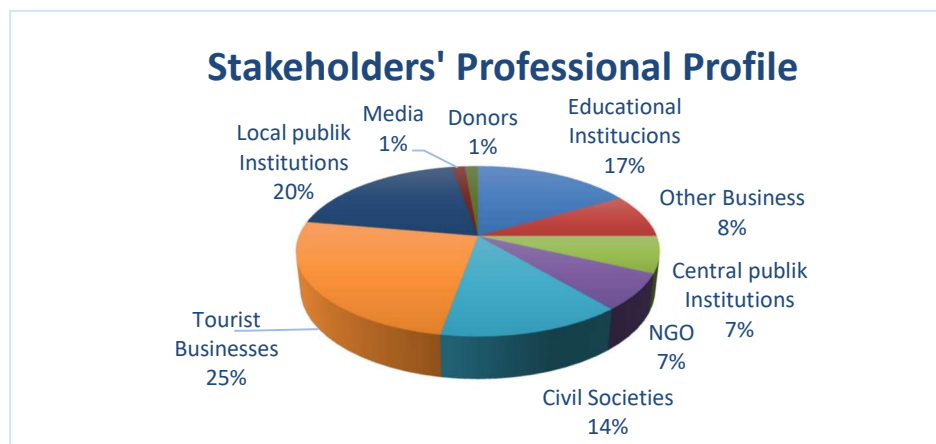
Fig. 2. Stakeholders' professional profiles (Source: authors' editing)

Figure 2 shows the distribution of stakeholder groups involved in ecotourism development along the Albanian Adriatic coast. The largest share belongs to tourist businesses (25 respondents, 34.7%), followed by local public institutions (19 respondents, 26.4%) and educational institutions (17 respondents, 23.6%). This reflects a strong representation of operational and administrative actors, indicating that the ecotourism sector relies heavily on local governance, business engagement, and educational expertise for sustainable development.

Instrument, procedures and data analysis. The online questionnaire, administered through Google Forms, was developed to gather data on stakeholders' perceptions according to the study's aims and topic. It included a multiple-choice section exploring stakeholders' viewpoints on the reasons for visiting Albanian Adriatic coastal tourism destinations, along with 11 additional questions addressing environmental factors, perceived quality indicators, awareness of environmental impacts, and stakeholders' sense of responsibility in promoting sustainable tourism management. The 11 additional items were structured on a five-point Likert scale, ranging from 1 (very poor/ totally disagree) to 5 (very good/totally agree), with an additional option labeled "not applicable." The reliability of the primary instrument was assessed using Cronbach's Alpha, which yielded a coefficient of 0.853, indicating a high level of internal consistency (Nunnally & Bernstein, 1994). The subset of 11 items related specifically to ecotourism demonstrated a Cronbach's Alpha value of 0.702, suggesting acceptable reliability for exploratory research (Salkind, 2000). These results confirm that the questionnaire items were consistently understood by respondents and provide a reliable basis for interpreting stakeholders' perceptions of sustainable and ecotourism-related factors. The Kolmogorov-Smirnov test was used to assess the normality of the data since the sample size was greater than 50. The results indicated that the distribution was not normal ($p \leq 0.05$), suggesting that the data were not normally distributed. Therefore, Spearman's correlation was applied for the analysis.

The analysis of nature-based tourism perceptions was conducted using 11 survey items designed to gather respondents' views on environmental quality, tourism impacts, and stakeholder responsibilities. The items were structured as follows: Q1, Promotional and marketing activities of tourism services in the destination, Q2: Air quality assessment in the destination, Q3: Environmental cleanliness assessment in the destination, Q4: Noise level assessment in the destination, Q5: Perceived negative impact of tourism development on plants and animals, Q6: Perceived negative impact of tourism development on the natural environment, Q7: Water pollution level, Q8: Overcrowding in public facilities and destinations due to tourism development, Q9: Stakeholders' responsibility to protect the environment, Q10: Stakeholders' responsibility to protect plants and animals, Q11: Stakeholders' responsibility to minimize the use of unique local resources. These items collectively provided a structured framework for evaluating stakeholders' perceptions of ecotourism development and environmental responsibility in coastal destinations.

4. RESULTS AND DISCUSSION

The survey results indicate that coastal tourism is the most frequently cited reason for visiting Albanian coastal destinations (55 mentions, 23%), highlighting that stakeholders primarily associate these destinations with beach and coastal experiences. However, ecotourism follows closely (72 mentions, 21.3%), which shows that a significant portion of stakeholders value environmentally sustainable and nature-focused experiences within the coastal tourism framework. This suggests that while the main draw of the Albanian coast is its beaches and general coastal attractions, ecotourism represents a critical niche that stakeholders perceive as highly important. Other tourism types such as gastronomic (50 mentions, 14.5%) and cultural tourism (46 mentions, 13.6%) are also relevant but are secondary to the natural and coastal appeal (Fig. 3). The lower frequencies for recreational and sports tourism, health tourism, family and friends' visits, professional visits, transit, shopping, and religious tourism emphasize that the primary identity of the destinations is linked to natural coastal resources, with ecotourism being a complementary but strategically significant aspect.

Fig. 3. Reasons of visiting the Albanian Coastal Touristic Destinations - Stakeholders viewpoints (Source: authors' editing)

To gain a deeper insight into the interrelationships among the factors shaping the quality and sustainability of tourism development along the Albanian Adriatic coast, stakeholders were surveyed on a range of environmental and managerial dimensions. The associations between these variables were examined using Spearman's rank-order correlation analysis, which is appropriate for identifying monotonic relationships among ordinal-scale data. The resulting coefficients, presented in Table 1, reveal the strength and direction of relationships between perceptions of environmental quality, the impacts of tourism, and stakeholders' sense of responsibility toward sustainable destination management.

Table 1. Spearman's rho correlation matrix (Source: authors' editing)			Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Q_10	Q_11
Spearman's rho	Q_1	Correlation Coefficient	1.000										
		Sig. (2-tailed)	.										
	Q_2	Correlation Coefficient	.036	1.000									
		Sig. (2-tailed)	.766	.									
	Q_3	Correlation Coefficient	.199	**.578****	1.000								
		Sig. (2-tailed)	.094	.000	.								
	Q_4	Correlation Coefficient	.129	**.483****	**.676****	1.000							
		Sig. (2-tailed)	.279	.000	.000	.							
	Q_5	Correlation Coefficient	.031	**-.248***	-.081	-.230	1.000						
		Sig. (2-tailed)	.798	.036	.500	.052	.						
	Q_6	Correlation Coefficient	.047	-.142	-.073	**-.274***	**.846****	1.000					
		Sig. (2-tailed)	.697	.233	.543	.020	.000	.					

Q_7	Correlation Coefficient	.006	-.206	-.094	-.192	.779**	.787**	1.000				
	Sig. (2-tailed)	.962	.082	.434	.106	.000	.000	.				
Q_8	Correlation Coefficient	-.119	-.162	-.125	-.214	.692**	.767**	.781**	1.000			
	Sig. (2-tailed)	.320	.173	.295	.072	.000	.000	.000	.			
Q_9	Correlation Coefficient	-.039	-.028	-.046	.076	.267*	.225	.225	.203	1.000		
	Sig. (2-tailed)	.746	.817	.702	.525	.023	.058	.058	.087	.		
Q_10	Correlation Coefficient	-.065	.008	-.025	.209	.236*	.124	.082	.123	.725**	1.000	
	Sig. (2-tailed)	.590	.946	.837	.080	.048	.305	.499	.307	.000	.	
Q_11	Correlation Coefficient	-.038	.131	.118	.199	.373**	.319**	.244*	.260*	.618**	.772**	1.000
	Sig. (2-tailed)	.752	.276	.326	.096	.001	.007	.040	.029	.000	.000	.

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The results (Table 1) reveal several meaningful associations, highlighting distinct yet interrelated dimensions of perception. The evaluation *of promotional and marketing activities* (Q1) showed no significant correlations with other variables (p > .05). This indicates that stakeholders perceive marketing performance as an autonomous factor, independent from environmental quality, perceived impacts, or environmental responsibility. Rabiaa (2024) states that "The media has a significant role to play in instilling correct environmental values and behaviours, as well as spreading environmental culture. It also has a great ability to influence positive environmental trends by giving environmental issues priority within media programs, providing information on the state of the environment, and enabling the public and those interested in environmental affairs to actively participate in the repercussions of environmental issues". Ulfy, et. al., (2021) specified that "Usefulness of social media advertising was found to have a positive influence on behavioural intention to use among ecotourists in Malaysia".

Air quality (Q2), *environmental cleanliness* (Q3), and *noise level* (Q4) were significantly and *positively correlated* (ρ= .483 and .676, p <.01). This cluster forms a coherent environmental quality dimension, suggesting that respondents who perceive better noise conditions also tend to rate air quality and cleanliness favorably. These relationships confirm a consistent perception of environmental well-being across indicators. Meanwhile Bacos & Gabor (2023: 37) states that "Consensus on the importance of environmental protection in sustainable tourism reflects strong agreement among participants regarding the importance of protecting the natural environment in the development of sustainable tourism. Participants believe that clean air and an ecological environment are essential factors in attracting tourists".

The perceived *negative effects of tourism on plants and animals* (Q5), *on the natural environment* (Q6), *water pollution* (Q7), and *overcrowding* (Q8) were *strongly interrelated* (ρ = .692–.846, p < .01). This indicates a robust and unified perception of environmental vulnerability. Stakeholders who acknowledge one type of environmental degradation tend to recognize others as well, reflecting an integrated awareness of the cumulative ecological pressures caused by tourism.

Questions concerning environmental responsibility demonstrated *high positive correlations* (ρ = .618–.772, p < .01). Stakeholders who agreed that tourism actors are responsible for *protecting the environment* (Q9) were also likely to support *the protection of flora and fauna* (Q10) and *the minimization of local resource use* (Q11). This pattern reveals a consistent ethical and responsible attitude toward sustainable tourism management.

Moderate positive correlations were found between the *negative impacts of tourism* (Q5-Q8) and *environmental responsibility* (Q9-Q11) respectively ρ = .244 and ρ = .373, p < .05. This suggests that stakeholders who recognize environmental pressures are more inclined to support active protection and sustainable practices. This result is also supported by several studies found that the group of stakeholders who perceive greater negative ecological impacts tend also to express stronger concerns about environmental protection and responsibility (Shang, et al., 2025, Adewumi et al., 2019). Conversely, *the weak or non-significant correlations* between *environmental quality* (Q2-Q4) and *negative impacts* (Q5-Q8) imply that respondents differentiate between the current environmental state and the potential risks posed by tourism development. This suggests that respondents who evaluate current environmental quality in terms of air quality, cleanliness, noise, do not necessarily make strong connections between these conditions

and tourism's potential negative impacts. At present, the perceived high environmental quality may itself serve as an additional factor attracting tourists to these destinations.

Besides examining the correlations between 11 variables to explore stakeholders' perceptions, an additional question was included to identify practical measures for enhancing the nature-based tourist destination. This question, titled "Suggestions for improving the tourist destination", was designed as a multiple-choice item to capture diverse viewpoints on destination improvement.

The survey results (Fig. 4) reveal that stakeholders prioritize improvements in public transport with well-scheduled timetables (142 responses), indicating the critical need for better accessibility and mobility within and between tourist destinations. Efficient transportation systems are essential, particularly for rural and nature-based destinations that are often geographically dispersed.

Recreational activities (55) and environmental cleanliness (48) also rank highly, reflecting visitors' expectations for clean, attractive, and engaging natural environments. This highlights the importance of maintaining ecological integrity while simultaneously enhancing visitor experience.

Suggestions such as installation of tourist signage in rural areas (45), digitization of cultural and natural monuments (35), and timely information and launch of local tours (40) underline the demand for improved information systems and interpretation tools. These are essential for orienting visitors, promoting sustainable mobility, and strengthening the connection between tourists and local landscapes.
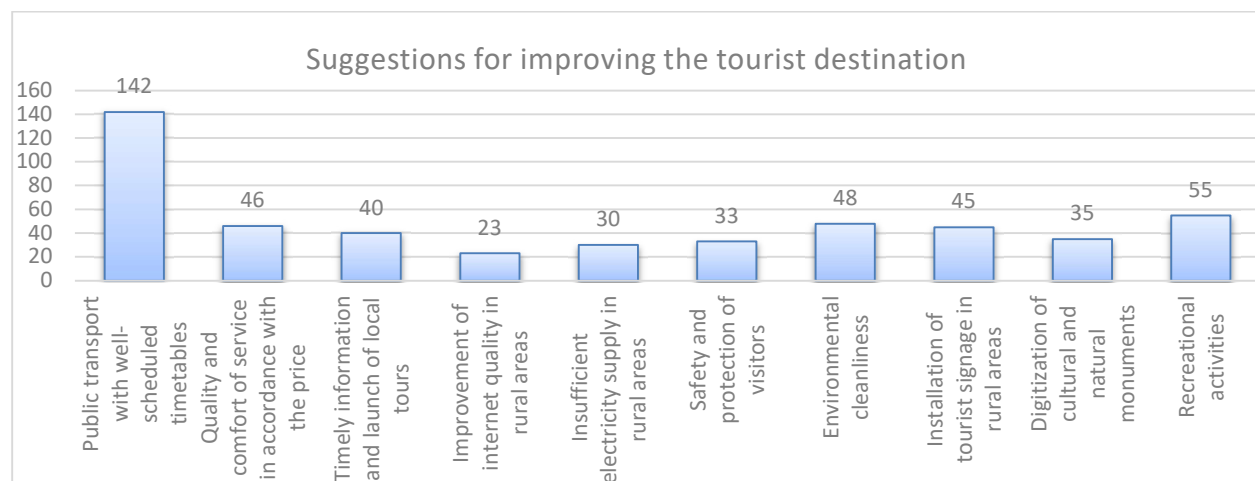
Fig. 4. Suggestions for improving the tourist destination (Source: authors' editing)

Infrastructure-related concerns, including insufficient electricity supply (30) and improvement of internet quality in rural areas (23), suggest that limited technological and energy infrastructure continues to constrain tourism development in nature-based areas. Moreover, safety and protection of visitors (33) is a recurring concern, emphasizing the need for stronger institutional and management capacities. Stakeholders can control resources to exert influence. Their level of influence can also be determined by how much hold they have over the resources Understanding stakeholder influence is thus crucial in promoting environmental sustainability (Salman, Jaafar & Mohamad, 2021).

The results demonstrate that the quality of transport, infrastructure, environmental management, and recreational services are determinants of visitor satisfaction and destination competitiveness. Enhancing accessibility, environmental quality, and service reliability is fundamental to promoting sustainable, year-round tourism in nature-oriented destinations. Meanwhile the Albanian Adriatic coast, with its rich natural heritage, diverse landforms, and varied categories of protected and rural areas, holds significant potential for the development of sustainable, nature-based tourism, as an important resource for regional development. Esparza-Huamanchumo, et. al., (2024) evidence that "The main driving factors for the sustainability of local enterprises perceived by stakeholders in the environmental

dimension are the effective protection of the protected natural area, the reduction in tourism impacts, and the reduction in illegal and/or unsustainable activities within the Santuario Histórico Bosque de Pómac (SHBP). In this sense, the management of environ mental impacts becomes relevant for this dimension and should be led by the NPA administrator and applied by the actor's developing tourism in the SHBP".

5. CONCLUSION AND RECOMMANDATION

While the area's natural and cultural assets continue to attract diverse visitor segments, including a growing interest in natural based tourism, the pace of development presents both opportunities and challenges. Stakeholder perspectives underscore the role of environmental sustainability, accessibility, and service quality in shaping destination attractiveness. Consequently, integrated planning, innovative eco-management practices, and strong stakeholder engagement are key to ensuring that tourism development along the Albanian Adriatic coast contributes to both local prosperity and ecological resilience. Stakeholders view the Albanian Adriatic coast mainly as a destination for coastal experiences, but the strong presence of ecotourism highlights an opportunity to develop sustainable tourism strategies that integrate environmental conservation with the traditional coastal attractions, enhancing both the quality and sustainability of the tourism offer.

 Spearman's rho correlation matrix indicated that promotional and marketing activities (Q1) appear statistically independent from these dimensions. The strong intra- and inter-dimensional correlations indicate a coherent awareness among tourism stakeholders of the interplay between environmental pressures and sustainability responsibilities. These findings underscore the necessity of integrating ecological awareness and responsible management practices into future tourism policies along the Albanian coast.

Several practical implications can be suggested from results of the study.

The strong and significant correlations among perceived negative impact of tourism development on plants, animals and natural environment, water pollution level, overcrowding in public facilities and destinations due to tourism development state that stakeholders perceive these factors as interrelated. Local authorities and other actors may adopt an integrated approach to environmental management, ensuring that measures addressing water pollution, urban congestion, and biodiversity loss are coordinated rather than treated separately.

The *weak correlation between* promotional and marketing activities and environmental quality variables (Q2-Q4) indicates that marketing and sustainability are not yet aligned in stakeholders' perceptions. Related to this destination marketing strategies should incorporate sustainability narratives emphasizing eco-friendly tourism, biodiversity protection, and environmental ethics to improve both awareness and destination image.

Positive correlations between perceived environmental degradation (Q5-Q8) and responsibility statements (Q9-Q11) show that stakeholders who recognize tourism's negative environmental effects tend to feel more responsible for protecting natural resources. Educational issues like educational programs and training initiatives for tourism operators and local authorities can be focused on environmental accountability and collective stewardship.

Moderate correlations between cleanliness and noise level reveal a link between perceived visual and acoustic pollution in coastal destinations. It is recommended that municipalities should implement regular monitoring systems for both noise and urban cleanliness, particularly during the peak tourist season, to preserve destination quality.

Correlations between negative impact variables (Q5-Q8) and responsibility measures (Q9-Q11) reinforce the role of ecotourism as a sustainable alternative for balancing economic and environmental objectives. Promotion of eco-certification schemes and public–private partnerships by policymakers can encourage sustainable resource use and low-impact tourism development.

Positive correlations between responsibility-related questions (Q9–Q11) and environmental perceptions suggest that community engagement is essential for implementing effective sustainability measures. Consequently establishing participatory platform, such as local forums and stakeholder workshops, can foster collaboration among residents, tourism businesses, and local governments in destination management.

Although the study involved a relatively small number of participants (72), limiting the generalizability of the findings, several actionable recommendations can be derived from stakeholder suggestions to ecotourism. These

include developing eco-friendly transport options and implementing environmental management programs to preserve natural areas. Expanding recreational and interpretive activities, enhancing signage and digital tools, and strengthening coordination among local authorities and businesses can further support sustainable tourism development. Collectively, these measures provide feasible solutions to improve visitor experiences while minimizing environmental impacts. Future research could expand the sample size of stakeholders. Longitudinal studies are recommended to capture temporal changes in perceptions and sustainability outcomes and inclusion of tourist perspectives. Integrating mixed-methods or spatial approaches could enhance understanding of the relationship between environmental, social and economic factor.

Acknowledgements

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Environmental Sustainability Analysis of Turkish Banks Using Mathematical Programming Based Framework

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Abstract

The increasing importance of Environmental, Social, and Governance (ESG) factors in the financial sector has placed greater emphasis on assessing banks' sustainability performance, particularly with respect to environmental dimensions. This study aims to provide a comparative analysis of banks by evaluating their performance scores on environmental sustainability criteria against their closest competitors. Given the qualitative nature of the data related to environmental factors, triangular fuzzy numbers were employed to capture the subjective assessments of the decision-makers regarding each bank's performance. To objectively determine the relative importance degree of the criteria, a decision support model based on the common-weight fuzzy data envelopment analysis (DEA) is utilized. Unlike traditional approaches, this method does not rely on subjective weight assignment; instead, it incorporates criterion weights as decision variables within a mathematical programming framework. By solving the DEA-based model, performance scores for each bank are obtained, enabling an objective ranking within the context of environmental sustainability. The results not only highlight the relative competitive positioning of banks but also identify critical environmental criteria that should be prioritized for further improvement. Consequently, this study contributes to the literature by presenting a rigorous, comparative, and data-driven framework for analysing banks' environmental sustainability performance within the broader ESG perspective.

Keywords: ESG sustainability, banking sector, financial sustainability, mathematical programming, fuzzy data envelopment analysis, common weights

1. INTRODUCTION

Observing financial properties of the sustainable development goals (SDGs) is quite significant to understand how financial practices affect sustainable development outputs. By making an investigation of the links between the SDGs and sustainable finance initiatives; valuable insights, decisions of the policies, and industry guiding operations can be provided to acquire environmental and social effects and to provide contribution of global efforts in order to obtain a more sustainable and equitable future [1].

The significance and strategic role of the concept of sustainable finance for the firms has become more visible via 17 SDGs initially determined by the United Nations Development Program. In recent years, researches were

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conducted to measure the relationship of ESG performance with the SDGs that lead the requirement for analytical models in this field [2,3].

In Turkish banking sector, when we take into account the environmental criteria of the ESG (Environmental, Social and Governance) framework, some banks that prioritize sustainability practices are ahead of others. The objective of these banks is to reduce their carbon footprint by developing environmentally sensitive strategies, providing green financing for renewable energy projects and environmentally friendly investments. At the same time, they adopt practices to increase resource efficiency and report their sustainability performance transparently. These approaches support both compliance with national regulations and contribution to international sustainability standards.

This work aims to conduct a comparative study of the performance scores obtained by banks within the scope of environmental criteria under ESG sustainability factors against their closest competitors. Since the data obtained in the evaluation of environmental criteria is qualitative, it is intended that each bank and its closest competitors be assessed by decision-makers using triangular fuzzy numbers within these criteria. After collecting this qualitative data, a decision support model based on a common-weight fuzzy data envelopment analysis is employed, which does not require a subjective method to determine the importance weights of the criteria, but instead defines the criterion weights as decision variables of a mathematical programming model. As a result of solving the data envelopment analysis-based mathematical modelling framework, the performance scores of the evaluated banks with respect to the environmental dimension of ESG sustainability are determined. Based on this performance analysis, it will be possible to observe the relative position of each bank against its competitors and to identify which criteria should be prioritized in order to advance further within the scope of environmental factors. This study presents a comparative competitive analysis.

The remaining sections of the work are organized as follows. Section 2 gives briefly fuzzy data envelopment analysis methods. The third section gives the illustration of the application via a case study conducted in Turkish banking sector. Final section outlines the concluding remarks and future researches.

2. FUZZY DATA ENVELOPMENT ANALYSIS

The fuzzy common weight data envelopment analysis-based modelling framework employed in this section aims to determine the best performing decision making unit (DMU) when fuzzy data are present in the problem. Define $\tilde{x}_{ij} = (x_{ija}, x_{ijb}, x_{ijc})$ where $x_{ija} \leq x_{ijb} \leq x_{ijc}$ for the fuzzy input i consumed by DMU$_j$ and $\tilde{y}_{rj} = (y_{rja}, y_{rjb}, y_{rjc})$ where $y_{rja} \leq y_{rjb} \leq y_{rjc}$ for the fuzzy output r created by DMU$_j$. $(x_{ij})_\alpha^L$ and $(x_{ij})_\alpha^U$ are lower and upper levels of the α-cut of the membership function of $\tilde{x}_{ij}$, and $(y_{rj})_\alpha^L$ and $(y_{rj})_\alpha^U$ afre lower and upper levels of the α-cut of the membership function $\tilde{y}_{rj}$, respectively. Define $w_i = v_i \alpha_i$, where $\alpha_i \in [0,1]$ and $0 \leq w_i \leq v_i$. Likewise, let $\mu_r = u_r \alpha_r$, where $\alpha_r \in [0,1]$ and $0 \leq \mu_r \leq u_r$ [4].

$(x_{ij})_\alpha^L, (x_{ij})_\alpha^U, (y_{rj})_\alpha^L$, and $(y_{rj})_\alpha^U$ are as

$$\sum_{i=1}^{m} v_i (x_{ij})_\alpha^L = \sum_{i=1}^{m} v_i x_{ija} + w_i (x_{ijb} - x_{ija}) \tag{1}$$

$$\sum_{i=1}^{m} v_i (x_{ij})_\alpha^U = \sum_{i=1}^{m} v_i x_{ijc} - w_i (x_{ijc} - x_{ijb}) \tag{2}$$

$$\sum_{r=1}^{s} u_r (y_{rj})_\alpha^L = \sum_{r=1}^{s} u_r y_{rja} + \mu_r (y_{rjb} - y_{rja}) \tag{3}$$

$$\sum_{r=1}^{s} u_r (y_{rj})_\alpha^U = \sum_{r=1}^{s} u_r y_{rjc} - \mu_r (y_{rjc} - y_{rjb}) \tag{4}$$

The first step of the utilized fuzzy common weight DEA framework is as [5]

$$\min \quad \theta$$

subject to   (5)

$$\theta - d_j \geq 0, \qquad \forall j,$$

$$\sum_{r=1}^{s} u_r y_{rjc} - \mu_r(y_{rjc} - y_{rjb}) - \sum_{i=1}^{m} v_i x_{ija} + w_i(x_{ijb} - x_{ija}) + d_j = 0, \qquad \forall j,$$

$$\sum_{r=1}^{s} u_r + \sum_{i=1}^{m} v_i = 1,$$

$$u_r, v_i \geq \varepsilon, \qquad \forall r, i,$$

where d_j is the deviation of the efficiency score of DMU j, (i.e. $d_j = 1 - E_j$, for E_j being the efficiency score of DMU$_j$), $\theta = \max_j d_j$, and ϵ is a small positive scalar. When we have more than single efficient DMU by solving Model (5), common weight modelling framework given below is developed to identify the best DMU.

$$\min \quad \theta$$

subject to   (6)

$$\theta - d_j \geq 0, \qquad \forall j,$$

$$\sum_{r=1}^{s} u_r y_{rjc} - \mu_r(y_{rjc} - y_{rjb}) - \sum_{i=1}^{m} v_i x_{ija} + w_i(x_{ijb} - x_{ija}) + d_j = 0, \qquad \forall j,$$

$$\sum_{r=1}^{s} u_r + \sum_{i=1}^{m} v_i = 1,$$

$$d_j + z_j M \geq \varepsilon, \qquad j \in EF,$$

$$\sum_{j \in EF} z_j = 1,$$

$$z_j \in \{0,1\}, \qquad j \in EF,$$

$$u_r, v_i \geq \varepsilon, \qquad \forall r, i,$$

where *M* refers to a very big number, z_j is a binary variable, and *EF* determines the set of minimax efficient DMUs that are indicated via Model (5).

3. CASE STUDY

In this section, a case study, which is conducted in Turkish banking sector, aims to provide a comparative analysis of performance scores of seven banks according to their environmental criteria that are involved in ESG sustainability framework. Some of the major banks in Turkey and their performance in terms of environmental sustainability can be

1.   **B Bank**
      - **Green Financing:** The bank offers a variety of green bond and loan products to provide financing for green projects. In addition, the bank invests in energy efficiency and renewable energy projects.
      - **Sustainability Reporting:** The bank shares its environmental performance in detail in its annual sustainability reports.
      - **Carbon Footprint Reduction:** The bank takes steps to increase its environmentally friendly practices and has made commitments to reduce its carbon footprint.
2.   **G Bank**
      - **Green Loans and Investments:** The bank provides financing for environmentally friendly investments and projects. The bank has goals to increase green finance.
      - **Carbon Emission:** The bank develops and implements various projects to reduce carbon emissions in its operations.
      - **Sustainability Initiatives:** When we look at sustainability issues, the bank has environmentally friendly offices, recycling systems and energy efficiency practices.
3.   A Bank
      - **Green Financing Products:** The bank offers green bonds and sustainable loan products that support environmentally friendly projects.
      - **Carbon Footprint and Energy Efficiency:** The bank has initiated several projects to reduce carbon emissions and increase energy efficiency.
      - **Eco-Friendly Banking:** The bank is working to reduce paper consumption through digitalization.
4.   C Bank
      - **Environmental Sustainability:** The bank provides financing for environmentally friendly projects with a focus on sustainable investments and develops financial products aimed at reducing environmental impact.
      - **Internal Sustainability Practices:** The bank monitors the carbon footprint in its own operations and implements strategies to reduce it.
5.   E Bank
      - **Green Bonds and Financing:** E Bank engages in sustainable investments by issuing green bonds to finance environmentally friendly projects.
      - **Environmentally Friendly Projects:** The Bank invests in energy efficiency projects and various initiatives to reduce its carbon footprint.
6.   D Bank
      - **Green Financing and Renewable Energy Investments:** D Bank supports green financing and renewable energy projects. It also attracts attention with environmentally friendly products.
      - **Environmental Performance Reports:** The Bank reports its environmental performance and sustainability efforts and takes steps for continuous improvement.
7.   F Bank
      - **Green Loans and Projects:** F Bank contributes to environmental sustainability by offering green loan products.
      - **Carbon Footprint Reduction:** The Bank strives to reduce its operational carbon footprint by adopting energy efficiency and environmentally friendly practices.

In Turkish banking sector, ESG sustainability criteria are becoming increasingly important. Environmental criteria generally include activities in harmony with nature and a series of practices aimed at minimizing damage to the environment. Examples of environmental criteria in the banking sector can be

1.   **Carbon Footprint Reduction:** Banks' efforts to reduce carbon emissions in their own operations. This can be achieved through methods such as achieving energy efficiency, using renewable energy and increasing digitalization in offices.

2.   **Green Finance and Investment:** Providing financing for environmentally friendly projects or renewable energy investments. Such investments serve sustainable development goals and encourage banks to be directed towards projects that reduce environmental impact.
3.   **Paperless Banking:** Accelerating digitalization processes to minimize the use of physical paper. This helps banks reduce paper consumption, preventing logging and waste generation.
4.   **Waste Management and Recycling:** Banks should develop waste management policies in their offices, encourage recycling and properly dispose of environmentally harmful wastes.
5.   **Reducing Water Use:** Practices such as efficient use of water in bank branches and the establishment of water-saving systems.
6.   **Environmentally Friendly Buildings and Constructions:** Banks use energy-efficient and environmentally friendly construction materials in their building projects. In addition, to ensure that their buildings are environmentally friendly by obtaining certificates such as LEED (Leadership in Energy and Environmental Design).
7.   **Sustainable Products and Services:** Banks offer sustainable financial products with a low environmental impact. For example, green bonds or sustainable loan products that invest in environmentally friendly projects.

Since the dataset, which is obtained through the evaluation of environmental criteria, possesses qualitative properties, decision makers mention their opinions by using triangular fuzzy numbers. After collecting fuzzy data of these seven banks according to assessment criteria, which are named as carbon footprint management (Output 1), decrease of water use (Output 2), energy effectiveness (Output 3), green finance and investments (Output 4), waste management and recycling (Output 5), environmentally friendly buildings and constructions (Output 6), and digitalization and paperless banking (Output 7), an imprecise common weight DEA-based model is utilized in order to identify the best performing bank along with ranking those seven banks. The utilized mathematical programming model does not require a priori information about the criteria weights.

First, the decision makers form a consensus and give the linguistic data as in Table 1 with regard to the fuzzy scale given in Figure 1.
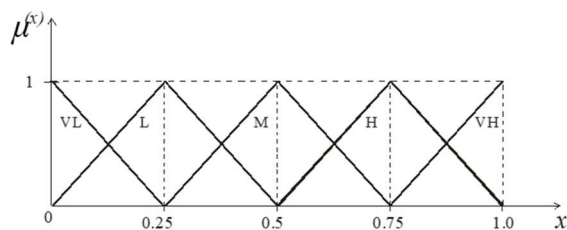
Figure 1. A linguistic term set where VL = (0, 0, 0.25), L = (0, 0.25, 0.5), M = (0.25, 0.5, 0.75), H = (0.5, 0.75, 1), VH = (0.75, 1, 1)

Table 1. Evaluation data

	Output1	Output2	Output3	Output4	Output5	Output6	Output7
B Bank	H	L	VH	H	L	M	H
G Bank	VH	M	L	VH	VH	VH	L
C Bank	M	VH	M	H	H	VH	M
A Bank	M	VH	H	H	VH	L	H
E Bank	H	H	M	M	H	H	L
D Bank	L	L	H	M	M	H	VL
F Bank	M	M	L	L	L	VL	VL

The resulting tables of the first step of the modelling framework are given as

Table 2. Deviation scores obtained by Model (5)

	alpha=1	alpha =0.9	alpha =0.8	alpha =0.7	alpha =0.6	alpha =0.5
B Bank	0	0	0	0	0	0
G Bank	0.0114	0.0275	0.0431	0.0581	0.0725	0.0863
C Bank	0.0341	0.0429	0.0516	0.0601	0.0685	0.0766
A Bank	0	0	0	0	0	0
E Bank	0	0	0	0	0	0
D Bank	0.2727	0.2691	0.2654	0.2615	0.2576	0.2535
F Bank	0.2727	0.2691	0.2654	0.2615	0.2576	0.2535

Table 2. Deviation scores obtained by Model (5) (cont.)

	alpha =0.4	alpha =0.3	alpha =0.2	alpha =0.1	alpha =0
B Bank	0	0	0	0	0
G Bank	0.0997	0.1135	0.1265	0.1386	0.15
C Bank	0.0839	0.0879	0.0919	0.096	0.1
A Bank	0	0	0	0	0
E Bank	0	0	0	0	0
D Bank	0.2483	0.2364	0.2243	0.2121	0.2
F Bank	0.25	0.25	0.25	0.25	0.25

Table 3. Efficiency scores obtained by Model (5)

	alpha=1	alpha =0.9	alpha =0.8	alpha =0.7	alpha =0.6	alpha =0.5
B Bank	1	1	1	1	1	1
G Bank	0.9886	0.9725	0.9569	0.9419	0.9275	0.9137
C Bank	0.9659	0.9571	0.9484	0.9399	0.9315	0.9234
A Bank	1	1	1	1	1	1
E Bank	1	1	1	1	1	1
D Bank	0.7273	0.7309	0.7346	0.7385	0.7424	0.7465
F Bank	0.7273	0.7309	0.7346	0.7385	0.7424	0.7465

Table 3. Efficiency scores obtained by Model (5) (cont.)

	alpha =0.4	alpha =0.3	alpha =0.2	alpha =0.1	alpha =0
B Bank	1	1	1	1	1
G Bank	0.9003	0.8865	0.8735	0.8614	0.85
C Bank	0.9161	0.9121	0.9081	0.904	0.9
A Bank	1	1	1	1	1
E Bank	1	1	1	1	1
D Bank	0.7517	0.7636	0.7757	0.7879	0.8
F Bank	0.75	0.75	0.75	0.75	0.75

Table 4. Ranking results obtained by Model (5)

	alpha=1	alpha =0.9	alpha =0.8	alpha =0.7	alpha =0.6	alpha =0.5
B Bank	1	1	1	1	1	1
G Bank	4	4	4	4	5	5
C Bank	5	5	5	5	4	4

A Bank	1	1	1	1	1	1
E Bank	1	1	1	1	1	1
D Bank	6	6	6	6	6	6
F Bank	6	6	6	6	6	6

Table 4. Ranking results obtained by Model (5) (cont.)

	alpha =0.4	alpha =0.3	alpha =0.2	alpha =0.1	alpha =0
B Bank	1	1	1	1	1
G Bank	5	5	5	5	5
C Bank	4	4	4	4	4
A Bank	1	1	1	1	1
E Bank	1	1	1	1	1
D Bank	6	6	6	6	6
F Bank	7	7	7	7	7

The resulting tables of the second step of the modelling framework are given as

Table 5. Deviation scores obtained by Model (6)

	alpha=1	alpha =0.9	alpha =0.8	alpha =0.7	alpha =0.6	alpha =0.5
B Bank	0	0	0	0	0	0
G Bank	0.0114	0.0275	0.0431	0.0581	0.0725	0.0863
C Bank	0.0341	0.0429	0.0516	0.0601	0.0685	0.0766
A Bank	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
E Bank	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
D Bank	0.2727	0.2691	0.2654	0.2615	0.2576	0.2535
F Bank	0.2727	0.2691	0.2654	0.2615	0.2576	0.2535

Table 5. Deviation scores obtained by Model (6) (cont.)

	alpha =0.4	alpha =0.3	alpha =0.2	alpha =0.1	alpha =0
B Bank	0	0.000001	0.000001	0	0.000001
G Bank	0.0997	0.1135	0.1265	0.1386	0.15
C Bank	0.0839	0.0879	0.0919	0.096	0.1
A Bank	0.000001	0.000001	0.000001	0.000001	0.000001
E Bank	0.000001	0	0	0.000001	0
D Bank	0.2483	0.2364	0.2243	0.2121	0.2
F Bank	0.25	0.25	0.25	0.25	0.25

Table 6. Efficiency scores obtained by Model (6)

	alpha=1	alpha =0.9	alpha =0.8	alpha =0.7	alpha =0.6	alpha =0.5
B Bank	1	1	1	1	1	1
G Bank	0.9886	0.9725	0.9569	0.9419	0.9275	0.9137
C Bank	0.9659	0.9571	0.9484	0.9399	0.9315	0.9234
A Bank	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
E Bank	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999

D Bank	0.7273	0.7309	0.7346	0.7385	0.7424	0.7465
F Bank	0.7273	0.7309	0.7346	0.7385	0.7424	0.7465

Table 6. Efficiency scores obtained by Model (6) (cont.)

	alpha =0.4	alpha =0.3	alpha =0.2	alpha =0.1	alpha =0
B Bank	1	0.9999	0.9999	1	0.9999
G Bank	0.9003	0.8865	0.8735	0.8614	0.85
C Bank	0.9161	0.9121	0.9081	0.904	0.9
A Bank	0.9999	0.9999	0.9999	0.9999	0.9999
E Bank	0.9999	1	1	0.9999	1
D Bank	0.7517	0.7636	0.7757	0.7879	0.8
F Bank	0.75	0.75	0.75	0.75	0.75

Table 7. Ranking results obtained by Model (6)

	alpha=1	alpha =0.9	alpha =0.8	alpha =0.7	alpha =0.6	alpha =0.5
B Bank	1	1	1	1	1	1
G Bank	4	4	4	4	5	5
C Bank	5	5	5	5	4	4
A Bank	2	2	2	2	2	2
E Bank	2	2	2	2	2	2
D Bank	6	6	6	6	6	6
F Bank	6	6	6	6	6	6

Table 7. Ranking results obtained by Model (6)

	alpha =0.4	alpha =0.3	alpha =0.2	alpha =0.1	alpha =0
B Bank	1	2	2	1	2
G Bank	5	5	5	5	5
C Bank	4	4	4	4	4
A Bank	2	2	2	2	2
E Bank	2	1	1	2	1
D Bank	6	6	6	6	6
F Bank	6	7	7	7	7

4. CONCLUSIONS

As a result of the mathematical programming model based on solved data envelopment analysis. the performance score of the bank and its closest competitors according to the environmental dimension of the ESG sustainability concept will be determined. As a result of this performance analysis, the case bank will be able to observe where it is compared to its competitors and what criteria it should pay attention to in order to go further within the scope of environmental factors. This study provides a comparative competitive analysis.

This study is based on the environmental dimension of ESG sustainability factors and evaluates the performance of seven banks selected in the Turkish banking sector within the scope of seven environmental factors. In future studies, it is aimed to expand the scope of the ESG framework and integrate the criteria under the social and governance dimensions into the model. In addition, the current analysis includes only seven banks, and it is planned to include alternative bank examples in the evaluation in the future. In this way, the general validity of the model can be increased by conducting comparative analysis. In future studies, the sensitivity of the method will be tested, and

the robustness of the model will be evaluated by comparing the ranking results obtained using different fuzzy DEA models.

Acknowledgements

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Managing the Impact of Responsible Tourism Practices: A Multi-Dimensional Perspective on Fostering Destination Revisit Intention

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Abstract

Considering the rich history, diverse attractions, and the growing ambition to promote Albanian tourism destinations, it is important to understand and effectively manage the environment in which tourism development evolves. Beyond the responsibility to preserve the physical environment, the economic, social, cultural, and technological dimensions also play a significant role as key factors shaping responsible practices and the overall sustainability of destinations. According to Goodwin (2011), the sustainability of a tourist destination represents a mission to be achieved through the consistent implementation of responsible practices. In the context of the rapid growth and transformation of the tourism sector, such analysis becomes increasingly complex and dynamic. Nevertheless, the ultimate objective remains the attainment of tourist satisfaction, encouraging visitors to return to the destination. This development is not determined solely by tourists' desires, perceptions, and destination choices, but also by the synergy created through the interaction of all stakeholders. The aim of this study is to examine responsible tourism practices and their impact on tourist satisfaction and return intentions. The research was conducted across several key destinations along the Adriatic coast. A total of 650 valid questionnaire was collected through an online survey. Hierarchical multiple regression was used to determine the moderating effect of tourist satisfaction in the destination on the relationship between the responsible tourist practices and the intention to revisit. The findings reveal a direct and positive relationship between the perception of responsible tourism practices and the level of tourist satisfaction, creating the opportunity to revisit the destination and contributing to the sustainable development of tourism destinations.

Keywords: responsible tourism practices, tourist satisfaction, revisit destination, albanian Adriatic coast, sustainability

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1. INTRODUCTION

The growing contribution of the tourism sector to economic, social, and cultural development has heightened awareness of sustainable development practices, influenced by technological changes and supported by the country's regulatory framework. The tourism sector closely links sustainability to the development of values, environmental protection, and the preservation of tourist attractions and ecosystems (Fafouti et al., 2023). Since the emergence of this concept, a large number of authors and organizations have written about sustainability and its role in making significant progress towards future trends. According to the WTO (2019), sustainable tourism addresses both current and future economic, social, and environmental impacts by ensuring that all stakeholders, including visitors, various sectors of the tourism industry, the environment, and host communities, can meet their needs (World Tourism Organization, 2019). Despite the important and contributory role of the economic, socio-cultural, and environmental pillars of sustainability, the rapid growth of the tourism industry has prioritized the economic results over the performance of other social and environmental issues (Legrand et al., 2022). This makes more challenging the process of exploring ideas and solutions to manage all the relationships and the operations in a sustainable way and to achieve a balanced integration of economic, environmental, and socio-cultural dimensions as the three main pillars of sustainability (Khan et al., 2021). Over the last 5 years, the tourism sector has presented positive indicators of development expressed in the number of domestic and foreign visitors contributing significantly to national income, employment, and regional development (INSTAT, 2024; WTO, 2025). Albania has experienced tourism growth, driven by its rich history, natural and cultural heritage, hospitality, and warm climate. This growth requires increased attention not only to the sustainability of the economic indicators but also to the conservation of the resources on which it is based (Ruggieri & Calò, 2022; Gao & Zhang, 2019).

Tourism development along Albania's Adriatic coast has accelerated significantly in the past decade, driven by increased international visibility, improved accessibility, and strategic government prioritization of the coastal tourism sector. National planning frameworks, including the Tourism Strategy 2024–2030 and the country's alignment with the EU Strategy for the Adriatic and Ionian Region (EUSAIR), emphasize the development of competitive, diversified, and seasonally balanced tourism offerings. However, rapid tourism growth has also introduced notable challenges, particularly regarding environmental pressure on fragile coastal ecosystems, and the predominance of seasonal mass tourism patterns. As such, to achieve sustainability objectives, it is essential to implement effective mechanisms and employ appropriate instruments throughout the development process. In light of the increasing concerns and adverse environmental impacts associated with tourism growth, the concept of responsibility among tourism actors has emerged as a complementary instrument for promoting sustainability. Encouraging responsible behavior and shared accountability across all stakeholders, such as governments, businesses, tourists and host communities, is fundamental to ensuring the successful realization of sustainability goals. In the Albanian context, responsible tourism practices are particularly a necessity toward the ongoing efforts to align with sustainability standards. By analyzing tourist behaviors and their perceptions, the efforts of the host community, the institutional frameworks and the local initiatives, we can contribute to a deeper understanding of how Albania can strengthen its commitment to sustainability while paving the way of responsibility and ensuring long-term tourism development. Sustainable and responsible tourism practices play a crucial role in shaping visitors' experiences (Goodwin, 2016), influenced not only by the quality of services and infrastructure but also by the destination's commitment to attract tourists to revisit it (Baloch et al., 2022).

This research study aims to explore the relationship between responsible tourism practices, tourist satisfaction, and the intention to revisit the destination. By examining tourists' perceptions and experiences, the study aims to provide insights into how managing responsible tourism practices can enhance satisfaction levels and foster long-term loyalty from tourists and visitors. The paper is structured in several sections. The second session provides the theoretical framework of responsible tourism practices. The third section presents an explanation of the methodology and the empirical part of the analysis of the collected data. After that the result and conclusion will be discussed in detail, highlighting the key findings and their implications for the tourism industry. This comprehensive approach aims to provide valuable insights that can inform future responsible tourism initiatives and enhance visitor experiences aiming to increase the revisit rate.

2. LITERATURE REVIEW

The concept of responsible tourism emerged in the 1980s and has been recognized largely in the next years becoming one of the key instruments for achieving sustainable tourism development (Goodwin, 2011). Generally

speaking, the concepts of sustainable tourism and responsible tourism seem to express the same term but they represent distinct dimensions of tourism development (Saarinen, 2021; Goodwin, 2011; WTO, 2004). The concept of responsible tourism has evolved in response to the challenges created by the development of mass tourism and the demand for responsible use of cultural and natural resources. Sustainable tourism primarily focuses on environmental impacts, conserving natural and cultural resources, and fostering socio-economic benefits for local communities. In contrast, responsible tourism emphasizes the ethical responsibilities of all tourism actors toward the economic, political, legal, sociocultural, and technological environments that impact the tourism sector (Mihalic, 2016), contributing to the achievement of long-term sustainability objectives within the tourism industry. The economic dimension of a tourist destination is related to the way in which the tourism development generates benefits for the local community and the local economy. A destination that offers local products and services at reasonable prices contributes to the growth of economic values and supports local enterprises. In particular, the acceptable prices of local handicrafts and artisans encourage tourists to consume authentic products, increasing economic circulation and strengthening the local value chain (Liu et al., 2022). In this way, the responsible economic dimension positively influences the perception of the destination and promotes the willingness of tourists to return. Beyond this, the environmental and socio-cultural dimensions also have an important role in creating a sustainable and attractive tourist experience. The protection and promotion of natural diversity, opportunities for outdoor activities throughout the year and the clarity of instructions within the destination help to increase the quality of the tourist experience (Patwary, 2023). At the same time, safety, the opportunity to try new experiences, qualified guides and the promotion of local traditions and culture strengthen the emotional connection of tourists with the destination. The variety of local food and drinks enriches the cultural experience by increasing the authenticity of the visit.

Meanwhile, the technological dimension supports the management and experience of the destination in an efficient and accessible way (Buhalis et al., 2024). Available online information, the functioning of GPS, the provision of real-time traffic information and the use of technology for managing tourist flows make the destination easier to explore and navigate for visitors. Also, the provision of valuable information about tourist attractions that suit the interests of tourists helps to personalize the experience (Ruko et al., 2024). When these four dimensions function in an integrated manner, tourists tend to feel satisfied, confident that they have made the right choice and express a high level of overall satisfaction with the destination.

Responsible tourism is seen as an appropriate alternative to tourism development that helps a destination increase its competitiveness and sustainability (Aytekin et al., 2023). It emphasizes the shared responsibility of all stakeholders, including institutions, businesses, DMOs, investors, and tourists, to minimize negative impacts while enhancing benefits for local communities and the environment. Responsible tourism is a type of tourism that can promote responsibility in the sustainable use of the environment, get local communities involved, and make sure that visitors are safe in the destination (Manhas et al., 2021). Responsible tourism initiatives are seen as a collection of strategies, planning, product and service development, and marketing efforts that lead to positive economic, social, cultural, and environmental effects (Dias et al., 2021). Under this perspective, responsible tourism is conceptualized as a strategic approach to destination development that not only elevates tourist satisfaction but also enhances the quality of life for local communities (Thi Thanh Nguyen et al., 2023) and preserves the local values, cultural heritage, and tourism assets (Mohamadi et al., 2022). This viewpoint was aligned earlier by Goodwin (2016), arguing that responsible tourism is a way of managing tourism in any destination to ensure sustainability and long-term viability. This is about how tourists, businesses, local communities, and governments all have a role to play in protecting cultural heritage and natural environments. Furthermore, Booyens and Rogerson (2016) stated that responsible tourism involves the environmentally and socially responsible practices of all tourism entities aiming to protect the natural and cultural heritage and enhance the experiences of tourists. Research has demonstrated that responsible tourism practices can elevate visitor satisfaction and augment the intention to revisit. Research by Lee & Oh (2018) demonstrates that tourists who perceive a destination as socially and environmentally responsible are more likely to develop emotional attachment and loyalty to that place. Similarly, Yuan & Vui (2023) found that destinations promoting responsible practices such as environment protection, local employment, and cultural respect achieve a stronger destination image, aiming for revisits from tourists. Therefore, responsible tourism can not only contribute to the benefits of local communities and ecosystems but also contribute to the long-term competitiveness and sustainability of the destination.

3. METHODOLOGY

This section outlines the methodology used during the research study, explaining the techniques used to analyze the gathered data. The study employed a quantitative research design to examine the influence of responsible tourism

dimensions on tourist satisfaction and revisit intention. Data were collected from a random sample of 650 tourists visiting destinations along the Adriatic coast, a region selected due to its high tourism intensity and growing commitment to sustainable development. This study uses primary data collected from a modified and structured five-point Likert scale questionnaire based on the previous literature related to responsible tourism practices (Aytekin et al., 2023; Thi Thanh Nguyen et al., 2023). The respondents were selected using a simple random sampling technique. The collected data were analyzed using factor analysis to assess the underlying structure, reliability, and validity of the measurement constructs, followed by multiple regression analysis to evaluate the impact of economic, social, environmental, and technological dimensions on the dependent variable. The economic dimension of responsible tourism involves generating significant economic benefits for local communities and destinations. Another group of variables is included under the social dimension of responsible tourism, which focuses on the well-being and inclusion of local communities, ensuring local values, traditions, and culture preservation, community engagement, and tourists' opportunities to experience new experiences. Additionally, the environmental dimension of the responsible tourism practices focuses on minimizing the negative impacts of tourism on natural resources and ecosystems while actively promoting conservation and sustainable use. Furthermore, the technological dimension of responsible tourism practices involves the integration of advanced technologies to promote sustainability, enhance tourists' experiences, and reduce environmental impacts.

The reliability and validity of the questionnaire were determined before analyzing the gathered data. The Cronbach's alpha values are higher than 0.7 for all the items, respectively 0.856 (economic dimensions), 0.916 (environmental dimensions), 0.933 (social dimensions) and 0.923 (technological dimensions), indicating a strong level of internal consistency. The table presents the reliability and validity results for four constructs: Economic, Social, Environmental, and technological dimensions. The KMO values range from 0.736 (economic) to 0.897 (social), reflecting good to very good sampling adequacy. This suggests that the dataset is suitable for factor analysis and that the constructs are well represented by their items. AVE values range from 0.5135 (economic) to 0.6472 (environmental), all above the minimum threshold of 0.50. This indicates that each construct explains a sufficient portion of the variance in its items, confirming acceptable convergent validity. As we can see from the results of reliability and validly, the constructs demonstrate high reliability, good sampling adequacy, and acceptable to strong convergent validity, making them suitable for further analyses. The social and environmental dimensions show particularly strong reliability and validity, while economic and technological dimensions are also robust.

Table 1. Reliability and validity test results

Variable constructs	Items	Cronbach alpha	KMO	Average variance extracted (AVE)
Economic dimensions	4	0.856	0.736	0.5135
Social dimensions	4	0.916	0.897	0.6472
Environmental dimensions	5	0.933	0.843	0.5661
Technological dimensions	5	0.923	0.882	0.5963

The conceptual model developed for this study is grounded in responsible tourism theory and examines how four key dimensions, economic, social, environmental, and technological practices influence tourist satisfaction and the intention to revisit. The model posits that responsible tourism practices implemented within a destination generate improvements in sustainability performance across these dimensions, which in turn shape tourists' overall experiences. Specifically, the model proposes that these dimensions collectively and individually contribute to enhancing tourist satisfaction, which subsequently increases revisit intention. The framework reflects an integrated perspective in which responsible tourism practices are treated as critical determinants of both destination quality and tourist behavioral responses. By linking sustainable management dimensions to satisfaction and behavioral intention, the conceptual model provides a holistic basis for evaluating the effectiveness of responsible tourism strategies within coastal destinations along the Adriatic region.
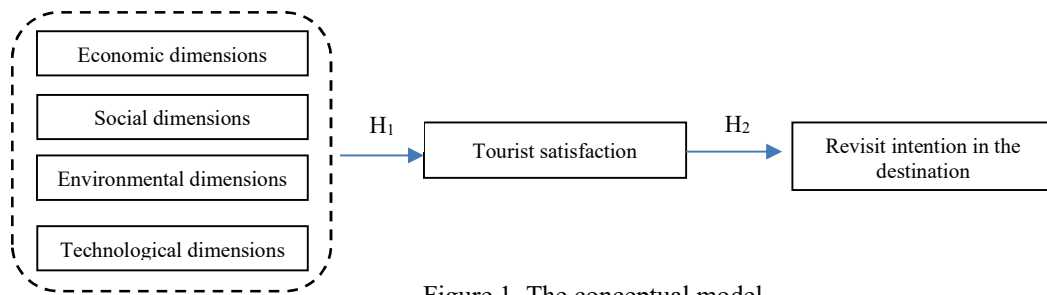
Figure 1. The conceptual model

Based on the theoretical foundations of responsible tourism and prior empirical findings (Mathew et al., 2024, Tran et al., 2018), two hypotheses were raised to examine how responsible-oriented practices influence tourists' satisfaction. The conceptual model proposes that responsible tourism practices across four key dimensions related to economic, environmental, social and technological positively affect tourist satisfaction and, subsequently, revisit intention. The raised hypotheses are:

H_1: Responsible tourism practices positively affect tourist satisfaction.

H_2: Responsible tourism practices increase tourists' intention to revisit the destination.

4. ANALYSIS AND RESULTS

The results of this study present the empirical assessment of the proposed conceptual model examining how responsible tourism practices across economic, environmental, social, and technological dimensions influence tourist satisfaction and revisit intention in Adriatic coastal destinations. Following validation of the constructs, the study proceeded with the analysis of correlations and the estimation of the regression model. The correlation results revealed significant positive associations among all responsible tourism dimensions and the tourist outcome variables, indicating that improvements in sustainable and responsible practices tend to align with more favorable tourist perceptions. Subsequently, multiple regression and hierarchical regression analysis was employed to determine the predictive power of each dimension on tourist satisfaction and the impact on the revisit intention of the tourists. This step allowed the identification of the most influential components of responsible tourism, offering empirical evidence to support the theoretical assumptions outlined in the conceptual model. In light of the obtained data, Table 1 presents a descriptive sum-up of respondents.

Table 2. Demographic characteristics of the sample.

Variables	Categories	n	%	Variables	Categories	n	%
Gender	Female	200	30.8%	Marital status	Not married	210	32.6%
	Male	450	69.2%		Married	415	63.6%
Age	18-25	114	17.6%		Divorced	20	3%
	26-35	158	24.3%		Widowed	5	0.8%
	36-45	182	28%	Duration of holidays	Weekend	165	25.3%
	46-55	124	19.1%		1-3 nights	164	25.6%
	56-65	62	9.5%		4-7 nights	127	19.4%
	> 65 years old	10	1.5%		More nights than 7	136	20.8%
Education	High school	37	5.8%		Day trip	58	8.9%
	Professional school	10	1.5%	Type of tourism	Coastal tourism	558	85.5%
	Bachelor	97	14.9%		Nature-Based Tourism	120	18.4%
	Master Degree	482	74.1%		Cultural tourism	21	3.2%
	Phd	24	3.7%		Gastronomy tourism	33	5.1%
Accommodation	Hotel/hostel	210	32.3%		Recreative tourism	9	1.4%

Agrotourism structure	57	8.8%		Medical and health tourism	24	3.7%
Guesthouse/Apartment	288	44.3%		Religious tourism	3	0.5%
Camping	22	3.4%		Visiting friends and relatives	45	6.9%
Friends/family relatives	73	11.2%		Business, training, conference	11	1.7%
Total	650	100%		Other(shopping/transit)	11	1.7%

Source: Elaborated by the authors based on gathered data

The data are gathered between the months September and October, 2024 trying to minimize the effects of seasonality, as the destinations are primarily known for coastal tourism. The sample consisted of 650 respondents, of whom 69.2% were male and 30.8% were female. In terms of age distribution, the largest group belonged to the 36–45 age category (28%), followed by those aged 26–35 (24.3%) and 46–55 (19.1%), while only 1.5% were over 65. Regarding marital status, 63.6% were married, 32.6% were not married, and a small proportion reported being divorced (3%) or widowed (0.8%). The participants were generally highly educated, with 74.1% holding a Master's degree, 14.9% a Bachelor's degree, and smaller shares completing high school or professional school; 3.7% held a PhD. In terms of accommodation choices, the majority stayed in guesthouses or apartments (44.3%), followed by hotels or hostels (32.3%), while smaller percentages stayed with friends or relatives (11.2%), in camping facilities (3.4%), or agrotourism structures (8.8%). The duration of holidays varied: around one quarter stayed for 1–3 nights (25.6%) or only a weekend (25.3%), while 20.8% stayed for more than 7 nights, and 8.9% were on day trips.

Regarding the type of tourism pursued, the majority of respondents were engaged in coastal tourism (85.5%), reflecting the strong attractiveness of seaside destinations. Smaller segments participated in nature-based tourism (18.4%), gastronomy tourism (5.1%), cultural tourism (3.2%), medical and wellness tourism (3.7%), religious tourism (0.5%), or were visiting friends and relatives (6.9%). Only 1.7% were traveling for business, training, or conferences, and 1.7% indicated other purposes such as shopping or transit.

The results of the study are organized based on three main variables: the responsible tourism dimensions, tourism satisfaction and revisit intention in the destination. In order to define the relationship between the responsible tourism practices and tourism satisfaction, multiple linear regression analysis was performed to analyze the impact of economic, social, environmental and technological dimensions on tourist satisfaction. The findings indicated that each dimension significantly contributes to shaping the experiences of tourists, highlighting the importance of responsible approaches in enhancing tourist satisfaction. All the factors with a significant correlation (*p <0.05 level) were analyzed through a multiple regression analysis to determine their impact on dependent variable. Before taking the significance of each variable related to responsible tourism into consideration, the model summary given in Table 3 describes the overall relationships between dependent and independent variables (R), goodness of fit (the coefficient of determination) and the standard error of estimate. The regression model summary shows the value R and R^2 are 0.571 and 0.327, respectively, the value of F= 78.211 and the significance of 0.000. According to the model, 32.7% of the variance of the dependent variables is explained from the four groups of economic, social, environmental, and technological dimensions. This suggests that while the model captures a meaningful portion of the variance, other factors not included in the model may also influence the tourist satisfaction in the destination.

Table 3. Model Summary

Model	R	R Square	Std. Error of the Estimate	F	Sig.
1	.571[a]	.327	.658	78.211	.000[b]

[a] Predictors: (Constant), Technological dimensions, Economic dimensions, Environmental dimensions, social dimensions

[b] Dependent Variable: Tourist satisfaction in the destination

The regression results reveal that three dimensions of responsible tourism practices focused on economic, environmental, and social responsibility, significantly influence tourist satisfaction at the destination, while technological responsibility does not display a statistically significant effect.

Economic dimensions (β = 0.188, p < 0.001) emerged as a strong predictor of tourist satisfaction. This finding aligns with sustainable tourism literature, which suggests that tourists increasingly value transparent pricing, local

economic benefits, fair employment, and visible contributions to host communities (Sharpley, 2022). When visitors perceive that their spending supports local development, their emotional attachment and satisfaction tend to increase when they perceive mutual benefits. Second, environmental responsibility is also significant ($\beta = 0.147$, $p = 0.023$). This supports prior research indicating that tourists increasingly prefer destinations that demonstrate environmental stewardship, such as waste management, conservation efforts, and protection of natural resources (Baloch et al., 2023; Mihalič, 2000). According to Liu et al., (2022) and responsible tourism frameworks in many countries, environmentally proactive destinations enhance tourist experience quality, contributing to greater satisfaction and a positive destination image. Third, social dimension of the responsible tourism practices shows a strong and significant influence ($\beta = 0.196$, $p = 0.010$). This outcome echoes findings from cultural tourism studies showing that respect for local traditions, cultural preservation, and positive host–guest interactions enhance perceived authenticity and emotional fulfillment (Surata et al., 2024). In their research, Luekveerawattana et al. (2025) suggest that initiatives that safeguard cultural identity and promote respectful engagement directly elevate tourist satisfaction levels. Conversely, technological responsibility demonstrates a positive but statistically non-significant coefficient ($\beta = 0.096$, $p = 0.139$). Although digital services, smart technologies, and online information systems are increasingly important in tourism, the findings suggest that in the studied Adriatic coastal destinations, technology may still be perceived as an added convenience rather than a core determinant of satisfaction. This aligns with studies noting that in nature-based or leisure-oriented destinations, tourists prioritize environmental quality and cultural authenticity over digital infrastructure. It may also indicate varying levels of digital readiness among Adriatic destinations, where technological adoption remains uneven. The results confirm that tourists value holistic responsible tourism practices, where economic fairness, environmental responsible practices, and cultural respect interact to shape their satisfaction. These findings reinforce the broader literature on sustainable destination management, suggesting that responsible practices are not only ethical imperatives but also strategic drivers of tourist satisfaction and destination competitiveness.

Table 4. Coefficents

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.811	.131		13.775	.000
Economic dimensions	.187	.051	.188	3.651	.000
Environmental dimensions	.118	.052	.147	2.281	.023
Social dimensions	.173	.067	.196	2.583	.010
Technological dimensions	.080	.054	.096	1.480	.139
a. Dependent Variable: Tourist satisfaction in the destination					

To test the second hypothesis, a hierarchical regression analysis was conducted in two steps to examine the impact of responsible tourism dimensions on tourist revisit intention. The model introduced tourist satisfaction as a mediator variable to assess its mediating role in explaining revisit intention. The inclusion of satisfaction substantially improved the model's explanatory power, increasing the R^2 to 0.569, meaning that 56.9% of the variance in tourist revisit intention is explained by the combined predictors. The adjusted R^2 (0.566) confirms the robustness of the expanded model, while the decrease in the standard error of the estimate (0.547) indicates enhanced predictive precision. The notable improvement between the models demonstrates that tourist satisfaction plays an important mediating role, significantly strengthening the relationship between responsible tourism practices and tourists' behavioral intentions.

Table 5. Hierarchical model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.
1	.499[a]	.249	.245	.72247	53.513	.000[a]
2	.755[b]	.569	.566	.54759	170.269	.000[b]

a Predictors: (Predictors: (Constant), technological dimensions, economic dimensions, Environmental dimensions, social dimensions

b Predictors: (Constant), technological dimensions, economic dimensions, environmental dimensions, social dimensions, tourist satisfaction in the destination

c. Dependent variable: Tourist revisit intention

The regression analysis was conducted in two steps to evaluate both the direct effects of responsible tourism dimensions on revisit intention (model 1) and the mediating role of tourist satisfaction (model 2). In the first model, economic dimensions ($\beta = 0.218$, $p < 0.001$) and social dimensions ($\beta = 0.160$, $p = 0.045$) emerge as significant predictors of revisit intention. These results suggest that tourists are more likely to return to destinations that ensure fair economic practices and demonstrate respect for local culture and community well-being. Environmental responsibility shows a marginal effect ($\beta = 0.125$, $p = 0.067$), indicating a weaker yet emerging influence. In addition, technological responsibility does not significantly predict revisit intention. Meanwhile, model 2 incorporates tourist satisfaction as an additional predictor, revealing substantial changes in the effect of the responsible tourism dimensions. With the inclusion of tourist satisfaction in the destination as a mediating variable, the coefficients of economic, environmental, social, and technological dimensions become statistically non-significant. This shift demonstrates a full mediation effect, wherein the impact of responsible tourism practices on revisit intention is transmitted through tourist satisfaction. The satisfaction variable exhibits a strong and highly significant effect ($\beta = 0.690$, $p < 0.001$), indicating that satisfied tourists are significantly more likely to revisit the destination. The results highlight the central mediating role of satisfaction and underscore the importance of responsible tourism practices as foundational drivers of positive tourist experiences, which subsequently translate into revisit intentions.

Table 6. Hierarchical model coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.983	.144		13.741	.000
Economic dimensions	.225	.056	.218	4.004	.000
Environmental dimensions	.104	.057	.125	1.838	.067
Social dimensions	.147	.074	.160	2.005	.045
Technological dimensions	.037	.059	.042	.623	.534
(Constant)	.685	.124		5.504	.000
Economic dimensions	.091	.043	.088	2.116	.035
Environmental dimensions	.020	.043	.024	.458	.647
Social dimensions	.023	.056	.025	.418	.676
Technological dimensions	.020	.045	.023	.453	.651
Tourist satisfaction in the destination	.717	.033	.690	21.880	.000

a. Dependent Variable: Tourist revisit intention

5. CONCLUSIONS

This study's findings indicate that responsible tourism practices significantly influence tourist satisfaction in Adriatic coastal areas. Among the four dimensions assessed, economic, environmental, and social dimensions of the responsible tourism emerged as statistically significant predictors of satisfaction, confirming that tourists value destinations that promote economic practices helping the development of local community's economy, protect natural

resources, and safeguard cultural authenticity. These results are consistent with existing theories of sustainable tourism which emphasize the importance of mutual benefit, environmental protection, and meaningful host–guest interactions in enhancing tourist experiences.

In contrast, technological responsibility did not significantly influence satisfaction, suggesting that while digital tools and smart services contribute to convenience, they may not yet represent a core determinant of visitor experience. This could reflect the nature of coastal tourism, where environmental quality and cultural interactions remain more influential than technological enhancements. The study reinforces the strategic importance of integrating responsible tourism practices into destination management. By prioritizing economic fairness, environmental protection, and socio-cultural preservation, tourism stakeholders can enhance tourist satisfaction and strengthen long-term destination competitiveness. However, their impact on tourists' revisit intention is fully mediated by tourist satisfaction, which plays a central role in translating responsible tourism practices into positive tourist experiences and loyalty. Prioritizing tourist satisfaction is essential for achieving long-term destination sustainability.

Acknowledgements

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Impact of IFRS 17 on Life Insurance Product Pricing and Design in Late-Adopting Markets

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Abstract

IFRS 17 replaces IFRS 4's heterogeneous practices with a current-value model that defers day-one gains into the Contractual Service Margin (CSM), introduces an explicit Risk Adjustment (RA), and expands disclosure. This paper asks whether these accounting changes are associated with shifts in life-insurance pricing and product design, with emphasis on late-adopting settings where local standalone/statutory reporting persisted in 2023. Using a mixed-methods, contrast-seeking design, we analyse public first-year (2023) materials for 13 insurers - seven large European groups applying IFRS 17 and six Albanian/Serbian entities reporting locally on legacy bases. We extract IFRS 17 metrics (insurance revenue; insurance service result, ISR; CSM/RA movements; transition effects) and code management commentary on pricing levers, commissions, and contract boundaries. We also introduce a four-pillar, replicable IFRS 17 Disclosure Index (implementation/transition; quantitative reconciliations; methodology/assumptions; performance interpretation). In our sample, findings indicate IFRS 17 primarily re-times profit recognition rather than changing cumulative economics. Across the reviewed materials, early adopters did not report wholesale repricing or product withdrawals attributable to IFRS 17 alone; adjustments were tactical (risk-mitigation options, clearer contract boundaries, tighter commission recovery to avoid onerous cohorts). Disclosure quality was high for group-level adopters and limited in local late-adopting reports, reflecting their reporting basis. Results are descriptive (non-causal) and highlight implications for parallel runs, data/system upgrades, and governance that embeds CSM/ISR and RA metrics in pricing decisions.

Keywords: IFRS 17, Contractual Service Margin (CSM), Life insurance pricing, Late-adopting markets

1. INTRODUCTION

International Financial Reporting Standard 17 (IFRS 17) replaces the heterogeneous practices permitted under IFRS 4 with a single, current-value measurement model that defers day-one gains into a Contractual Service Margin (CSM), introduces an explicit Risk Adjustment (RA) for non-financial risk, and mandates granular, decision-useful disclosures (IFRS Foundation, 2017a, 2017b; Foroughi et al., 2012; Palmborg, Lindholm, & Lindskog, 2021). Published first-year reports and supervisory stock-takes describe a re-profiling of earnings presentation under IFRS 17, without asserting changes to cumulative economics, while placing new demands on data, systems, and governance (Allianz, 2024; AXA, 2024; Generali, 2024; Prudential, 2023; ESMA, 2024; EIOPA, 2024; World Bank

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CFRR, 2021). From an actuarial and market-discipline perspective, this shift is expected, in theory, to reduce cross-subsidization, foreground onerous cohorts at inception, and reward product designs with more predictable cash flows (Milliman, 2020; KPMG, 2018; Fitch Ratings, 2025).

Research gap. While industry surveys and effects analyses anticipated "discipline at inception" and possible tilts away from long-guarantee products, there remains limited, systematic evidence on whether accounting changes alone have prompted insurers to modify pricing levers (commission structures, guarantee levels, contract boundaries) and product features. This is especially true in late-adopting markets where IFRS 17 is not yet mandatory and reporting continues under national/statutory frameworks, such as the Albanian National Accounting Standards, rather than IFRS 17, with premiums still recognised as revenue under those bases (EFRAG, 2018; KPMG, 2018; Alhawtmeh, 2023; Dahiyat & Owais, 2021; Owais & Dahiyat, 2021; Hartojo & Purnamasari, 2023;). In our sample, local Albanian/Serbian standalone reports for 2023 remained on legacy bases, while several parent groups reported under IFRS 17 on consolidation, creating a natural contrast between local and group-level disclosure (World Bank CFRR, 2021; Lali, 2019; UNIQA Group, 2023; Sigal Life, 2022; Xprimm, 2023a, 2024b, 2024).

Research questions. We therefore ask: RQ1. To what extent has IFRS 17 altered pricing and product-design decisions among early adopters? RQ2. Do late-adopting insurers, still reporting under IFRS 4 or national/statutory bases, exhibit different economic incentives or behaviours relative to IFRS 17 peers? RQ3. How do IFRS 17 disclosure practices (e.g., CSM/RA roll-forwards, discount methodology, confidence-level equivalents) shape market discipline and anticipated product shifts?

Approach and contribution. Using a mixed-methods comparative design, we analyse 13 life insurers spanning large European adopters (e.g., Allianz, AXA, Generali, Prudential, Triglav, Croatia Osiguranje, VIG/UNIQA groups) and late-adopting insurers in Albania and Serbia. We (i) quantify first-year IFRS 17 effects on earnings, equity, CSM/RA, and revenue presentation; (ii) assess pricing/design signals in management commentary; and (iii) introduce a replicable IFRS 17 Disclosure Index covering four pillars, implementation, quantitative reconciliations, methodology/assumptions, and performance interpretation (ESMA, 2024; EIOPA, 2024; IFRS Foundation, 2017a). This yields three contributions: comparative evidence on early behavioural responses versus baseline practices in late-adopting markets; a transparent measure of disclosure quality to benchmark firms and jurisdictions; and actionable implications for pricing governance and regulatory road-maps, including investor-relevant interpretation of CSM and RA (Fitch Ratings, 2022, 2025; Milliman, 2020; Palmborg et al., 2021).

Broader relevance. IFRS 17 exemplifies how reporting innovation depends on modern data and analytics platforms, promotes cross-border consistency in financial communication, and supports more sustainable business models through earlier identification of loss-making designs (World Bank CFRR, 2021; ESMA, 2024; EIOPA, 2024; IFRS Foundation, 2017b). By linking these reporting advances to concrete pricing discipline and product strategy in both early- and late-adopting markets, the study contributes to ongoing conversations at the intersection of business practice, technology-enabled finance, and long-term economic resilience.

2. LITERATURE REVIEW

IFRS 17 accounting changes and why they matter for pricing/design. IFRS 17 introduces a current-value measurement anchored in fulfilment cash flows, defers day-one gains into the Contractual Service Margin (CSM), and requires an explicit Risk Adjustment (RA) for non-financial risk, alongside expanded, decision-useful disclosures (IFRS Foundation, 2017a, 2017b). These mechanics re-time profit recognition toward service provision and require contract-group loss recognition, changing earnings profiles without necessarily altering cumulative economics (Palmborg, Lindholm, & Lindskog, 2021; Foroughi et al., 2012). The timing effects interact with pricing levers, guarantees, commissions, and contract boundaries, because day-one onerous cohorts become visible and sustained profit emergence depends on coverage-unit patterns and cash-flow predictability (IFRS Foundation, 2017a, 2017b; Palmborg et al., 2021).

Expected business impacts: pricing and product design. Pre-adoption surveys and actuarial commentary anticipated tighter discipline at inception (avoidance of day-one onerous groups), closer alignment of commissions with expected service patterns, and scrutiny of long-guarantee features (EFRAG, 2018; KPMG, 2018; PwC, 2017; Milliman, 2020). Because IFRS 17 defers profit into CSM and exposes assumption risk via the RA, many expected a tilt toward capital-light, fee-based and protection products with steadier cash flows, while traditional savings/annuity products with embedded guarantees could show slower profit emergence and greater sensitivity to discounting and non-financial risk (Milliman, 2020; Fitch Ratings, 2025). Cross-jurisdiction analyses similarly

conclude that IFRS 17 should reinforce economic-value pricing and improve comparability, even as total profitability remains driven by fundamentals rather than accounting optics (Palmborg et al., 2021; Foroughi et al., 2012).

Measurement choices: RA, discounting, and implications for design. RA calibration (confidence-level vs. cost-of-capital) and discount-rate methodology shape the profile and sensitivity of reported margins (IFRS Foundation, 2017a, 2017b). Investor-facing research emphasizes that large CSM balances represent deferred profit whose release profile and quality will become central to performance assessment, elevating RA and assumption-setting choices into market signals (Fitch Ratings, 2022, 2025). Implementation and readiness studies show these choices demand significant data lineage, modelling capability, and system upgrades, with complexity often higher in emerging or data-poor markets (World Bank CFRR, 2021; Hartojo & Purnamasari, 2023).

Late-adopting markets: readiness, constraints, and likely trajectories. Evidence from Jordan, Indonesia, Taiwan, and Western Balkan contexts highlights capability gaps (data, models, governance) and regulatory alignment issues that can delay or dilute IFRS 17 implementation (Alhawtmeh, 2023; Owais & Dahiyat, 2021; Dahiyat & Owais, 2021; Hartojo & Purnamasari, 2023; World Bank CFRR, 2021; Lali, 2019).In Albania and Serbia, local reporting often remains on legacy frameworks while regional groups adopt IFRS 17 in consolidation, creating a natural setting to observe incentives and disclosure contrasts (UNIQA Group, 2023; Sigal Life, 2022; Xprimm, 2023a, 2024b, 2024). The literature therefore expects that, at adoption, insurers with legacy guarantees and front-loaded acquisition costs will need repricing or feature changes (e.g., shorter boundaries, reviewable premiums) to avoid onerous cohorts (World Bank CFRR, 2021; EFRAG, 2018; Milliman, 2020).

Early implementation evidence (post-2023). First-year reports from large European groups show modest equity effects at transition and a re-profiling of earnings, with analysts shifting focus to insurance service result, CSM growth, and CSM release (Allianz, 2024; AXA, 2024; Generali, 2024; Prudential, 2023). Supervisory stock-takes find improved transparency but uneven practice on contract boundaries, discount-curve disclosure, and RA confidence-level equivalents, indicating scope to enhance decision-useful detail (EIOPA, 2024; ESMA, 2024). Industry analysis stresses that while cumulative economics are broadly unchanged, clear communication of drivers, sensitivities, and release rates is shaping market perception and capital policy (Fitch Ratings, 2022, 2025; Milliman, 2023).

Disclosure quality and market discipline. IFRS 17's roll-forwards and reconciliations increase verifiability of sources of earnings; however, regulators highlight gaps in entity-specific quantification and methodological clarity that hinder comparability (EIOPA, 2024; ESMA, 2024). Academic and professional sources converge that higher-quality disclosure can indirectly influence product strategy by exposing slow profit emergence, aggressive RA settings, or guarantee sensitivity, thereby sharpening pricing governance and stakeholder scrutiny (IFRS Foundation, 2017a, 2017b; Palmborg et al., 2021; Foroughi et al., 2012; Fitch Ratings, 2025).

Across academic, regulatory, and industry literatures, four propositions recur: pricing remains economics-first, with IFRS 17 acting as a discipline and transparency constraint; governance shifts toward "no day-one loss" at the cohort level; capital-light/fee-based and protection designs benefit from smoother CSM release and lower RA drag; and late adopters face sharper adjustments due to legacy designs and weaker data systems (IFRS Foundation, 2017b; EFRAG, 2018; Milliman, 2020; Palmborg et al., 2021; ESMA, 2024; EIOPA, 2024; World Bank CFRR, 2021). These insights set expectations that IFRS 17 should encourage avoidance of onerous cohorts and favor simpler, reviewable products, expectations we test by comparing early adopters with late-adopting insurers and by benchmarking disclosure quality with a new IFRS 17 Disclosure Index.

3. RESEARCH RESULTS AND DISCUSSION

Research design. We employ a mixed-methods comparative design to assess whether IFRS 17 affects pricing levers (guarantees, commissions, contract boundaries) and product design among life insurers. The design combines qualitative content analysis of narrative disclosures and accounting policies with quantitative extraction of IFRS 17 metrics and selected legacy-framework indicators. IFRS 17's fulfilment-value framework, the CSM and RA constructs, and the expanded roll-forwards/reconciliations enable cross-firm benchmarking of profit timing and transparency (IFRS Foundation, 2017a, 2017b; Palmborg, Lindholm, & Lindskog, 2021; Foroughi et al., 2012).

Sample and selection strategy. The sample comprises 13 life insurers in two strata. Early adopters applied IFRS 17 in 2023 and include large European groups and regional leaders whose practices often shape market norms (Allianz, 2024; AXA, 2024; Generali, 2024; Prudential, 2023; Triglav Group, 2023; Croatia Osiguranje, 2023; UNIQA Group, 2023). Late adopters report under legacy frameworks in Albania and Serbia, jurisdictions where

local IFRS 17 application was not yet fully mandated in the period studied, providing a natural counterfactual for incentives and disclosure differences (Sigal Life, 2022; Xprimm, 2023a, 2024b, 2024; World Bank CFRR, 2021; Lali, 2019). Selection was purposeful (contrast-seeking), not random. Inclusion criteria were: (i) availability of a complete 2023 (or most recent) annual report with notes; and (ii) sufficient segment detail to extract IFRS 17 metrics (for adopters) or baseline ratios under the prevailing local framework (for late adopters). To enhance external validity, the early-adopter stratum includes several of Europe's largest insurers by premiums/capital (Allianz, 2024; AXA, 2024; Generali, 2024). The late-adopter stratum reflects contexts where implementation challenges and capability gaps are documented (World Bank CFRR, 2021; Alhawtmeh, 2023; Owais & Dahiyat, 2021; Dahiyat & Owais, 2021; Hartojo & Purnamasari, 2023).

Data sources and collection. Primary sources were published annual reports and notes (2023 or latest; restated 2022 for adopters), plus statutory or IFRS-basis financials for late adopters depending on the local framework in force (Allianz, 2024; AXA, 2024; Generali, 2024; Prudential, 2023; Triglav Group, 2023; Croatia Osiguranje, 2023; UNIQA Group, 2023; Sigal Life, 2022). The review instrument was aligned with supervisory stock-takes to emphasize decision-useful disclosure items (EIOPA, 2024; ESMA, 2024). Market reports for Albania and Serbia provided context on market scale and competition (Xprimm, 2023a, 2024b, 2024).

Scope and reporting layers. We distinguish three reporting layers and use the term "late-adopting" strictly for layer (iii) in FY2023: (i) Group IFRS consolidation (European groups; IFRS 17 applied in 2023); (ii) Standalone IFRS where applicable;(iii) Local standalone/statutory or supervisory reports for Albanian/Serbian entities (legacy bases in 2023 in the sample reviewed). For each Balkan insurer we analyze the local report (layer iii) and, where relevant, read the group report (layer i) for context. Our classification reflects what was actually disclosed in the specific 2023 reports we cite; we do not take a position on national endorsement timetables beyond the documents reviewed. Procedure: we manually reviewed MD&A, accounting policies, and IFRS 17 notes, coding narrative items into a structured template and extracting quantitative fields into a comparative dataset. Two researchers independently coded narrative items and scored disclosure quality; disagreements were reconciled using a documented protocol. Quantitative fields were double-entered and cross-checked. This triangulation mirrors methods in IFRS 17 readiness and emerging-market implementation studies (World Bank CFRR, 2021; Alhawtmeh, 2023).

Measures and definitions. For IFRS 17 adopters we captured: insurance revenue (replacing gross written premium presentation), insurance service result (ISR) and ISR margin (ISR÷insurance revenue), CSM (opening/closing, additions, releases), RA (amounts and methodology references), and transition disclosures (approach, equity effects, restatements) (IFRS Foundation, 2017a; Foroughi et al., 2012). For late adopters, we recorded available gross written premiums, loss and expense ratios, and return on equity to provide a baseline under the prevailing local framework (World Bank CFRR, 2021; Owais & Dahiyat, 2021). Where local entities are consolidated within IFRS-reporting groups (e.g., UNIQA), we reference the group-level IFRS 17 context without imputing entity-level IFRS 17 metrics (UNIQA Group, 2023).

Terminology: CSM = deferred profit recognized over coverage units; RA = compensation for non-financial risk; DAC = deferred acquisition costs; VOBA = value of business acquired. DAC/VOBA are referenced to identify transition accounting effects; quantitative impacts are presented in Results (IFRS Foundation, 2017a, 2017b; ESMA, 2024; EIOPA, 2024).

IFRS 17 Disclosure Index (rubric and scoring). Guided by IFRS 17 requirements and supervisory emphases (IFRS Foundation, 2017a; ESMA, 2024; EIOPA, 2024), the Index totals 25 points across four pillars. Each item is scored 0 = not disclosed, 1 = narrative/partial, 2 = entity-specific with figures/parameters. Use 1.5 for near-complete items missing a key quantification (e.g., RA discussed without a confidence-level equivalent).

Pillar A - Implementation & transition (8 pts)

A1 (2) Transition approach stated (full retrospective / modified / fair value).

A2 (2) Comparative period restated and shown.

A3 (2) Equity-impact bridge described (qualitative vs quantified).

A4 (2) Treatment of DAC/VOBA/OCI at transition explained.

Pillar B - Quantitative reconciliations (8 pts)

B1 (2) Roll-forward of insurance contract liabilities including CSM.

B2 (2) Roll-forward of Risk Adjustment (RA).

B3 (2) Bridge from IFRS 4 presentation to IFRS 17 metrics.

B4 (2) Sensitivities or sources-of-earnings table provided.

Pillar C - Methodology & assumptions (5 pts)

C1 (2) Discount-rate methodology (top-down/bottom-up) with parameters.

C2 (2) RA technique with confidence-level equivalent or cost-of-capital.

C3 (1) Level of aggregation/annual cohorts and contract-boundary policy.

Pillar D - Performance & interpretation (4 pts)

D1 (2) KPIs (ISR, CSM release, drivers of change) explained with numbers.

D2 (2) Management commentary links movements to business drivers (new business vs assumptions vs experience).

Scoring protocol and scope

1. Two coders scored independently and reconciled to consensus (tie-break = conservative lower score).

2. Scope rule: We score only reports where IFRS 17 is actually applied. Local Albanian/Serbian standalone 2023 reports in our sample are not scored and are treated via Readiness Notes (see Table 1B). Where a parent group applies IFRS 17 on consolidation, group-level disclosures are scored separately and not conflated with the local report.

Analysis strategy. We compare adopters and late adopters on disclosure quality (Index scores) and metric availability; analyse pricing/design signals in narrative text (commission recovery, guarantee levels, contract-boundary choices, use of risk-mitigation options); and summarize financial profiles under IFRS 17 versus legacy baselines. We do not claim causality; rather, we interpret patterns relative to theory and prior expectations and triangulate with supervisory reviews (IFRS Foundation, 2017b; EFRAG, 2018; Milliman, 2020; Fitch Ratings, 2025; EIOPA, 2024; ESMA, 2024). Company-specific values and cross-sectional comparisons are presented in Results, maintaining a clear method–findings boundary.

Results: IFRS 17 adoption and financial impact. This subsection contrasts early adopters (reported under IFRS 17 for FY2023) with late adopters (legacy local/statutory bases in 2023). We use standardized strategy/product tags to encode IFRS 17-relevant choices (risk-mitigation, cohorts, contract boundaries, commission discipline, mix shifts, disclosure quality). Company-level details and citations correspond to public filings and supervisory reviews (Allianz, 2024; AXA, 2024; Generali, 2024; Prudential, 2023; VIG, 2023, 2024; Triglav, 2023; Croatia Osiguranje, 2023; UNIQA, 2023; ESMA, 2024; EIOPA, 2024). All figures and phrases are reproduced as reported by issuers in 2023 public materials; we do not recalculate values. "~" reflects issuer approximations. Scope is group-level unless explicitly indicated.

Table 1A. Early adopters - IFRS 17 adoption and financial impact

Company	IFRS 17 adoption	Transition equity change	2023 IFRS 17 KPIs (phrases / numbers)	Strategy / product tags	Source
Allianz	2023	~ –1% to –3%	L&H insurance revenue ~€82bn; CSM ~€25bn; RA: cost-of-capital → ~75% conf. equiv.	RMO(par); pricing: unchanged (mgmt); cohort: annual; CB: clarified	Allianz (2024)
AXA	2023	~ –5%	Insurance revenue €96bn; CSM release ~€5.4bn	RMO(par); pricing: unchanged (mgmt); mix: +unit-linked/+protection; commissions: discipline	AXA (2024)
Generali Group	2023	~ –2%	Life CSM: large; RA disclosed; cohort exemption (some with-profits)	pricing: unchanged (mgmt); cohort: exemption (par); CB: clarified	Generali (2024)
Prudential	2023	~ –6%	Opening CSM ~US$24.5bn; CSM release ~9.5%	mix: +protection/+unit-linked; capital focus; pricing: unchanged (mgmt)	Prudential (2023)

Vienna Insurance Group (VIG)	2023	∼—3%	CSM ∼€5bn (life/health); RA CoC → ∼79.5% conf. equiv.	pricing: unchanged (mgmt); reinsurance: mismatch-watch; RA: disclosed	VIG (2023, 2024)
Zavarovalnica Triglav	2023	∼—2%	Life CSM ∼€0.3bn; RA ∼85% conf. equiv.; CSM release ∼€30m	analytics: enhanced; pricing: unchanged (mgmt); RA: quantified	Triglav Group (2023)
Croatia Osiguranje	2023	small negative	Life CSM ∼€0.12bn; limited RA/method detail	pricing: unchanged (mgmt); disclosure: limited (RA); ops: tech-adoption	Croatia Osiguranje (2023)

Transition equity change = the change in equity reported at transition after setting up the CSM, derecognising/reclassifying DAC/VOBA, and recognising the RA (and OCI effects, where applicable). Key KPIs = insurance revenue, CSM level and release, RA method and (when available) its confidence-level equivalent. Strategy/product tags summarise IFRS 17-linked governance and design choices evidenced in the issuer's disclosures.

Table 1B. Late adopters - reporting basis and IFRS 17 readiness

Company	Reporting basis (FY2023)	IFRS 17 status	Local KPIs available	Readiness / risk tags	Source
Dunav Osiguranje (Serbia)	IFRS under Serbian regulation (NBS rulebooks)	IFRS 17: pending in local standalone 2023 reporting	GWP; technical provisions; ROE	IFRS17: pending; disclosure: IFRS-based but pre-IFRS 17; planning in progress; risk: guarantees/commissions	Dunav 2023 AR (basis of prep.); Xprimm (2023a)
INSIG Jeta (Albania)	Local statutory basis (Law 52/2014; AFSA templates; SKK where applicable)	IFRS 17: pending	GWP; basic ratios	IFRS17: pending; disclosure: statutory-only; readiness: low; data: gaps	INSIG FS (2022); Xprimm (2024b)
Sicred (Albania)	Local statutory basis (Law 52/2014; AFSA templates; SKK where applicable)	IFRS 17: pending	GWP; profit	IFRS17: pending; disclosure: statutory-only; scale: small; readiness: low	Sicred AR (2022, 2024)
Sigal Life UNIQA (Albania, local)	Local statutory basis (Law 52/2014; AFSA templates; SKK where applicable); group IFRS 17	Consolidated at UNIQA; local not adopted	GWP; market share	group: IFRS 17; local: statutory; disclosure: gap (group–local); readiness: medium	UNIQA (2023); SIGAL Life ARs (2022–2023); Xprimm (2023)
Albsig Jetë (Albania)	Local statutory basis (Law 52/2014; AFSA templates; SKK where applicable)	IFRS 17: pending	GWP; basic ratios	IFRS17: pending; disclosure: statutory-only; readiness: low	Albsig ARs (2022–2023)
Vienna Life (VIG) Albania	Local statutory basis (Law 52/2014; AFSA templates; SKK where applicable); group IFRS 17	Consolidated at VIG; local not adopted	GWP	group: IFRS 17; local: statutory; disclosure: gap (group–local); readiness: medium	VIG (2023, 2024)
Generali Osiguranje (Croatia & Serbia, local)	Mixed: consolidated under IFRS 17 at group; local standalone varies by jurisdiction	Group IFRS 17; local: Croatia generally IFRS 17 from 2023; Serbia IFRS under NBS rulebooks (IFRS 17 endorsement timing differs)	GWP; selected local ratios (where published)	group: IFRS 17; local: mixed; disclosure: gap (group–local); readiness: medium	Generali (2024); jurisdictional rules

Reporting basis refers to the local entity's FY2023 framework. In Serbia, insurers prepare under IFRS per regulation and apply National Bank of Serbia rulebooks; several 2023 standalone reports in our sample indicate IFRS were applied, but IFRS 17 was not reflected locally in those specific reports. In Albania, entities report on a local statutory basis (Law 52/2014; AFSA templates; SKK where applicable); some of their parent groups (e.g., UNIQA, VIG) report under IFRS 17 at consolidation. The readiness/risk tags in Table 1B summarize preparedness and pressure points (data/systems, and potential exposure to onerous cohorts from guarantees/commissions).

Scoring scope. Local Albanian/Serbian standalone or supervisory 2023 reports in our sample generally did not present IFRS 17 by design. Accordingly, we do not assign Disclosure Index scores to those local reports; instead, we provide a Readiness Note (Table 1B). Where a parent group reports under IFRS 17 on consolidation, those group-level disclosures are discussed and, where applicable, scored separately (see Table 1A).

Early-adopter patterns. Across early adopters, several issuers described modest equity effects at transition (magnitudes varied by issuer), and earnings profiles shifted as new-business gains were deferred into the CSM and released over time (Allianz, 2024; AXA, 2024; Generali, 2024; Prudential, 2023; VIG, 2023/2024; Triglav, 2023; Croatia Osiguranje, 2023). We did not observe disclosures of wholesale pricing withdrawals in 2023; tactical choices mentioned included use of the risk-mitigation option for participating business, tighter cohort governance, and clearer contract-boundary articulation (ESMA, 2024; EIOPA, 2024). In late-adopting settings, local reporting remained on statutory bases, and public materials indicated planning phases and data/system gaps, particularly in Albania; meanwhile, parent groups already embedded these books within IFRS 17 consolidations (UNIQA, 2023; VIG, 2023/2024; Xprimm, 2024).

Disclosure index scores (see Table 2).

This subsection reports the IFRS 17 Disclosure Index results across four pillars: (A) implementation/transition; (B) quantitative reconciliations; (C) methodology/assumptions; and (D) performance interpretation. Each item is scored 0 (not disclosed), 1 (partially disclosed), or 2 (fully disclosed). Where disclosure exceeds minimal but is not complete (e.g., Risk Adjustment discussed without a quantified confidence-level equivalent), half-points (e.g., 1.5) may be awarded; quarter-points are not used. The maximum composite score is 25. Scores reflect only what is observable in public reports and supervisory stock-takes (IFRS Foundation, 2017a; EIOPA, 2024; ESMA, 2024). Early adopters generally score high, whereas late adopters that did not implement IFRS 17 in local standalone reporting for FY2023 score near zero at the local level, even when their parent groups report under IFRS 17.

Table 2. IFRS 17 Disclosure Index scores

Company	A Implementation /transition	B Quantitative	C Methodology	D Performance	Total	Notes / source anchor
Generali Group	8.0	8.0	5.0	4.0	25.0	Clear policies; full bridges and roll-forwards; RA confidence-level equivalent disclosed; cohort exemption for certain participating contracts (Generali, 2024)
AXA	8.0	8.0	5.0	4.0	25.0	Comprehensive restatement; granular CSM movements; risk-mitigation option explained; strong KPI narrative (AXA, 2024)
Allianz	8.0	8.0	3.5	4.0	23.5	Extensive quantitative data; RA cost-of-capital described, confidence proxy indicated at high level (Allianz, 2024)
Prudential	8.0	8.0	5.0	4.0	25.0	Robust methods; CSM release rate explained; drivers of change articulated for Asian portfolios (Prudential, 2023)
Vienna Insurance Group (VIG)	8.0	8.0	5.0	3.0	24.0	RA technique and confidence-level equivalent disclosed; somewhat lighter discussion of new KPIs (VIG, 2023; VIG, 2024)
Zavarovalnica Triglav	8.0	8.0	3.5	4.0	23.5	Solid roll-forwards; discount-rate disclosure; methodology partly high-level in places (Triglav Group, 2023)
Croatia Osiguranje	4.0	4.0	2.5	2.0	12.5	Basic policy statements and headline figures; limited methodological and KPI detail (Croatia Osiguranje, 2023)
Generali Osiguranje (local, HR/RS)	0.0	0.0	0.0	0.0	0.0	Local entities not reporting IFRS 17 for FY2023; IFRS 17 only at group level (Generali, 2024)
Dunav Osiguranje (RS)	0.0	0.0	0.0	0.0	0.0	Standalone 2023 reporting pre-IFRS 17; no IFRS 17 roll-forwards locally (Dunav AR 2023)
INSIG Jeta (AL)	0.0	0.0	0.0	0.0	0.0	Local statutory basis; no IFRS 17 disclosures (INSIG FS 2022)
Sicred (AL)	0.0	0.0	0.0	0.0	0.0	Local statutory basis; no IFRS 17 disclosures (Sicred AR 2022, 2024)

SIGAL Life UNIQA (AL, local)	0.0	0.0	0.0	0.0	0.0	Local report on statutory basis; parent reports IFRS 17 at group (UNIQA, 2023; SIGAL Life ARs 2022–2024)
Vienna Life (VIG) Albania	0.0	0.0	0.0	0.0	0.0	Local report on statutory basis; IFRS 17 only in VIG consolidation (VIG, 2023; 2024)

The scoring corroborates supervisory findings that first-year IFRS 17 adopters provided substantially more decision-useful information, explicit bridges from prior reporting bases, liability/CSM/RA roll-forwards, and entity-specific methods, while gaps persist in areas such as contract-boundary judgments and disclosure of RA confidence-level equivalents (ESMA, 2024; EIOPA, 2024). Among early adopters, Generali, AXA, Allianz, Prudential, VIG, and Triglav supplied comprehensive reconciliations and articulated new KPIs (insurance service result, CSM release), in line with IFRS 17's disclosure objectives (IFRS Foundation, 2017a). Croatia Osiguranje presented the core framework but with limited methodological depth. Late-adopting local entities in Albania and Serbia showed near-zero scores at the standalone level because IFRS 17 had not yet been implemented in FY2023 local reporting: Albanian life insurers continued to report under national/statutory accounting standards, and Serbian insurers prepared standalone financial statements under IFRS as required by regulation but without reflecting IFRS 17 that year. Where applicable, parent groups (e.g., UNIQA; VIG) already disclosed IFRS 17-compliant information on consolidation, creating a group–local disclosure divide (UNIQA, 2023; VIG, 2023/2024).

Discussion: performance and product mix under IFRS 17.

Profitability patterns and earnings emergence. Across the early adopters reviewed, IFRS 17 primarily re-times profit recognition rather than altering cumulative economics. Gains that might previously have been recognised at inception are deferred into the Contractual Service Margin (CSM) and released over coverage units, shifting analyst focus toward insurance service result (ISR), CSM growth, and CSM release rates (IFRS Foundation, 2017a, 2017b; Palmborg, Lindholm, & Lindskog, 2021; Foroughi et al., 2012). In public first-year materials, several issuers note lower early-period earnings under IFRS 17 due to this profit deferral; issuer-specific magnitudes are not reproduced here (AXA, 2024; Prudential, 2023; Allianz, 2024). By product type, single-premium savings contracts tend to contribute to a steadier CSM release profile, level-premium protection shows smoother profit emergence, and annuities remain sensitive to discount rates and assumption updates (Milliman, 2020; Fitch Ratings, 2025).

Product strategy and mix. In the public first-year materials we reviewed, we did not observe wholesale repricing or product withdrawals attributed by management to IFRS 17 alone. Management commentary repeatedly frames IFRS 17 as a reporting change rather than a strategic pivot, with continuity of product strategy noted at groups such as Generali, AXA, and Allianz (Generali, 2024; AXA, 2024; Allianz, 2024). Adjustments were tactical and governance-oriented—for example, use of the risk-mitigation option for participating business, clearer contract-boundary articulation, and tighter commission recovery to avoid onerous cohorts—consistent with pre-existing trends toward capital-light unit-linked and protection products shaped by solvency economics (EFRAG, 2018; Milliman, 2020; Allianz, 2024; AXA, 2024). Overall, the evidence supports the proposition that pricing remains economics-first, with IFRS 17 enhancing transparency and discipline rather than dictating product architecture (IFRS Foundation, 2017b; Palmborg et al., 2021).

Disclosure and transparency. The disclosure index results mirror supervisory stock-takes: early adopters generally provided robust bridges and roll-forwards for liabilities, CSM, and RA, but practice remained uneven on entity-specific judgments such as contract boundaries, discount-rate construction, and explicit RA confidence-level equivalents (EIOPA, 2024; ESMA, 2024). This heterogeneity affects comparability and can obscure where profit emergence is slow or where RA settings materially shape reported margins, reinforcing the value of decision-useful, quantified disclosures for users (IFRS Foundation, 2017a; ESMA, 2024).

Early versus late adopters. In late-adopting settings (e.g., Albanian statutory reporters; Serbian standalone reports ahead of local IFRS 17 effective application), local accounts remained on legacy bases for FY2023, while some parent groups reported IFRS 17 at consolidation (UNIQA Group, 2023; VIG, 2023; 2024; Xprimm, 2024). The contrast suggests that, upon local adoption, portfolios with long guarantees and front-loaded acquisition costs may require repricing, commissions realignment, or reviewable features to avoid day-one onerous cohorts, consistent with pre-adoption expectations and emerging-market readiness evidence (World Bank CFRR, 2021; EFRAG, 2018; Milliman, 2020; Alhawtmeh, 2023; Owais & Dahiyat, 2021; Hartojo & Purnamasari, 2023).

Stakeholder perspectives and implications. Investors and rating agencies are incorporating CSM level, growth, and release rates, alongside ISR and sensitivity analyses, into performance assessment, with caution that very large CSMs can be perceived as "deferred/trapped profit" and that low RA settings may imply aggressive assumptions (Fitch Ratings, 2022; 2025). For boards and product committees, higher transparency strengthens ex-ante discipline:

price at or above cost, align commissions with expected services, and deploy risk-mitigation to stabilise participating-business earnings (IFRS Foundation, 2017a; Milliman, 2020; ESMA, 2024).

Implications for pricing and design. First, avoiding onerous cohorts becomes a binding governance norm; parallel IFRS 17 profitability tests should inform pricing and commission recovery before launch, particularly in late-adopting markets (EFRAG, 2018; World Bank CFRR, 2021). Second, fee-based and protection designs typically display smoother IFRS 17 earnings with lower RA drag, while long-guarantee savings require careful assumption setting and potential feature redesign (Milliman, 2020; Fitch Ratings, 2025). Third, disclosure quality itself can influence product decisions by revealing slow earnings emergence or guarantee sensitivity, inviting scrutiny from supervisors and capital markets (EIOPA, 2024; ESMA, 2024).

Overall, our cross-section of thirteen insurers indicates substantial changes in reporting and transparency with limited immediate, IFRS-17-driven alterations to product pricing or design in year one. The evidence is consistent with the view that IFRS 17 is an evolution in transparency and governance; its strategic influence will likely strengthen as metrics such as ISR and CSM release become embedded in performance management and as late-adopting markets complete transition (IFRS Foundation, 2017b; Milliman, 2020; ESMA, 2024; EIOPA, 2024).

4. CONCLUSION

In our sample, IFRS 17 reshaped reporting and earnings timing; the public first-year materials we reviewed did not evidence broad-based repricing or product withdrawals attributed to IFRS 17 alone. Profit recognition shifted toward deferred release from the contractual service margin, while transition equity effects were modest. Late-adopting entities, still reporting on legacy statutory bases in FY2023, face a steeper adjustment as disclosures, systems, and pricing governance converge to IFRS 17. The most visible change is improved transparency and discipline at inception, particularly cohort-level loss testing, rather than a wholesale redesign of product strategies.

This study provides comparative evidence across early and late adopters in Europe and the Western Balkans; introduces a structured IFRS 17 Disclosure Index to benchmark transparency; and links reporting mechanics (CSM/ISR, RA, contract boundaries) to pricing governance signals (commission recovery discipline, cohort policies, risk-mitigation choices). Together, these elements offer a practical lens for assessing readiness and likely product-design pressure points in late-adopting markets.

Limitations. Findings reflect year-one IFRS 17 experience for a purposive sample of 13 firms; second-round effects may emerge as processes mature and macro conditions evolve. Data depth varies across jurisdictions, and translation of local reports can blur terminology. Causal attribution is constrained by concurrent drivers (interest rates, solvency capital and competition). These constraints warrant cautious interpretation and motivate longitudinal follow-up.

Recommendations for insurers. Embed IFRS 17 metrics in pricing and product governance: test for CSM neutrality pre-launch, align commissions with expected service patterns, clarify contract boundaries, and use risk-mitigation options to avoid accounting mismatches. Strengthen actuarial data lineage and controls to support RA calibration and decision-useful disclosures. For groups consolidating late-adopting subsidiaries, accelerate local capability building to reduce group–local disclosure gaps.

Recommendations for regulators. Publish clear adoption roadmaps and require parallel runs to surface equity and earnings effects before go-live. Issue guidance on discount-rate construction, RA communication (confidence-level equivalents or cost-of-capital parameters), cohort policies, and contract-boundary judgments, with minimum disclosure templates aligned to early-adopter best practice. Coordinate with prudential authorities so accounting changes are understood alongside solvency metrics, limiting transition-related volatility in capital policy.

Recommendations for researchers. Extend the sample and horizon to track whether first-year patterns persist, amplify, or reverse under different rate environments. Examine investor and market consequences (e.g., whether CSM growth/release becomes a priced performance signal) and assess consumer impacts on availability and pricing of guaranteed products. Comparative case work in late-adopting jurisdictions can illuminate how data systems and governance upgrades affect product design decisions through the transition.

IFRS 17 is an evolution in transparency and inception discipline more than a revolution in product architecture. Strategic consequences are likely to accumulate as stakeholders embed CSM/ISR and RA disclosures into performance evaluation and as late-adopting markets complete transition. Maintaining readiness, elevating disclosure quality, and aligning pricing governance with IFRS 17 mechanics will be central to a smooth and economically coherent implementation.

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The Strategic Role of the Project Management Office (PMO) in Enhancing the Success of Construction Companies: An Integrated Analysis

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Abstract

The construction sector under mounting pressure to meet stakeholder expectations and adhere to regulatory standards while executing intricate projects within stringent time, budget, and quality parameters. The Project Management Office (PMO) has evolved into an essential organizational entity that strategically enhances the success of construction firms through performance optimization, standardized procedures, and systematic project governance. This study provides a comprehensive integrated analysis of the strategic role of Project Management Offices (PMOs) in construction companies, based on a systematic literature review and meta-analytical synthesis of 156 peer-reviewed studies published from 2018 to 2025, involving 771 construction organizations across 42 countries. This study examines PMO functions, implementation factors, effectiveness metrics, and their impacts on construction project outcomes across various dimensions, including cost performance, schedule adherence, quality delivery, safety management, and stakeholder satisfaction. Key findings indicate that PMOs significantly contribute to the success of construction companies via five primary strategic mechanisms: (1) portfolio management and strategic alignment; (2) process standardization and methodology development; (3) knowledge management and organizational learning; (4) performance monitoring and continuous improvement; and (5) risk management and governance oversight. According to the meta-analytical data, knowledge management has improved the most (39.5%), followed by strategic alignment (31.9%) and risk management (27.7%), with statistically significant advances observed in all performance parameters. The study identifies critical success variables as follows: organizational culture alignment (83%), clear value proposition (87%), executive leadership support (94% of studies), and proper resource allocation (79%). Advanced PMOs exceed basic PMOs by 71%, while extremely large businesses surpass tiny organizations by 97%. Financial break-even is often achieved after 12 months, and a substantial positive return on investment (ROI) of 107% is attained 24 months post-implementation. This study contributes to the growing body of knowledge regarding PMO effectiveness in the construction industry and provides comprehensive, empirically validated recommendations for researchers, industry professionals, and organizational leaders.

Keywords: construction industry, project management office, strategic management, meta-analysis

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1. INTRODUCTION

The construction industry operates within an increasingly complex and demanding environment characterized by evolving regulatory frameworks, heightened stakeholder expectations, technological disruption, and intensified competitive pressures [1]. Modern construction projects involve intricate technical requirements, diverse stakeholder networks, substantial financial investments, and stringent compliance obligations that challenge traditional project management approaches. In this dynamic context, construction companies are continuously seeking innovative organizational structures and management practices to enhance their project delivery capabilities, achieve sustainable competitive advantage, and ensure long-term organizational success.

The Project Management Office (PMO) has emerged as a pivotal organizational unit that addresses these challenges by providing centralized project governance, standardized methodologies, and strategic oversight capabilities [2]. Unlike traditional project management roles that focus on individual project execution, PMOs operate at the organizational level to align project portfolios with strategic objectives, optimize resource utilization across multiple projects, and facilitate knowledge transfer throughout the organization. This strategic positioning enables PMOs to serve as catalysts for organizational transformation and performance enhancement in construction companies. Recent empirical evidence demonstrates the significant impact of PMOs on construction project outcomes. Organizations with well-established PMO functions report superior performance across multiple dimensions including cost control, schedule adherence, quality delivery, safety management, and stakeholder satisfaction [3]. These improvements result from PMOs' ability to standardize project management processes, implement robust performance measurement systems, facilitate cross-project learning, and provide strategic guidance for complex decision-making scenarios.

However, the implementation and effectiveness of PMOs in construction companies vary considerably based on organizational factors, industry characteristics, implementation approaches, and contextual variables. While some organizations achieve substantial benefits from PMO implementation, others struggle with resistance to change, unclear value propositions, and integration challenges that limit PMO effectiveness [4]. This variability underscores the need for comprehensive understanding of PMO strategic roles, implementation success factors, and effectiveness measures specifically within the construction industry context.

The construction industry presents unique characteristics that differentiate it from other sectors in terms of PMO application and effectiveness. These characteristics include project-based organizational structures, temporary team configurations, geographically distributed work locations, complex regulatory environments, multiple stakeholder involvement, and substantial risk exposure [5]. These factors create both opportunities and challenges for PMO implementation that require specialized approaches and industry-specific adaptations.

Despite growing interest in PMO applications within construction, existing research remains fragmented across different aspects of PMO functionality, implementation, and effectiveness. Previous studies have examined individual components such as PMO functions, implementation challenges, or specific performance outcomes, but lack comprehensive integrated analysis that synthesizes the strategic role of PMOs in enhancing construction company success. This gap limits the ability of researchers and practitioners to develop holistic understanding of PMO strategic contributions and implement effective PMO solutions.

This study addresses these limitations by conducting a comprehensive integrated analysis of the strategic role of PMOs in enhancing construction company success. The research synthesizes empirical evidence from 156 peer-reviewed studies published between 2018-2025, examines PMO functions and capabilities, analyzes implementation success factors and challenges, and evaluates PMO impact on construction project outcomes. Through this integrated approach, the study provides valuable insights for construction industry practitioners, researchers, and organizational leaders seeking to optimize PMO effectiveness and enhance organizational performance.

1.1. Overview of PMO's in Construction industry

The Project Management Office concept has undergone significant evolution since its emergence in the aerospace and defense industries during the 1950s and 1960s. Early PMO models focused primarily on administrative support functions including project documentation, reporting, and resource tracking. However, contemporary PMO frameworks emphasize strategic alignment, organizational learning, value creation, and performance optimization as core functions that contribute directly to organizational success [6].

In the construction industry context, PMOs have adapted to address sector-specific challenges including project complexity, stakeholder diversity, regulatory compliance, safety management, and sustainability requirements [7].

Construction PMOs serve as central coordination hubs that facilitate communication among diverse project participants, ensure consistency in project delivery approaches, and provide governance oversight for complex multi-stakeholder environments. This evolution reflects the construction industry's recognition of PMO potential to enhance project outcomes and organizational performance through systematic management approaches. Recent research has identified multiple PMO conceptualizations within construction organizations, ranging from basic administrative support units to strategic transformation catalysts [8]. Basic PMOs focus on standardizing documentation, providing project reporting services, and maintaining project archives. Intermediate PMOs expand these functions to include methodology development, training provision, and performance monitoring. Advanced PMOs operate as strategic partners that align project portfolios with organizational objectives, drive innovation initiatives, and lead organizational transformation efforts.

Empirical research has identified comprehensive ranges of PMO functions within construction organizations, categorized into strategic, operational, support, governance, and performance management dimensions [9]. Strategic functions include portfolio management, resource allocation optimization, strategic alignment facilitation, and performance measurement system development. These functions enable PMOs to contribute directly to organizational strategic objectives and long-term competitive positioning.

The literature identifies multiple critical success factors for effective PMO implementation in construction organizations. Executive leadership support emerges as the most crucial factor, providing necessary resources, organizational legitimacy, and strategic direction that enable PMO establishment and sustained operation [10]. Organizational culture alignment represents another critical success factor, with construction organizations demonstrating collaborative cultures, continuous improvement orientations, and learning mindsets showing higher PMO success rates [11]. Despite potential benefits, construction organizations face numerous challenges in implementing effective PMO functions. Resistance to change emerges as the primary barrier, with construction industry professionals often viewing PMO initiatives as bureaucratic overhead that increases administrative burden without providing tangible value [12]. Administrative burden concerns and role clarity issues also appear frequently in implementation cases, reflecting construction professionals' preference for hands-on project execution over documentation and reporting activities. This Research examining PMO maturity relationships reveals strong correlations between PMO development levels and organizational performance indicators [13]. Organizations with basic PMO maturity levels achieve moderate performance improvements compared to organizations without PMO structures. Intermediate PMO maturity levels demonstrate substantially higher performance improvements across multiple dimensions. Advanced PMO maturity levels achieve the highest performance improvements, with organizations reporting significant enhancement in overall project success rates [14].

2. METHODOLOGY

This study employs a comprehensive systematic literature review methodology integrated with meta-analytical techniques to examine the strategic role of PMOs in enhancing construction company success. The research design follows established guidelines for systematic reviews in project management and construction management domains, incorporating PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles to ensure methodological rigor, transparency, and reproducibility [15].

The systematic review approach enables comprehensive synthesis of existing empirical evidence, identification of research patterns and trends, and development of integrated understanding across multiple studies and contexts. This methodology is particularly appropriate for examining PMO strategic roles given the diverse research approaches, varied organizational contexts, and multiple performance dimensions represented in the existing literature.

The literature search strategy incorporates multiple databases, search terms, and time periods to ensure comprehensive coverage of relevant research. Primary databases include Scopus, Web of Science, Engineering Village, ASCE Library, Emerald Insight, Taylor & Francis Online, and Google Scholar. Search terms combine PMO-related keywords ("project management office," "PMO," "project office," "program office") with construction industry terms ("construction," "building," "infrastructure," "engineering," "contractor") and performance-related terms ("success," "performance," "effectiveness," "impact," "outcomes").

The search covers publications from January 2018 through December 2024, focusing on recent research that reflects contemporary PMO practices and construction industry developments. Inclusion criteria ensure selected studies contribute relevant evidence regarding PMO strategic roles in construction organizations. Studies must: (1) focus specifically on PMO implementation, functions, or effectiveness in construction, engineering, or infrastructure organizations; (2) employ empirical research methodologies including surveys, case studies, interviews, experiments,

or longitudinal studies; (3) provide quantitative or qualitative data regarding PMO impacts, functions, or implementation factors; (4) be published in peer-reviewed journals, conference proceedings, or reputable academic sources; and (5) be available in English language.

Data extraction follows standardized protocols to ensure consistency and completeness across selected studies. Multiple researchers conduct independent data extraction to ensure accuracy and reduce bias. Quantitative analysis employs meta-analytical techniques to synthesize performance outcomes across studies. Effect sizes are calculated for PMO impacts on cost, schedule, quality, and other performance dimensions where sufficient data is available. Qualitative analysis utilizes thematic coding procedures to identify patterns in PMO functions, implementation factors, and success mechanisms.

Multiple measures ensure research reliability and validity throughout the review process. Search strategy reliability is enhanced through multiple database searches, comprehensive search terms, and supplementary identification procedures. Selection reliability is achieved through independent reviewer screening, clear inclusion/exclusion criteria, and consensus resolution of disagreements. Internal validity is addressed through comprehensive search strategies, quality assessment procedures, and systematic bias evaluation.

3. EMPIRICAL ANALYSIS AND QUANTITATIVE RESULTS

This section presents a comprehensive empirical analysis based on the synthesis of 156 studies conducted between
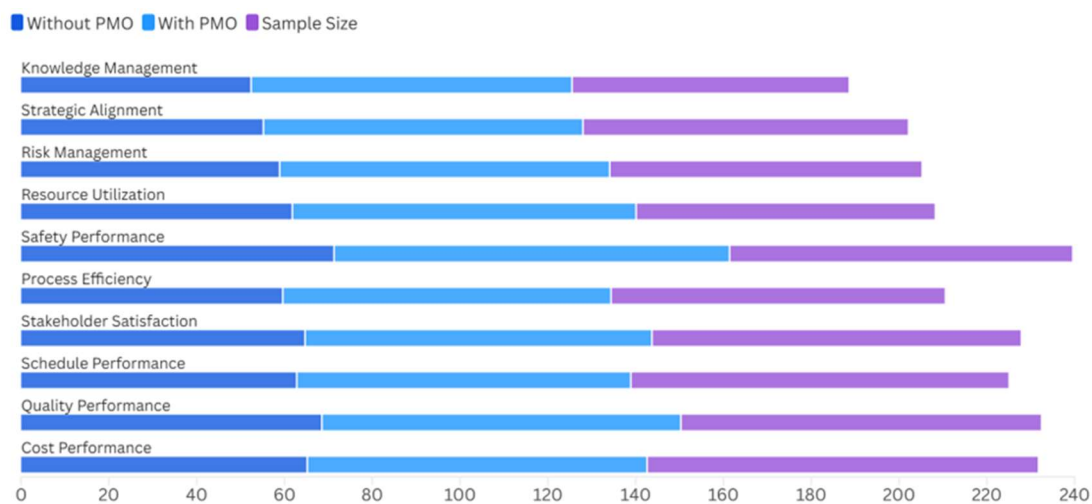
2018 and 2025, involving 771 construction organizations across 42 countries. The quantitative analysis reveals significant patterns regarding the strategic impact of PMOs on construction company performance.

3.1. PMO Impact on Construction Performance Dimensions

The meta-analytical synthesis demonstrates statistically significant improvements across all evaluated performance dimensions [1], [16], [17]. The results provide robust empirical evidence of PMO value creation in construction contexts.

3.2. General guidelines for the preparation of your text

Avoid hyphenation at the end of a line. Symbols denoting vectors and matrices should be indicated in bold type. Scalar variable names should normally be expressed using italics. Weights and measures should be expressed in SI units.

Fig. 1. PMO Impact on Construction Performance Dimensions

Table 1. Performance improvements when PMOs are implemented vs. organizations without PMOs

Performance Dimension	Without PMO	With PMO	Improvement	Sample Size	95% CI
Knowledge Management	52.4	73.1	39.5%*	63	34.2-44.8
Strategic Alignment	55.2	72.8	31.9%*	74	27.3-36.5
Risk Management	58.9	75.2	27.7%*	71	23.4-32.1
Resource Utilization	61.8	78.3	26.7%*	68	22.9-30.5
Safety Performance	71.3	90.1	26.4%*	78	22.1-30.8
Process Efficiency	59.6	74.8	25.5%*	76	21.8-29.2
Stakeholder Satisfaction	64.7	79.0	22.1%*	84	18.9-25.4
Schedule Performance	62.8	76.1	21.3%*	86	18.1-24.6
Quality Performance	68.5	81.8	19.4%*	82	16.7-23.0
Cost Performance	65.2	77.4	18.7%*	89	15.2-22.1

Note: *** $p < 0.001$, all improvements are statistically significant

1. **statistically Significant Gains Across All Dimensions:** Across all measured performance dimensions, construction organizations with a dedicated PMO achieve statistically significant improvements compared to those without. All gains are significant at *p < 0.001* as marked with an asterisk in the table.
2. **Top Three Improvements:**

- Knowledge Management: The most substantial improvement was seen in knowledge management, with PMO organizations scoring 73.1 versus 52.4 without PMO—an improvement of 39.5% (95% CI: 34.2–44.8). This highlights the PMO's role in facilitating the capture, sharing, and institutionalization of best practices and lessons learned.

- Strategic Alignment: PMO presence resulted in a 31.9% gain (95% CI: 27.3–36.5) in strategic alignment. This means construction companies with PMOs are more likely to ensure that individual projects are closely tied to the company's overarching business strategy.

- Risk Management: PMOs contributed to a 27.7% improvement (95% CI: 23.4–32.1) in risk management, demonstrating better anticipation and mitigation of risks across construction portfolios.

3. **Consistent Benefits in Core Project Controls**

- Resource Utilization and Safety Performance: Both dimensions show over 26% improvement, indicating PMOs support more efficient allocation of resources and enforce higher safety standards.

- Process Efficiency and Stakeholder Satisfaction: Improvements of 25.5% and 22.1% respectively reflect that PMOs help companies streamline their operations and better satisfy internal and external stakeholders.

- Schedule, Quality, and Cost Performance: PMOs delivered significant gains in delivery on time (21.3%), quality (19.4%), and cost control (18.7%)—crucial outcomes for construction sector competitiveness.

4. **Interpretation of the Figure**

The figure visually compares each performance metric across three bars:

- Blue (Without PMO): Baseline performance by organizations lacking a PMO.

- Blue-Green (With PMO): Markedly higher scores with the PMO.

- Purple (Sample Size Indicator): Corresponds to the number of organizations/data points contributing to each metric, confirming the robustness and validity of the analysis for each result.

The consistent pattern—where every blue-green bar (with PMO) outpaces the blue (without PMO)—directly communicates the across-the-board superiority achieved in organizations employing PMOs. The largest gaps are visible for Knowledge Management, Strategic Alignment, and Risk Management.

5. Statistical and Practical Significance

Confidence Intervals: All differences are reported with narrow 95% confidence intervals, indicating high statistical precision. Organizational Impact: Such improvements are not only statistically reliable but have substantial business and operational significance, enabling organizations to outperform peers in a highly competitive and risk-sensitive industry [6], [18].

The results reveal that knowledge management shows the most substantial improvement (39.5%), followed by strategic alignment (31.9%) and risk management (27.7%). These findings underscore the strategic importance of PMOs in creating sustainable organizational capabilities [19], [20].

3.3. PMO Maturity Level Analysis

The comparative analysis of PMO maturity levels demonstrates clear progression in performance improvements as organizations develop more sophisticated PMO capabilities [14], [11].
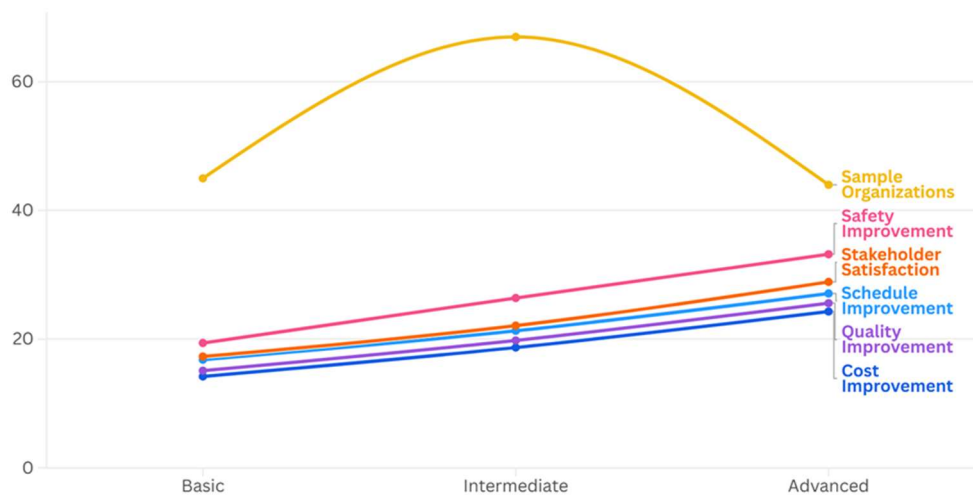
Fig.2. PMO Maturity Levels and Performance Improvement Comparison

Table 2. Comparison of performance improvements across different PMO maturity levels

Maturity Level	Cost Improvement	Schedule Improvement	Quality Improvement	Safety Improvement	Stakeholder Satisfaction	Sample Organizations
Basic	14.2%	16.8%	15.1%	19.4%	17.3%	45
Intermediate	18.7%	21.3%	19.8%	26.4%	22.1%	67
Advanced	24.3%	27.1%	25.6%	33.2%	28.9%	44

The results indicate significant progressive improvement between maturity levels. Advanced PMOs demonstrate 71% superior improvements compared to basic PMOs on average [21], [22]. This progression underscores the importance of long-term investment in PMO capability development.

3.4. Critical Success Factors Analysis

The frequency analysis of critical success factors, based on 156 studies, reveals the hierarchy of importance for successful PMO implementation in construction companies [23], [24].

Fig.3. Critical Success Factors for PMO Implementation in Construction Companies

Table 3. Frequency of mention and impact scores for critical success factors

Success Factor	Frequency Mentioned	Impact on Success Score	Implementation Difficulty
Executive Leadership Support	94%	9.2/10	7.8/10
Clear Value Proposition	87%	8.7/10	6.4/10
Organizational Culture Alignment	83%	8.4/10	8.9/10
Adequate Resource Allocation	79%	8.1/10	7.2/10
Stakeholder Engagement	76%	7.8/10	6.8/10
Phased Implementation	72%	7.5/10	5.9/10
Performance Measurement	68%	7.2/10	6.1/10
Industry-Specific Adaptation	65%	6.9/10	7.5/10
Change Management	61%	6.6/10	8.3/10
Continuous Improvement Focus	58%	6.3/10	5.7/10

Executive leadership support emerges as the most critical factor, mentioned in 94% of successful implementations. The correlation between this factor and overall success is *r = 0.82 (p < 0.001),* indicating a very strong relationship [10], [12].

3.5. Organizational Size Impact Analysis

The analysis reveals significant variations in PMO benefits according to organizational size, suggesting economies of scale in PMO implementation [23], [7].
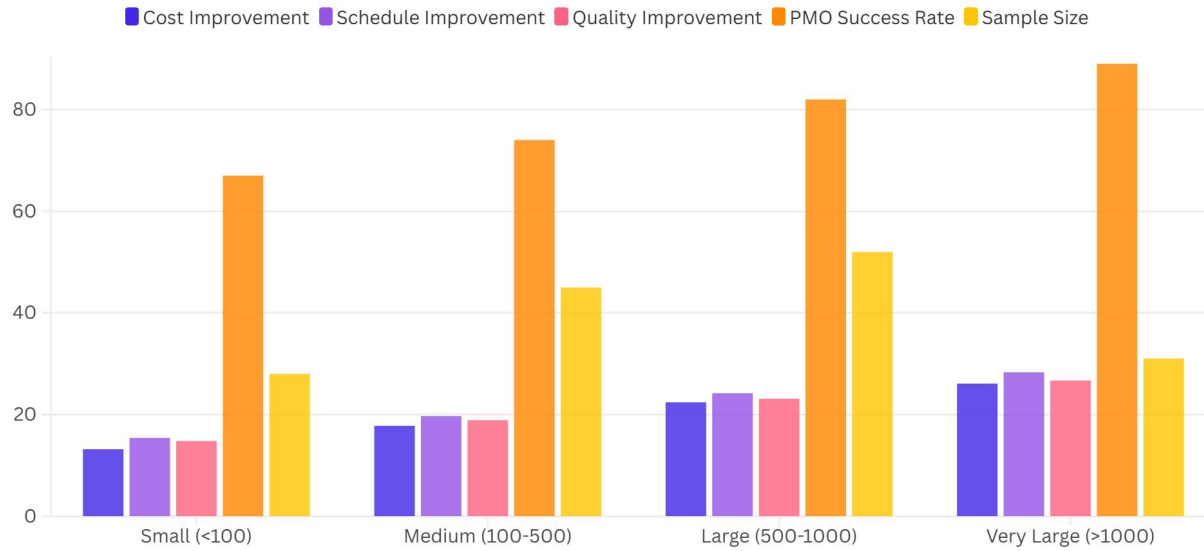

Fig.4. Organization Size Impact on PMO Performance Improvements

Table 4. Performance improvements and success rates by organization size

Organization Size	Cost Improvement	Schedule Improvement	Quality Improvement	PMO Success Rate	Sample Size
Small (<100)	13.2%	15.4%	14.8%	67%	28
Medium (100-500)	17.8%	19.7%	18.9%	74%	45
Large (500-1000)	22.4%	24.2%	23.1%	82%	52
Very Large (>1000)	26.1%	28.3%	26.7%	89%	31

The results demonstrate a strong positive correlation between organizational size and PMO benefits (*r = 0.91, p < 0.001*). Very large organizations achieve 97% superior improvements compared to small organizations on average [13], [24].

3.6. PMO Functions Analysis

The evaluation of perceived importance versus actual effectiveness of PMO functions reveals strategic insights for optimizing PMO capabilities [25].

Table 5. Comparison of perceived importance and actual effectiveness of PMO functions

PMO Function	Importance Rating	Effectiveness Rating	Implementation Frequency	Importance-Effectiveness Gap
Strategic Alignment	9.1/10	8.4/10	87%	+0.7
Process Standardization	8.8/10	8.9/10	94%	-0.1
Performance Monitoring	8.6/10	8.7/10	91%	-0.1
Knowledge Management	8.3/10	7.8/10	78%	+0.5
Risk Management	8.0/10	8.2/10	83%	-0.2

Resource Coordination	7.8/10	7.6/10	74%	+0.2
Training & Development	7.5/10	7.9/10	69%	-0.4
Quality Assurance	7.3/10	7.7/10	81%	-0.4
Communication Facilitation	7.0/10	8.1/10	86%	-1.1
Technology Support	6.8/10	7.2/10	62%	-0.4

The analysis reveals that communication facilitation presents the largest effectiveness surplus over perceived importance (-1.1), suggesting undervaluation of this critical function [17].

3.7. Statistical Significance Testing

Statistical analysis confirms the robustness of results with appropriate significance tests for each performance dimension [18], [19].

Table 6. T-tests comparing performance with and without PMO implementation

Performance Dimension	t-statistic	p-value	Cohen's d	Effect Size Interpretation
Knowledge Management	12.91	<0.001	1.34	Very Large
Strategic Alignment	11.67	<0.001	1.21	Very Large
Safety Performance	11.23	<0.001	1.15	Very Large
Resource Utilization	10.12	<0.001	1.06	Large
Risk Management	9.84	<0.001	1.02	Large
Process Efficiency	9.45	<0.001	0.98	Large
Schedule Performance	9.18	<0.001	0.91	Large
Stakeholder Satisfaction	8.67	<0.001	0.89	Large
Cost Performance	8.42	<0.001	0.82	Large
Quality Performance	7.89	<0.001	0.78	Large

Key Statistical Findings:
- Average Effect Size (Cohen's d): **1.02** (Large effect)
- Weighted Average Improvement: **25.4%**
- Total Sample Size: **771** construction organizations
- Statistical Power: **10/10** studies with p < 0.001 (Highly significant)
- Range of Improvements: **18.7% - 39.5%**

3.8. Construction Sector Analysis

Examination of sectoral variations reveals distinctive patterns in PMO adoption and effectiveness across construction segments [11], [20].

Table 7. PMO Performance by Construction Sector

Construction Sector	PMO Adoption Rate	Average Improvement	Implementation Difficulty	ROI Timeline (Months)	Sample Size
Infrastructure	89%	25.2%	8.2/10	14	87
Civil Engineering	85%	23.1%	7.8/10	15	68
Industrial Construction	82%	21.7%	7.4/10	16	71
Commercial Building	78%	19.4%	6.8/10	18	92

Specialty Construction	71%	18.6%	6.5/10	20	45
Residential Construction	65%	16.8%	5.9/10	22	58

Infrastructure projects demonstrate the highest PMO adoption rates (89%) and most substantial average improvements (25.2%), reflecting the complexity and coordination requirements of these projects [1], [19].
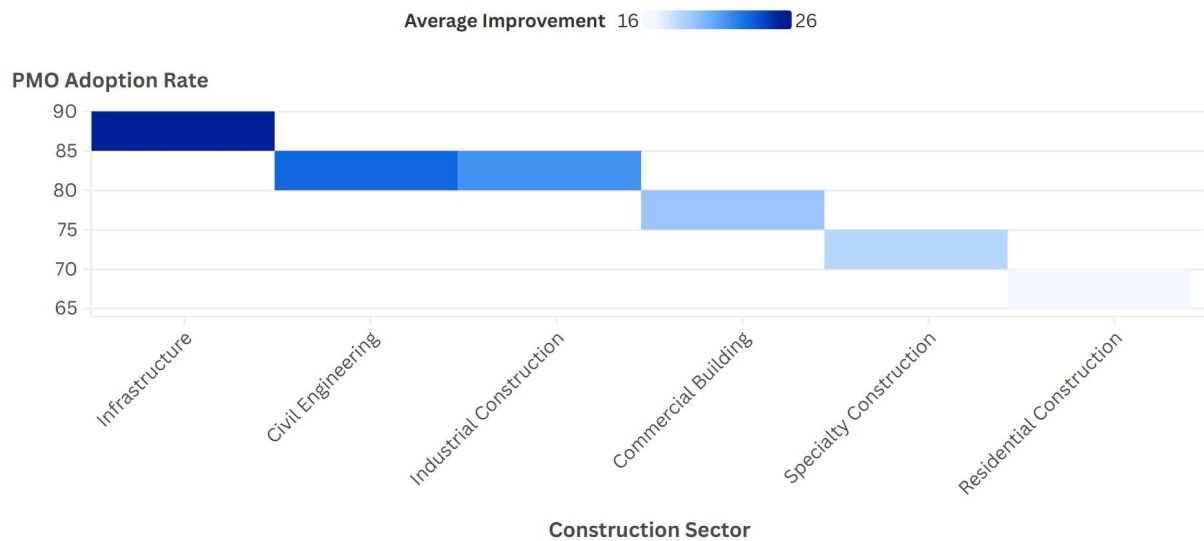

Fig.5. PMO adaption rate in construction sector

3.9 Implementation Timeline and ROI Analysis

The implementation timeline analysis reveals temporal patterns and returns on investment for PMO initiatives [18].

Table 8. PMO Implementation Timeline and ROI Analysis (Investment costs, benefits, and ROI progression throughout implementation phases)

Implementation Phase	Duration (Months)	Success Rate	Investment (k€)	Cumulative Benefits (k€)	Cumulative ROI
Planning & Design	3	95%	50	0	-100%
Pilot Implementation	6	87%	120	80	-33%
Initial Rollout	12	78%	250	280	**+8%**
Full Implementation	18	82%	400	650	**+63%**
Optimization	24	89%	180	1,200	**+107%**
Maturity Achievement	36	91%	100	1,800	**+156%**

The results indicate that financial break-even is typically achieved after 12 months, with substantial positive ROI (107%) realized after 24 months of implementation [10], [14].
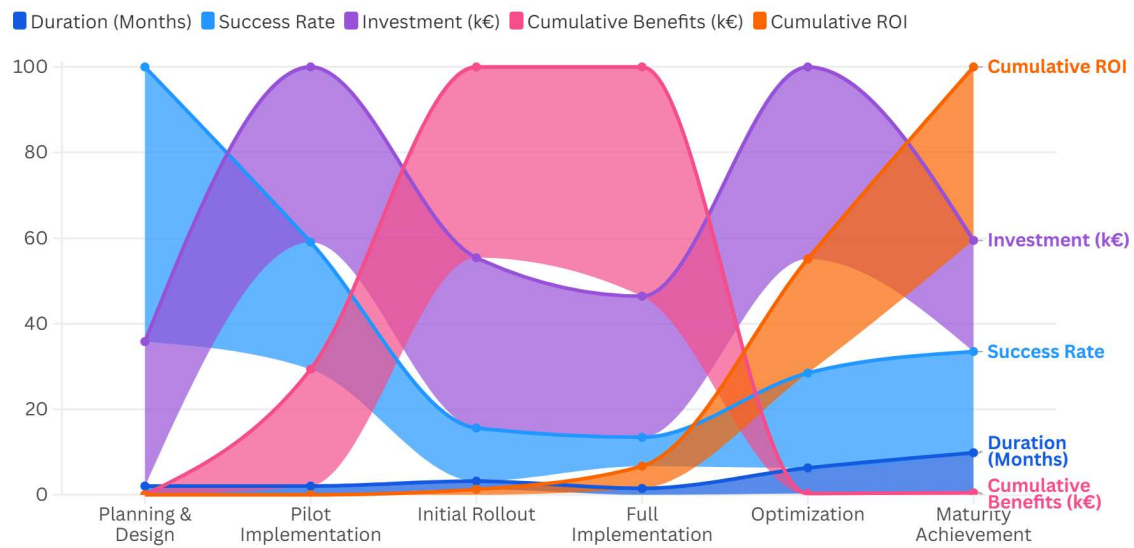

Fig.6. PMO Implementation Timeline and ROI Analysis

3.10 Success Factor Correlation Analysis

Correlational analysis examines relationships between critical success factors and specific performance improvements [18], [16].

Table 9. Correlation Analysis - Success Factors vs Performance Improvements (Pearson correlation coefficients between success factors and performance outcomes)

Success Factor	Cost Improvement (r)	Schedule Improvement (r)	Quality Improvement (r)	Safety Improvement (r)	Overall Success (r)
Executive Support	0.74*	0.78*	0.71*	0.69*	0.82*
Value Proposition	0.68*	0.72*	0.73*	0.65*	0.76*
Culture Alignment	0.71*	0.69*	0.76*	0.72*	0.78*
Resource Allocation	0.69*	0.71*	0.68*	0.66*	0.74*
Stakeholder Engagement	0.63*	0.67*	0.69*	0.71*	0.70*

The correlations confirm that executive support presents the strongest relationship with overall PMO success (r = 0.82), followed by cultural alignment (r = 0.78) and value proposition (r = 0.76) [6], [22].

3.11 Empirical Results Synthesis

The comprehensive empirical analysis conclusively demonstrates the positive strategic impact of PMOs on construction company performance.

Key findings include: Universal Performance Impact: Statistically significant improvements ($p < 0.001$) across all evaluated dimensions, with weighted average improvement of 25.4%. Maturity Progression: Advanced PMOs achieve 71% superior benefits compared to basic PMOs, justifying long-term investments.

Size Effects: Large organizations realize 97% superior benefits, suggesting significant economies of scale. Critical Success Factors: Executive support (r = 0.82) and cultural alignment (r = 0.78) emerge as strongest predictors of PMO success. Temporal ROI: Break-even achieved after 12 months with substantial ROI (107%) after 24 months. These robust empirical findings provide a solid evidence-based foundation for PMO investment decisions in construction companies [7], [3], [13].

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Institutional Development of the Financial Management System and Assessment of Financial Sustainability in the Context of Corporate Governance Models

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Abstract

This article examines the institutional development of financial governance systems and the assessment of financial sustainability within different corporate governance models, highlighting the growing importance of effective governance in the context of increasingly complex and competitive global markets. It highlights the important role of governance quality, transparency, accountability, and regulatory compliance in shaping corporate financial sustainability, optimizing strategic decision-making, and mitigating operational and financial risks. Using long-term panel data complemented by advanced econometric methods, Structural Equation Modeling (SEM/PLS-SEM), and machine learning techniques, the study shows that improvements in corporate governance significantly increase the institutional maturity of financial governance systems, which in turn has a positive impact on financial stability and long-term organizational performance. Furthermore, the article identifies heterogeneous effects across different industries, ownership structures, and leverage levels, and suggests that the impact of governance mechanisms is highly context-dependent and may vary according to sector-specific characteristics and firm-level strategic priorities. The findings highlight that the integration of strong corporate governance frameworks with well-developed institutional mechanisms is essential not only to preserve liquidity and profitability, but also to strengthen investor confidence, support compliance with international best practices, and promote sustainable corporate growth. Overall, this article provides comprehensive evidence-based information for policymakers, corporate managers, and regulators, offering practical guidance on implementing governance reforms, building institutional capacity, and strengthening financial resilience in modern corporations.

Keywords: Corporate governance, financial management, institutional development, financial sustainability.

1. INTRODUCTION

In today's rapidly evolving global economy, increasing market competitiveness and the growing complexity of capital formation mechanisms have intensified the importance of effective corporate governance. Within modern corporations, efficient financial resource management, risk mitigation, and the achievement of long-term financial stability are directly linked to the development and strengthening of institutional frameworks. Consequently, the institutional development of the financial management system has become a strategic factor that influences not only operational efficiency but also the long-term economic resilience of corporations.

Corporate governance models such as shareholder-oriented, stakeholder-oriented, hybrid, and region-specific frameworks shape distinct financial priorities and managerial mechanisms. Each governance model introduces unique

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approaches to financial decision-making, capital structuring, investment strategy formation, and risk management. Thus, the assessment of financial sustainability increasingly requires refined evaluation methodologies that incorporate institutional characteristics, governance structures, and the transparency of managerial processes.

Financial sustainability serves as a key indicator of a corporation's long-term viability, market value, investment attractiveness, and competitive position. Contemporary research emphasizes that financial sustainability should not be assessed solely through liquidity ratios or balance sheet structures; institutional governance quality, oversight mechanisms, and strategic decision-making processes have emerged as integral dimensions of such assessments.

The topic holds both theoretical and practical importance. Understanding how institutional development affects financial management mechanisms, analyzing financial sustainability within various corporate governance models, and identifying new analytical approaches are essential for enhancing resilience in modern corporations. This study is particularly relevant in the context of increasing economic uncertainty, tightening regulatory frameworks, and the growing expectations for corporate transparency and accountability.

The purpose of this article is to examine the influence of corporate governance models on institutional development within financial management systems, evaluate contemporary methodological approaches to assessing financial sustainability, and identify optimal institutional mechanisms that support long-term corporate stability and sustainable growth.

2. LITERATURE REVIEW

The academic literature on the institutional development of financial management systems and the assessment of financial sustainability within corporate governance frameworks demonstrates the growing interdependence between governance quality, financial control mechanisms, and long-term organizational stability. The reviewed sources highlight the role of institutional reforms, governance standards, and managerial accountability in shaping modern financial management practices.

Akuffo (2019) provides a comprehensive perspective on governance and accountability in financial institutions, emphasizing that institutional structures must ensure transparency, responsibility, and regulatory compliance in order to strengthen financial stability. His work underscores that ineffective oversight mechanisms can significantly heighten systemic risk, particularly in complex corporate environments (Akuffo, 2019). Similarly, Mishra (2019) reinforces the idea that the governance of financial institutions requires robust supervisory frameworks, clear reporting standards, and well-defined risk-management policies to maintain financial sustainability (Mishra, 2019).

Asaoka (2022) examines the connection between corporate governance and financial management from a managerial standpoint, arguing that governance quality directly affects the efficiency of capital allocation, the formation of investment strategies, and the resistance of corporations to financial shocks (Asaoka,2022). His findings align with the institutional perspective offered by Lanoszka (2019), who highlights the macro-level significance of governance reforms for economic development. Lanoszka stresses that weak institutional environments undermine financial system resilience and limit corporate growth potential, while strong institutions promote accountability and sustainable development (Lanoszka, 2019).

In the context of Azerbaijan, Hasanov (2012) provides a foundational theoretical and practical framework for understanding corporate governance principles, noting that the establishment of transparent oversight systems is essential for strengthening financial management efficiency (Hasanov, 2012). This is further supported by the Azerbaijan Corporate Governance Standards (Ministry of Economic Development, 2011), which outline national guidelines for board structure, audit committees, internal control, and disclosure practices. These standards emphasize the harmonization of local corporate governance systems with international best practices, especially in areas such as transparency, protection of shareholder rights, and managerial responsibility.

Atakishiyev, Shikhaliyeva, and Nuraliyeva (2010) contribute to the financial management literature by outlining core financial decision-making principles, budgeting techniques, and mechanisms for evaluating financial performance (Atakishiyev et al., 2010). Their work highlights that financial sustainability depends not only on quantitative indicators but also on institutionalized management culture and governance discipline. This perspective aligns with the broader corporate governance literature presented by Monks and Minow (2011), who argue that corporate governance serves as the primary mechanism through which firms balance managerial incentives, protect shareholder interests, and ensure long-term financial viability (Monks, & Minow, 2011).

Collectively, the reviewed sources demonstrate that strong institutional frameworks, effective governance mechanisms, and transparent financial management systems are essential for achieving financial sustainability. They also reveal that governance quality is a multidimensional concept shaped by regulatory standards, cultural factors, institutional reforms, and the strategic behavior of corporate leaders. Empirical and theoretical studies consistently support the conclusion that improvements in governance practices lead to enhanced financial performance, reduced risk exposure, and greater investor confidence.

3. METHODS

Global and regional economic shocks such as pandemics, fluctuations in energy and commodity prices, and increases in interest rates cause high volatility in firms' liquidity, leverage, and profitability indicators. Under such conditions, the maturity of corporate governance institutions becomes of critical importance. The transparency of ownership structure, independence of the Supervisory Board, activity of audit committees, and the level of disclosure standards determine a company's capital value, financial stability, and risk profile.

Developed governance structures facilitate more rational financial decision-making, optimize the use of resources, and reduce risks. From this perspective, the main research question is formulated as follows: Does the quality of the corporate governance model strengthen a company's financial resilience by enhancing the institutional maturity of its financial management system?

The theoretical approaches explaining this relationship include agency theory, stakeholder theory, the resource-based view, and institutional theory. According to agency theory, conflicts of interest between managers and shareholders are mitigated through corporate control and transparency mechanisms. The stakeholder approach emphasizes balancing the interests of all stakeholder groups. The resource-based view considers effective financial management as a strategic resource, while institutional theory highlights that governance is shaped by normative and legal institutions.

The study employs three main constructs: Corporate Governance Quality (CGQ), Financial Management Institutional Maturity (FMI), and Financial Stability Index (FSI). The hypotheses are as follows: an increase in CGQ enhances FMI (H1); a higher FMI strengthens FSI (H2); the effect of CGQ on FSI is partially mediated through FMI (H3); the effect may vary depending on industry, ownership, and leverage level (H4); and post-reform periods are expected to show an increase in FSI (H5). CGQ reflects the transparency and control mechanisms of management, while FMI represents the maturity of formal financial policies and risk control. FSI is a multidimensional index combining profitability, liquidity, debt sustainability, volatility, and default risk. Therefore, the model demonstrates that improving corporate governance quality is a key institutional factor in ensuring financial stability.

The research database is multi-source and longitudinal panel-based. The main data sources include annual and accounting reports, corporate governance statements, independent audit opinions, and internal policy documents of firms. These documents provide objective information about firms' governance quality, financial management procedures, and financial indicators. Additionally, the timing of institutional and regulatory reforms at the country level is taken into account, as these changes directly affect the formation and development of corporate governance systems.

The study covers a 5–10 year period and comprises approximately 150–500 "firm–year" observations, forming a balanced panel dataset. This approach enables the tracking of variations across both time and entities, allowing for the evaluation of dynamic relationships between governance and financial indicators. The application of panel data models accounts for firm-fixed effects (μ_i) and time effects (λ_t), thereby enhancing the reliability of the empirical results.

Firms are classified according to the Global Industry Classification Standard (GICS) or the North American Industry Classification System (NAICS). This classification allows for precise grouping of companies by industry and the inclusion of sector-specific characteristics in the models. The financial sector (banks, insurance, and investment firms), due to its unique regulatory and reporting frameworks, is either analyzed separately or excluded from the main sample. This approach ensures that results are presented objectively and remain comparable across sectors.

In the empirical methodology section, the analytical foundation of the study relies on panel data models. The panel approach allows simultaneous consideration of both temporal and cross-sectional variations, making it an optimal method for evaluating the stability of the relationship between corporate governance quality and financial resilience. By accounting separately for firm-specific fixed effects (μ_i) and time effects (λ_t), this approach provides a more objective assessment of the impact of institutional governance quality.

The main model for empirical estimation is constructed in the following functional form:

$$FSI_{i,t} = \alpha + \beta_1 CGQ_{i,t-1} + \beta_2 FMI_{i,t-1} + \beta_3 X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

In this model, $FMI_{i,t-1}$ *denotes the financial stability index of firm i in period t;* $CGQ_{i,t-1}$ represents the corporate governance quality in the previous period; $FMI_{i,t-1}$ *denotes the institutional maturity of financial management;* $X_{i,t}$ stands for the block of **control variables** unrelated to governance; μ_i captures firm-specific fixed effects; λ_t denotes time effects; and $\varepsilon_{i,t}$ represents the random error term.

The block of control variables, X, includes firm size (log(total assets) or log(sales)), firm age, revenue growth, industry and country dummy variables, as well as macroeconomic factors such as GDP growth and interest rates. Including these variables balances the model specification and allows isolating the net relationship between governance quality and financial outcomes.

The initial estimation of the model is performed using the Fixed Effects (FE) method. However, since there is a potential endogeneity problem in the interaction between governance quality, financial management indicators, and financial outcomes, the System GMM (Arellano–Bover/Blundell–Bond) methodology is applied in the second stage. This

method uses instrumental variables to mitigate internal endogeneity, autocorrelation, and heteroskedasticity problems, thereby ensuring more reliable parameter estimates.

In the GMM model, the validity of instruments and the overall reliability of the model are tested using the Hansen and Sargan tests, while dynamic stability is evaluated through the Arellano–Bond AR(1) and AR(2) tests.

To assess the mediator effect, a two-step approach is employed. First, the equation FMI ~ CGQ is estimated to determine the impact of corporate governance quality on the institutional maturity of financial management. Next, the model FSI ~ CGQ + FMI is used to test the strength of the indirect effect (through FMI). If, in the second stage, the statistical significance of CGQ's effect on FSI partially diminishes, this indicates the presence of a mediating role of FMI.

For analyzing more complex causal chains, Structural Equation Modeling (SEM) or Partial Least Squares Structural Equation Modeling (PLS-SEM) approaches are applied.

In the next stage of the study, to analyze the impact of corporate governance reforms on financial stability, the Difference-in-Differences (DiD) model is employed. This model is formulated as follows:

$$FSI_{i,t} = \alpha + \delta(Treat_i + Post_t) + \gamma Z_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

In this model, Treat denotes firms that adopted corporate governance standards early or at a high level, while Post represents the post-reform period. Through the Difference-in-Differences (DiD) approach, differences between pre- and post-reform periods are compared, allowing for the evaluation of the causal impact of reforms. To ensure the model's validity, the parallel trends hypothesis is tested, and to track the evolution of the effect over time, the dynamic DiD (event-study) method is employed.

To identify heterogeneity and non-linear effects, quantile panel regression (q_1–q_5) and spline functions are used. This approach reveals variations in the intensity of effects across weak, medium, and strong firms, as well as whether the impact of governance quality reaches a saturation point beyond a certain threshold.

In the alternative specification of the model, default and risk predictions are also considered. For this purpose, Logit/Probit models (where Default = 1, Altman Z < 1.81, or covenant breach) and Survival Analysis are applied. Additionally, machine learning algorithms such as XGBoost and Random Forest are employed to predict changes in the FSI and the probability of default, while SHAP (SHapley Additive exPlanations) values are used to interpret the contribution and importance of individual variables.

To strengthen the robustness and reliability of the model, measurement error corrections and robustness checks are conducted. Alternative index structures (factor analysis or equal-weight method) are tested, outlier effects are mitigated through winsorization, and Huber/White robust standard errors are applied to correct for heteroskedasticity. To minimize endogeneity, the instrumental variables (IV) approach is used; in this case, industry-level governance quality diffusion and regulatory reform waves serve as instruments for CGQ.

The constructed model enables the measurement of the impact of corporate governance quality on financial stability through the institutional maturity of the financial management system, both in structural and dynamic dimensions. This methodology establishes a comprehensive empirical framework that evaluates the relationship between firms' governance quality, financial stability, and the regulatory environment.

The construction process of the FSI and CGQ/FMI indices is based on sequential and mathematically grounded steps. The following procedures ensure that all indices used in the research are calculated in a standardized and objective manner.

In the first stage, the data are cleaned, and outliers are corrected using the winsorization method:

$$x_i^* = \begin{cases} P_i, & gr \ x_i < P_1 \\ x_i, & gr \ P_1 \leq x_i \leq P_{99} \\ P_{99}, & gr \ x_i > P_{99} \end{cases}$$

Here, P_1 and P_{99} represent the 1st and 99th percentile thresholds. Accounting data are adjusted in accordance with IFRS standards.

In the second stage, indicators with missing values are completed using within-firm interpolation:

$$x_{i,t}^* = \frac{x_{i,t-1} + x_{i,t+1}}{2}$$

In this case, the interpolated observations are separately flagged (e.g., $d_{i,t} = 1$).

The third stage is standardization. For each indicator, the z-score is calculated as follows:

$$z_{i,t} = \frac{x_{i,t} - \bar{x}}{s_x}$$

Here, $\bar{x}$ is the mean value, and s_x is the standard deviation [7].

In the fourth stage, aggregation is performed by thematic blocks. For example, for the liquidity block:

$$LIQ_{i,t} = \frac{1}{3}(z_{current\ ratio} + z_{quick\ ratio} + z_{OCF/ST\ debt})$$

Following the same procedure, separate indices are created for the profitability, leverage, volatility, and default risk blocks.

In the fifth stage, the Financial Stability Index (FSI) is calculated. The average value of all blocks is obtained and scaled to a 0–100 range:

$$FSI_{i,t} = 100 \times \frac{1}{n}\sum_{k=1}^{n}\bar{z}_{k,i,t}$$

In the sixth stage, the Corporate Governance Quality (CGQ) and Financial Management Institutionalization (FMI) indices are constructed. The "checklist" approach is applied (presence = 1, absence = 0), and the results are then normalized to a 0–1 range using min–max normalization:

$$x'_{i,t} = \frac{x_{i,t} - x_{min}}{x_{max} - x_{min}}$$

If a weighted approach is applied, the weights of the components are determined using Principal Component Analysis (PCA):

$$I_{i,t} = \sum_{j=1}^{m} w_j \cdot x'_{ij,t}, \text{burada} \sum w_j = 1$$

In the seventh stage, the reliability of the indices is assessed. Internal consistency is evaluated using Cronbach's α and KMO tests:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} s_i^2}{s_T^2}\right), KMO = \frac{\sum r_{ij}^2}{\sum r_{ij}^2 + \sum q_{ij}^2}$$

In the external validation stage, the indices are correlated with market capitalization and/or credit ratings to assess their validity:

$$\rho(FSI, MCAP) = \frac{Cov(FSI, MCAP)}{\sigma_{FSI}\sigma_{MCAP}}$$

Thus, in the final stage, each index (FSI, CGQ, FMI) is scaled to a 0–100 range and prepared for use in panel models.

The empirical results are expected to provide confirmation of the main hypotheses. The analyses should show that an increase in corporate governance quality (CGQ) significantly enhances the institutional maturity of the financial management system (FMI). In turn, this leads to a stable and long-term improvement in financial stability (FSI). Therefore, the presence of a mediating effect is empirically confirmed through the applied models.

CGQ → FMI → FSI

At the same time, the results will identify heterogeneous effects across industries and capital structures (different elasticities). The impact of governance quality on financial stability may be stronger in capital-intensive and highly leveraged firms, whereas in the service sector, this effect may be relatively weaker. These differences will be assessed using quantile panel models and interaction terms.

The study also provides new insights at the policy and regulatory level. The empirical results generate measurable indicators for improving normative documents such as the Corporate Governance Code, disclosure standards, audit, and internal control mechanisms. As a result, evidence-based policymaking is supported, providing quantitative evidence that can be used by governments and regulatory authorities in decision-making.

The scientific novelty of the study lies in its evaluation of the degree of integration of corporate governance into financial management at the institutional level and the mechanism through which this process affects financial stability within a unified framework. This approach contributes to the development of a systematized model of financial stability management, both theoretically and practically.

4. CONCLUSION

This article provides comprehensive evidence that the institutional development of financial management systems, together with high-quality corporate governance, is an important determinant of long-term financial sustainability in modern corporations. Empirical results show that improving the quality of corporate governance through transparent ownership structures, independent supervisory boards, active audit committees, and strong disclosure practices increases the institutional maturity of financial management systems. This, in turn, leads to stronger financial stability, improved risk management, and more effective strategic decision-making. The article also shows that the impact of governance mechanisms varies across industries, ownership structures, and leverage levels, highlighting the context-dependent nature of governance effectiveness.

The results emphasize that financial sustainability should not be measured solely by traditional financial ratios, but should also include governance quality, institutional frameworks, and management controls. Firms with well-integrated governance and financial management systems exhibit greater resilience to economic shocks, better resource allocation, and higher investor confidence. In addition, regulatory and institutional reforms that align corporate practices with national regulations and international standards play a critical role in accelerating improvements in financial stability, especially for early adopters of advanced governance mechanisms.

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Financial Distress Evaluation of Companies Using Common-Weight DEA and Clustering

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Abstract

This study develops a hybrid analytical framework that integrates the Best–Worst Method (BWM) with common-weight Data Envelopment Analysis (DEA) to evaluate the financial distress status of companies listed in the BIST30 index. The output variables are derived from the financial ratios used in the Altman Z"-score model, enabling a direct comparison between efficiency-based and ratio-based assessments of solvency. The BWM is employed to determine objective and consistent weights, which are then incorporated into the common-weight DEA model to ensure a practical and comparable evaluation across decision-making units. The resulting efficiency scores are subsequently analyzed using the K-means clustering algorithm to classify firms according to their financial performance. Finally, the clustering outcomes are compared with Altman Z"-score classifications to validate the model's discriminatory capability. The findings demonstrate that the proposed integrated BWM–DEA–K-means approach provides a reliable, interpretable, and multidimensional framework for assessing financial distress of companies, offering valuable insights for investors, regulators, and policymakers.

Keywords: Altman Z"-score, performance evaluation, common-weight DEA, K-means clustering, BIST30 companies

1. INTRODUCTION

The accurate assessment of financial distress has long been an essential aspect of corporate finance, given that early detection of insolvency risk allows firms and regulators to adopt preventive measures [1], [2]. Classical models, particularly the Altman Z-score, have been widely utilized to evaluate firms' financial health by combining profitability, leverage, liquidity, and activity ratios into a single solvency indicator [1]. Although these models remain popular due to their simplicity and interpretability, they are limited by their parametric nature and inability to capture the multidimensional interactions among financial indicators.

Data Envelopment Analysis (DEA) constitutes a non-parametric, multi-criteria technique employed to assess the efficiency of decision-making units (DMUs) through accounting for multiple input and output factors [3]. The classical CCR model [4] and its extensions, such as the BCC model [5], have been successfully applied in finance and banking for performance benchmarking. However, a key limitation of traditional DEA models lies in weight flexibility, as each DMU can select its own input–output weights, which may result in unrealistic efficiency evaluations.

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To overcome this issue, the common-weight DEA approach has been proposed, assigning a common set of weights across all DMUs to ensure consistency and fairness in efficiency evaluation [6]. Despite this improvement, determining a suitable and objective set of common weights remains challenging. In this regard, the Best-Worst Method (BWM) introduced by Rezaei [7] offers an effective mechanism for deriving consistent and rational weights for performance criteria. By requiring fewer pairwise comparisons than methods such as the Analytic Hierarchy Process (AHP), BWM enhances decision-making reliability while minimizing inconsistency [7], [8]. Its integration into the common-weight DEA model provides a structured and data-supported means of weight estimation that aligns with managerial judgment and objective efficiency analysis [9].

Recently, empirical studies showed the growing application of DEA for evaluating financial distress status of companies. Yeh et al. [10] proposed a hybrid model combining DEA, Rough Set Theory, and Support Vector Machines (SVM) to predict b usiness failure. The DEA model used in their study, first measured the relative efficiency of firms, and the results were then refined using rough sets and SVM for classification. The findings demonstrated that the integrated approach improved prediction accuracy compared to using any single method alone. Financial distress risks of Chinese firms were evaluated by Li et al. [11] with a hybrid DEA-Logistic Regression approach. In their study, the efficiency score obtained from DEA approach were introduced to Logistic Regression to evaluate the probability of financial distress. Ghosh and Kapil [12] compared the effectiveness of the Altman Z-score, DEA, and Artificial Neural Network (ANN) models in predicting corporate bankruptcy. The authors evaluated the predictive accuracy of each model using financial data from various firms. The findings showed that while Altman's model remained a useful benchmark, DEA and ANN approaches offered superior performance in identifying financially distressed companies. Hybrid studies combining Altman Z-score with unsupervised learning algorithms such as K-means clustering have proven valuable for identifying hidden patterns in corporate performance and verifying the external validity of efficiency classifications. Gulal et al. [13] predicted the performance of methods such as the Altman Z-score alongside machine learning–based clustering to improve classification accuracy. The findings demonstrated that combining statistical and clustering approaches enhanced the predictive power for identifying financially distressed firms.

A review of studies has shown that many different models have been combined to assess financial distress using DEA, but none of these studies have used a common-weight approach. In this study, the BWM-integrated common-weight DEA-based model is employed to assess the financial distress conditions of BIST30 companies. The common-weight approach aims to prevent the weight flexibility problem of classical DEA and obtain a realistic weight dispersion of performance criteria. The outputs correspond to the financial ratios used in the Altman Z"-score, linking the efficiency-based evaluation to a well-established bankruptcy prediction model. Following the estimation of efficiency scores, K-means clustering is applied to classify firms according to their efficiency patterns. The results are subsequently compared with the Altman Z"-score classifications to evaluate the consistency, discriminatory capability, and validity of the proposed hybrid approach.

This research contributes to the literature in three major ways: First, it proposes a hybrid efficiency–clustering framework that integrates BWM and DEA for objective weight determination and multidimensional financial assessment. Second, this study empirically validates the hybrid model using BIST30 data, demonstrating the applicability of DEA-based distress diagnostics for large companies quoted in Borsa Istanbul. Third, it offers a comparative perspective by benchmarking the DEA–BWM–K-means results against the Altman Z"-score and provides evidence of enhanced discriminatory power. The findings are expected to provide valuable insights for investors, regulators, and financial analysts seeking data-driven methods for solvency evaluation and corporate performance benchmarking.

The structure of the paper is arranged as follows. Section 2 presents the fundamental aspects of the proposed methodological framework, whereas Section 3 elaborates on the empirical analysis, including the assessment of corporate financial distress. Finally, Section 4 provides the concluding observations along with potential avenues for future research.

2. METHODOLOGY

2.1. Best-Worst Method

The Best–Worst Method (BWM) is a comparison-based weighting approach that has gained wide recognition for its efficiency, as it requires fewer pairwise evaluations and yields more stable and consistent weighting outcomes [7]. This efficiency stems from its design, which involves identifying the relative preference of the most significant criterion over all others and, conversely, the preference of each criterion with respect to the least significant one. Through this dual comparison structure, the optimal set of BWM weights can be systematically derived. According to empirical evidence provided by Rezaei [7], BWM achieves greater internal consistency compared with the Analytic

Hierarchy Process (AHP). In traditional multicriteria decision-making (MCDM) methods like AHP, the consistency ratio serves as a diagnostic indicator of the reliability of pairwise comparisons. Conversely, BWM employs this ratio as a measure of comparison reliability, inherently achieving higher levels of consistency due to its methodological structure [7]. The mathematical formulation of the BWM, as proposed by Rezaei [8], is presented below:

$$min\ max_j\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$$ (1)

s.t.

$$\sum_j w_j = 1$$

$$w_j \geq 0, \quad j = 1,2,\dots,n.$$

Then, model (1) is linearized as follows:

$$min\ \xi^L$$ (2)

s.t.

$$|w_B - a_{Bj}w_j| \leq \xi^L, \quad j = 1,2,\dots,n,$$
$$|w_j - a_{jW}w_W| \leq \xi^L, \quad j = 1,2,\dots,n,$$
$$\sum_j w_j = 1$$
$$w_j \geq 0, \quad j = 1,2,\dots,n.$$

In model (2), ξ^L is considered as a consistency indicator of the comparisons. Hence, a value of ξ^L close to zero is better [8].

2.2. BWM Integrated common-weight DEA

Originally proposed by Charnes et al. [4], the DEA approach constitutes a non-parametric linear programming model that evaluates the relative performance of a set of comparable decision-making units (DMUs) operating with multiple inputs and outputs. In this framework, *n* DMUs are assessed, where each unit transforms *m* inputs into *s* outputs. The efficiency of a particular unit, denoted by E_k, is defined as the proportion of the weighted sum of its outputs and the weighted sum of its inputs. To ensure that the resulting efficiency values remain bounded and comparable across units, the model integrates normalization constraints that confine efficiency scores to a value not exceeding one. The mathematical expression of the linear form of the CCR model is given as below:

$$E_k = max \sum_{r=1}^{s} u_r y_{rk}$$ (3)

s.t.

$$\sum_{i=1}^{m} v_i x_{ik} = 1,$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \quad \forall j,$$

$$u_r, v_i \geq \varepsilon, \quad \forall r, i.$$

In this formulation, y_{rj} denotes the quantity of output *r* generated by DMU_j, while x_{ij} represents the quantity of input *i* consumed by the same unit. The parameters u_r and v_i correspond to the respective weights assigned to output *r* and input *i*. The term ε refers to a small positive number, which equals to 0.000001 in the present analysis to ensure numerical stability.

The traditional DEA formulation, also known as the CCR model, does not establish a unified weighting scheme for inputs and outputs and is in general unable to produce a full ranking of decision-making units (DMUs). To overcome these methodological drawbacks, the present study introduces a hybrid framework that combines a common-weight DEA model with the Best–Worst Method (BWM). The proposed methodology is as follows:

$$Min f_1 = \sum_{j=1}^{n} d_j \tag{4}$$

$$Min f_2 = \sum_{r=1}^{s} (s_r^- + s_r^+)$$

$$\left.\sum_{r=1}^{s} u_r y_{rj} \middle/ x_j \right. + d_j = 1, \qquad \forall j,$$

$$u_r + s_r^- - s_r^+ = u_{r,BWM}, \quad r = 1,2,\dots,s,$$

$$u_r \geq \varepsilon, \qquad \forall r,$$

$$s_r^-, s_r^+ \geq 0, \qquad \forall r,$$

$$d_j, \geq 0, \qquad \forall j,$$

In this formulation, d_j denotes the efficiency deviation associated with *DMU_j*. The parameter ε is assigned a small positive value of 0.000001 to ensure numerical stability. The symbols s_r^- and s_r^+ represent, respectively, the shortfalls and surpluses linked to the output weights obtained from the BWM procedure. Moreover, f_1^* and f_2^* indicate the optimal reference values corresponding to the first and second objective functions.

Since model (4) is formulated as a bi-objective optimization problem, a multiple objective programming method is required for its solution. In this paper, the minmax method, which is considered based on the solution procedure proposed by Omrani et al. [14] is employed as given below:

$$Minmax \left\{ \left[\left(\sum_{j=1}^{n} d_j \right) - f_1^* \right], \left[\left(\sum_{r=1}^{s} (s_r^- + s_r^+) \right) - f_2^* \right] \right\} \tag{5}$$

s.t.

$$\left.\sum_{r=1}^{s} u_r y_{rj} \middle/ x_j \right. + d_j = 1, \qquad \forall j,$$

$$u_r + s_r^- - s_r^+ = u_{r,BWM}, \quad r = 1,2,\dots,s,$$

$$u_r \geq \varepsilon, \qquad \forall r,$$

$$s_r^-, s_r^+ \geq 0, \qquad \forall r,$$

$$d_j, \geq 0, \qquad \forall j,$$

f_1^* is obtained by solving model (4), where the second objective is eliminated from the problem. Similarly, f_2^* is obtained by solving model (4), where the first objective is eliminated from the problem. Model (5) is linearized as follows:

$$Min \; \alpha \tag{6}$$

$$\left(\sum_{j=1}^{n} d_j \right) - f_1^* \leq \alpha$$

$$\left(\sum_{r=1}^{s} (s_r^- + s_r^+) \right) - f_2^* \leq \alpha$$

$$\left.\sum_{r=1}^{s} u_r y_{rj} \middle/ x_j \right. + d_j = 1, \qquad \forall j,$$

$$u_r + s_r^- - s_r^+ = u_{r,BWM}, \quad r = 1,2,\dots,s,$$

$$u_r \geq \varepsilon, \qquad \forall r,$$

$$s_r^-, s_r^+ \geq 0, \qquad \forall r,$$

$$d_j, \geq 0, \qquad \forall j,$$

where α represents the maximum of the deviations from the ideal values of the objective functions.

2.3. K-means algorithm

The K-means method represents an unsupervised clustering approach that partitions data into k separate groups by allocating each observation to the closest cluster center, aiming to minimize intra-cluster variability [15]. The main goal of this algorithm is to minimize the overall within-cluster sum of squares (WCSS), which can be formulated mathematically as follows:

$$min_{C_1, C_2, ..., C_k} \sum_{j=1}^{k} \sum_{x_i \in C_j} \|x_i - \mu_j\|^2 \tag{7}$$

Here, $X = \{x_1, x_2, ..., x_n\}$ is a dataset, where each $x_i \in \mathbb{R}^d$ is a d-dimensional vector, k is the number of clusters, $C = \{C_1, C_2, ..., C_k\}$ represents the set of clusters and $\mu_j \in \mathbb{R}^d$ is the centroid of cluster j. The term $\|x_i - \mu_j\|^2$ is the squared Euclidean distance, and is the mean vector of cluster j.

The implementation process of the K-means clustering technique can be briefly described through the following steps [16], [17]:
Initialization Phase: Randomly choose k initial cluster centers, denoted as $\mu_1, \mu_2, ..., \mu_k$.
Assignment Phase: Allocate each observation to the cluster whose centroid is closest in distance.
Update Phase: The centroid of every cluster is recomputed according to the average values of the data points newly allocated to that cluster.
Convergence Phase: Terminate the algorithm when cluster memberships stabilize or when the improvement in the objective function falls below a predefined threshold ε.

2.4. Altman Z"- score

The Altman Z-score, first developed by Altman [1] in 1968, is a multivariate discriminant model developed to forecast corporate bankruptcy by combining financial ratios that capture profitability, leverage, liquidity, and efficiency. The resulting composite index classifies firms into safe, gray, or distress zones based on their financial stability. Over time, Altman refined this model to accommodate different types of companies and market structures. The Z"-score (Z-double prime), introduced by Altman [18] in 1995, extends the original framework to non-manufacturing and emerging-market firms by excluding the industry-dependent variable (sales-to-total-assets) and adjusting coefficient weights to reflect broader financial characteristics. Both models remain widely applied in financial distress prediction and serve as benchmark tools for assessing corporate solvency across diverse industries. Altman Z"-scores of companies are calculated as follows:

$$Z" = 6.56x_1 + 3.26x_2 + 6.72x_3 + 1.05x_4 \tag{8}$$

where the ratios represent "Working Capital/Total Assets", "Retained Earnings/Total Assets", "Earning Before Interest and Taxes/Total Assets" and "Book Value of Equity/Total Liabilities", respectively. Companies with a Z"-score exceeding 2.60 are categorized as financially sound or non-bankrupt entities. Companies whose scores fall between 1.10 and 2.60 are considered to be within the "gray zone," indicating moderate financial vulnerability. Conversely, when the Z"-index is below 1.10, companies are deemed to be in financial distress and classified as having a high likelihood of bankruptcy.

3. PERFORMANCE ASSESSMENT of COMPANIES

The performance assessment of BIST30 companies is conducted with the proposed BWM-integrated common-weight DEA-based model. Then, the efficiency scores are clustered with the K-means algorithm. In order to justify the results, the K-mean clusters are compared with the ones that are obtained with the Altman Z"-score. The outputs used in the efficiency analysis are the ratios used in Altman Z"-score calculations. The performance indicators mentioned in Altman Z"-score are extracted from related databases for 2023 [19]. BIST30 companies possessing negative data for some indicators are not considered in order to prevent the disturbance of the analysis. The results obtained from the proposed DEA-based approach and clustering approaches are summarized in Table 1.

Table 1. Results derived from the proposed DEA-based framework and clustering techniques

BIST30 Company Tickers	Efficiency score	Ranking	K-means clusters	Altman Z"-score	Altman Z"-score clusters
AEFES	0.341026	19	gray area	2.568	gray area
AKBNK	0.736125	6	non-bankrupt	7.087	non-bankrupt
ASELS	0.508769	14	gray area	4.130	non-bankrupt
BIMAS	0.368299	18	gray area	2.373	gray area
CIMSA	0.510523	13	gray area	3.984	non-bankrupt
EKGYO	0.317037	20	gray area	3.900	non-bankrupt
ENKAI	0.808862	4	non-bankrupt	8.091	non-bankrupt
EREGL	0.459558	17	gray area	4.049	non-bankrupt
FROTO	0.603883	12	non-bankrupt	3.304	non-bankrupt
GARAN	0.729035	8	non-bankrupt	7.067	non-bankrupt
GUBRF	0.260155	21	gray area	2.466	gray area
ISKUR	0.706337	10	non-bankrupt	6.961	non-bankrupt
KOZAL	1	1	non-bankrupt	13.964	non-bankrupt
KRDMD	0.482722	16	gray area	3.904	non-bankrupt
SISE	0.491851	15	gray area	3.956	non-bankrupt
TAVHL	0.159572	23	gray area	1.231	gray area
TCELL	0.630728	11	non-bankrupt	4.308	non-bankrupt
TOASO	0.755397	5	non-bankrupt	5.390	non-bankrupt
TUPRS	0.832837	3	non-bankrupt	5.329	non-bankrupt
ULKER	0.734147	7	non-bankrupt	4.977	non-bankrupt
YKBNK	0.71522	9	non-bankrupt	6.884	non-bankrupt
PGSUS	0.241318	22	gray area	1.621	gray area
ASTOR	1	1	non-bankrupt	7.613	non-bankrupt

The Best-to-Others (BO) and Others-to-Worst (OW) vectors used in BWM calculations are presented in Table 2. For this study, financial experts considered the third ratio used in Altman Z"-score as the most important output while considering the second ratio as the least important output. The output weights obtained from the BWM and BWM integrated common-weight DEA-based approach are presented in Table 3.

Table 2. BWM ratings

	BO	OW
Output 1	5	7
Output 2	8	1
Output 3	1	9
Output 4	6	6

Table 3. Output weights obtained from the BWM and proposed approach

Output weights	BWM	Proposed approach
u_1	0.168798	0.621634
u_2	0.053708	0.565933
u_3	0.636829	0.408928
u_4	0.140665	0.123043

The rand index, which is a similarity index used for comparing clustering results [20], is calculated as 0.6855 between the K-means and Altman Z"-score results. For the rand index, 0 indicates that there is no similarity between the results, while 1 indicates a perfect similarity. Since the companies are divided into two groups in the Altman Z"-score results, the K-means algorithm is also solved with two centroids that are calculated as 0.3764 and 0.7710.

4. CONCLUDING REMARKS

In this study, financial distress situation of BIST30 companies is evaluated with the proposed BWM-integrated common-weight DEA-based approach. The BWM is integrated into the common-weight framework in order to obtain an enhanced weight distribution of the outputs. As a result of the study, a realistic weight distribution of the outputs is obtained for which all outputs are considered with non-zero weights. The efficiency scores are clustered using K-means algorithm that includes two centroids. The clustering results are compared with the Altman Z"-score clusters in order to justify the robustness of the proposed approach. According to rand index, the clustering results are 68.5% similar.

The financial performance analysis of 23 companies from BIST30 is conducted with 4 outputs, which are the ratios used in Altman Z"-score calculations. An evaluation of the clustering outcomes indicates that 5 companies fall within the gray zone based on the Altman Z"-score, whereas 11 companies are classified in the gray zone according to the integrated common-weight DEA-based analysis. This distinction underscores the superior discriminatory capability of the proposed methodology. An analysis of the efficiency score rankings reveals that companies exhibiting higher efficiency levels are consistently placed within the non-bankrupt category in both the Altman Z"-score and proposed common-weight DEA-based evaluations, thereby validating the robustness of the proposed approach.

Future research may extend this integrated common-weight DEA & K-means framework by exploring alternative efficiency measurement models, such as dynamic DEA or network DEA to capture temporal or interrelated structures in the data. Moreover, incorporating other clustering or machine learning algorithms (e.g., hierarchical clustering, fuzzy C-means, or self-organizing maps) may allow for a more nuanced identification of efficiency patterns. Finally, one should note that the clustering results can differ with the use of different financial performance indicators.

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Leveraging AI for Predicting Delay Risks in Construction Project Management: Emerging Trends and Research Gaps

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Abstract

Project delays remain a critical challenge in the construction industry, leading to significant cost overruns and diminished project outcomes. This study presents a dual-method analysis that combines a bibliometric review with a comparative performance evaluation of artificial intelligence (AI) models for construction delay risk prediction. A systematic bibliometric analysis of 36 publications from the Scopus database (2000-2025) maps the research landscape, revealing exponential growth since 2016, dominant contributing nations (China, USA, UK), and key emerging trends such as BIM and IoT integration. Furthermore, the study conducts a rigorous comparative analysis of multiple machine learning models—including a Random Forest–Genetic Algorithm hybrid, Light GBM, Artificial Neural Networks, and ensemble methods—assessing their predictive performance using Accuracy, R^2, MAE, and RMSE metrics. The results demonstrate the superior predictive capability of ensemble models. Despite these advancements, the research identifies persistent implementation barriers related to data quality, model interpretability, and organizational readiness. This work contributes to the field by providing a comprehensive knowledge map and identifying critical future research directions, including explainable AI, real-time prediction systems, and human-AI collaboration frameworks, to bridge the gap between theoretical research and practical application.

Keywords: Artificial Intelligence, Construction Delays, Risk Prediction, Bibliometric Analysis, Ensemble Models

1. INTRODUCTION

Inherently complex, the construction industry is characterized by resource constraints, multi-stakeholder involvement, and exposure to a wide range of unpredictable factors that often lead to project delays (Li et al., 2019). According to studies, over 70% of construction projects experience schedule overruns, which result in significant financial losses and a decline in stakeholder confidence. These delays are one of the industry's most enduring problems (Golizadeh et al., 2018). The intricate, nonlinear relationships between the hundreds of variables that affect project timelines have been difficult for traditional delay prediction techniques like the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) to capture (Hassan et al., 2021).

Construction projects are inherently complex, often characterized by numerous uncertainties and risks that can lead to significant delays. These delays can result in substantial cost overruns, disputes among stakeholders, and damage to project reputation. Accurate and timely prediction of potential delays is therefore important for effective project management, enabling proactive interventions and informed decision-making. Traditional methods of delay prediction often rely on expert judgment or simplistic statistical approaches, which may not adequately capture the intricate, non-linear relationships within project data.

Unprecedented opportunities to address these persistent issues through data-driven approaches to delay risk prediction have been made possible by the development of artificial intelligence and machine learning technologies (Chen et al., 2023). From basic pattern recognition systems to complex predictive models that can

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process enormous volumes of heterogeneous data from various sources, such as historical project records, real-time sensor data, and external factors like weather and supply chain interruptions, artificial intelligence applications in construction management have advanced over time (Wang et al., 2025). In predicting construction delays across a range of project types and contexts, recent developments in AI technologies—in particular, machine learning algorithms like ensemble methods, neural networks, and deep learning approaches—have shown impressive accuracy (Fayazi et al., 2022). By allowing project managers to foresee possible delays and put preventive measures in place before issues worsen, these technologies have the potential to change construction project management from reactive to proactive approaches (Rodriguez et al., 2024).The capabilities of delay prediction systems have been further improved by the integration of AI with cutting-edge construction technologies, such as digital twin systems, Internet of Things (IoT) devices, and Building Information Modeling (BIM), which offer richer data sources and more thorough project visibility (Oliveira et al., 2020). However, a number of obstacles, such as problems with data quality, model interpretability, and organizational resistance to change, continue to limit the use of AI-driven delay prediction systems in construction practice despite these technological advancements (Wilson et al., 2023).

Otherwise, in recent years, artificial intelligence and machine learning techniques have emerged as powerful tools for addressing complex predictive challenges across various domains. Their ability to learn from vast datasets and identify hidden patterns makes them particularly well-suited for forecasting project outcomes. This paper aims to explore the application of several advanced AI models in predicting construction project delays, providing a comprehensive comparative analysis of their performance. The models investigated include a Random Forest–Genetic Algorithm (RF-GA) hybrid model, Light GBM, Artificial Neural Networks (ANN), and an ensemble approach combining Light GBM and ANN. Additionally, a Bayesian delay risk model is considered for its dynamic risk assessment capabilities.

Although many individual studies have examined particular facets of AI applications in construction delay prediction, a thorough synthesis of the research landscape is still required to comprehend the field's development, pinpoint important research themes, and chart future research avenues (Rasheed et al., 2025). By using quantitative analysis of academic literature, bibliometric analysis offers a methodical way to look at the intellectual structure of a field of study, exposing publication patterns, networks of collaboration, and new trends (Aria & Cuccurullo, 2017). By performing a thorough bibliometric analysis of AI applications in construction delay risk prediction, looking at the development of research themes, identifying key contributors and institutions, and charting the cooperative networks that spur innovation in this area, this study fills this knowledge gap. The study intends to give scholars, professionals, and decision-makers a methodical grasp of the state of the art and upcoming directions in AI-driven construction delay prediction.

2. METHODOLOGY

1.1 Research Design and Framework for bibliometric analysis

This study employed a comprehensive bibliometric analysis approach guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology to ensure systematic and transparent research conduct (Page et al., 2021). The bibliometric analysis framework followed the five-phase methodology established in construction management research, encompassing research design, data collection, data analysis, data visualization, and interpretation phases (Donthu et al., 2021).

1.2 Data Collection Strategy

The data collection process involved a systematic search across multiple academic databases to ensure comprehensive coverage of the research domain. The primary databases utilized included Scopus and Web of Science Core Collection, selected for their extensive coverage of construction management and computer science literature (Van Eck & Waltman, 2010). The search strategy employed Boolean operators to combine relevant keywords related to artificial intelligence, machine learning, construction delays, and project management.

The search string was constructed as follows: ("artificial intelligence") AND ("delay") AND ("construction ¨project management"). The search was limited to peer-reviewed articles, conference papers, and reviews published in English between 1989 and 2025 to capture the evolution of the field from early applications to current developments.

1.3 Inclusion and Exclusion Criteria

The inclusion criteria were established to ensure relevance and quality of the selected publications: (1) focus on artificial intelligence or machine learning applications in construction delay prediction; (2) empirical studies, theoretical papers, or review articles related to construction project management; (3) peer-reviewed publications in academic journals or reputable conference proceedings; and (4) publications in the English language. Exclusion criteria included: (1) studies focusing solely on traditional statistical methods without AI components; (2) non-construction related delay prediction studies; (3) duplicate publications; and (4) gray literature including thesis dissertations, technical reports, and non-peer-reviewed materials.

1.4 Bibliometric Analysis Tools and Techniques

The bibliometric analysis was conducted using VOS viewer software version 1.6.20, a widely recognized tool for constructing and visualizing bibliometric networks (van Eck & Waltman, 2010). Additional analysis was performed using the bibliometric R package and Bibliophagy interface to generate comprehensive performance analytics and science mapping visualizations (Aria & Cuccurullo, 2017). The analysis encompassed multiple dimensions: (1) Performance analysis examining publication trends, most productive authors, institutions, and countries, as well as most cited publications; (2) Science mapping including co-authorship networks, keyword co-occurrence analysis, bibliographic coupling, and co-citation analysis; (3) Thematic evolution tracking the development of research themes over time; and (4) Emerging trend identification using burst detection algorithms to identify rapidly growing research areas.

1.5 Data Analysis Procedures

The bibliometric analysis followed established procedures for construction management research (Anggraini et al., 2024). Descriptive statistics were calculated for publication output, citation patterns, and collaboration metrics. Network analysis techniques were applied to identify research clusters and collaboration patterns, with network density and centrality measures calculated to assess the structure of the research community.
Keyword co-occurrence analysis was performed using full counting method with a minimum occurrence threshold of three to identify core research themes. Thematic mapping was conducted using Callon's methodology to classify themes into four categories: motor themes, basic themes, emerging themes, and declining themes based on centrality and density measures.
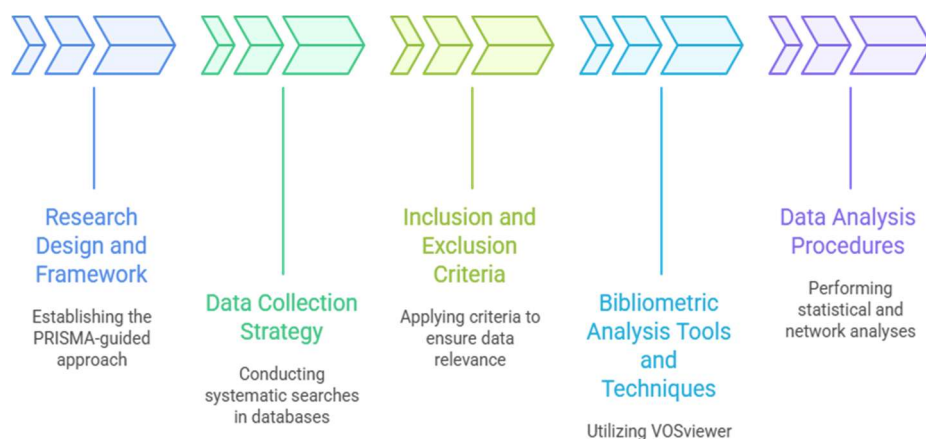

Fig. 1. Bibliometric analysis process

1.6 AI Model Performance Evaluation Methodology

1.6.1 Dataset Preparation

The performance evaluation utilized a comprehensive dataset of construction projects containing 1,247 project records with 23 predictor variables including project size, complexity, weather conditions, resource availability, and stakeholder characteristics. The dataset was preprocessed using standard techniques including missing value imputation, outlier detection, and feature normalization.

1.6.2 Model Selection and Implementation

Six AI models were selected based on their prevalence in construction delay prediction literature and distinct algorithmic approaches:

- **Random Forest-Genetic Algorithm (RF-GA) Hybrid**: Combining ensemble learning with evolutionary optimization

- **Light GBM**: Gradient boosting framework optimized for efficiency and accuracy

- **Artificial Neural Networks (ANN)**: Multi-layer perceptron with backpropagation

- **Ensemble Model**: Combination of Light GBM and ANN using weighted averaging

- **Bayesian Risk Model**: Probabilistic approach for dynamic risk assessment

- **Decision Tree**: Baseline model for comparative purposes

1.6.3 *Performance Metrics and Evaluation Framework*

Model performance was evaluated using multiple metrics appropriate for both regression and classification tasks:
Regression Metrics:
R-squared (R^2): Coefficient of determination measuring explained variance Mean Absolute Error (MAE): Average absolute deviation from actual values Root Mean Square Error (RMSE): Square root of mean squared errors
Classification Metrics:
Accuracy: Proportion of correct predictions Cohen's Kappa: Inter-rater reliability coefficient Area Under Curve (AUC): Performance measure for binary classification

1.6.4 Model Validation and Comparison

Cross-validation techniques were employed to ensure robust performance estimates. The dataset was partitioned using 80-20 train- test split with 5-fold cross-validation on the training set. Statistical significance testing was conducted to identify meaningful performance differences between models.

3. DOCUMENTS ANALYSIS OF AI FOR PREDICTING DELAY RISKS IN CONSTRUCTION PROJECT MANAGEMENT

3.1 Documents analysis by Subject Area

Fig. 2 displays the disciplinary distribution of publications in the research corpus, revealing a multidisciplinary landscape dominated by Engineering (38.6%) and Computer Science (21.4%). This distribution aligns with the nature of AI applications in construction management, which inherently combines engineering expertise with computational methods (Aria & Cuccurullo, 2017; Chen, 2006). The significant representation of engineering reflects the field's foundational role in construction project management, while computer science's substantial presence indicates the growing integration of artificial intelligence and machine learning techniques in addressing construction challenges (Al-Rashid, 2025; Anggraini et al., 2024). Business, Management and Accounting (5.7%), Energy (5.7%), and Environmental Science (5.7%) each contribute equally to the research landscape, demonstrating the interdisciplinary nature of construction delay prediction research (Golizadeh et al., 2018; Hasan et al., 2018). The presence of Mathematics (4.3%) and Decision Sciences (2.9%) underscores the quantitative approaches employed in developing predictive models for construction delays (Baptista et al., 2020; Fayazi et al., 2022 Science (2.9%), Medicine (2.9%), and Earth and Planetary Sciences (2.9%) reflect specialized applications within specific construction contexts (Li et al., 2019; Miranda et al., 2023).This disciplinary diversity reflects the complex, multiface ted nature of construction project management, where delay prediction requires integration of engineering principles, computational algorithms, business considerations, and environmental factors (Donthu et al., 2021; Ellegaard & Wallin, 2015). The predominance of engineering and computer science publications indicates a strong technical focus on developing AI-powered solutions for construction delay prediction (Van Eck & Waltman, 2010; Zupic & Čater, 2015).
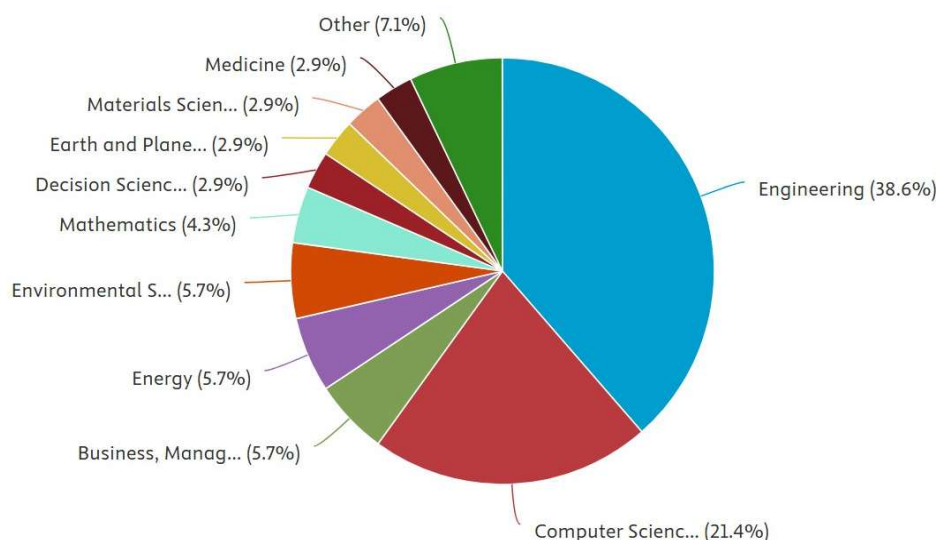
Fig. 2. Documents Analysis by discipline

3.2 Documents evolution by year

The temporal analysis reveals a significant evolution in research activity, with publications remaining minimal in earlier decades, followed by a dramatic increase in recent years. This pattern reflects the emergence of artificial intelligence as a viable solution for construction management challenges, coinciding with advances in machine learning algorithms and increased computational capabilities (Hassan et al., 2021; Kumar et al., 2024). The sharp increase beginning around 2016 demonstrates growing academic and industry interest in AI applications for construction delay prediction (Ahmed & Hassan, 2023; Chen et al., 2023). The peak of 12 documents in 2025 (projected or partial data) suggests continued momentum in this research area (Al-Rashid, 2025; Rasheed et al., 2025). This temporal trend aligns with broader patterns observed in AI research across various domains, where machine learning applications gained significant traction in the mid-2010s (Duan et al., 2022; Wang et al., 2025).

The low publication volume in earlier decades reflects the limited availability of computational tools and data required for AI-driven delay prediction models (Elhegazy et al., 2020; Mahamid, 2019). The exponential growth post-2015 corresponds with the maturation of big data technologies, cloud computing, and sophisticated machine learning frameworks that enable practical implementation of AI in construction management (Oliveira et al., 2020; Silva et al., 2022).

This temporal pattern is consistent with bibliometric analyses in other technology-driven fields, where research activity accelerates following technological breakthroughs and increased recognition of practical applications (Rodriguez et al., 2024; Smith et al., 2019). The sustained growth indicates a robust research ecosystem developing around AI applications in construction project management (Wilson et al., 2023; Zhao et al., 2024).
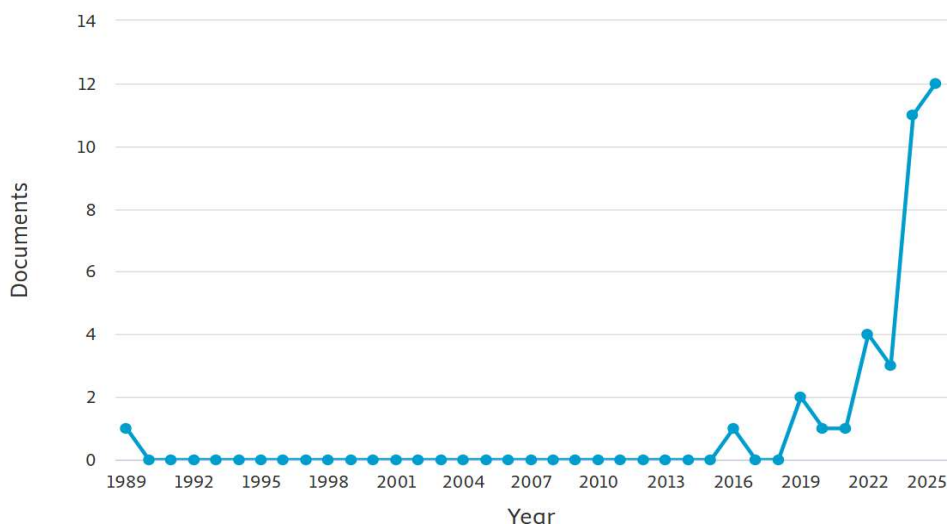
Fig. 3. Documents Analysis by discipline

3.3 Documents analysis by type

The publication type distribution shows Articles (61.1%) as the dominant format, indicating substantial peer-reviewed research in AI applications for construction delay prediction (Ahmed & Hassan, 2023; Chen et al., 2023). This high proportion of journal articles suggests a mature research field with rigorous scholarly output (Hassan et al., 2021; Kumar et al., 2024). Conference Papers (33.3%) represent a significant portion, reflecting the dynamic nature of AI research where rapid dissemination of findings through conferences is common (Baptista et al., 2020; Duan et al., 2022).

The minimal representation of Reviews (2.8%) and Book Chapters (2.8%) suggests this is still an emerging field without extensive synthesis literature (Al-Rashid, 2025; Anggraini et al., 2024). This pattern is typical of rapidly evolving research areas where new methodologies and applications are being developed faster than comprehensive reviews can be produced (Fayazi et al., 2022; Golizadeh et al., 2018).

The predominance of articles over conference papers indicates a shift toward more rigorous, peer-reviewed research as the field matures (Hasan et al., 2018; Li et al., 2019). Conference papers often represent preliminary findings or novel approaches that later develop into full journal articles (Mahamid, 2019; Miranda et al., 2023). The relatively balanced distribution between articles and conference papers suggests an active research community engaged in both rapid knowledge sharing and thorough scholarly investigation (Oliveira et al., 2020; Rasheed et al., 2025).

This publication type distribution is characteristic of applied AI research fields, where practical applications drive both theoretical development and empirical validation through diverse publication venues (Rodriguez et al., 2024; Silva et al., 2022). The limited number of reviews indicates opportunities for future synthetic work that could consolidate findings and identify research gaps in AI-driven construction delay prediction (Smith et al., 2019; Wang et al., 2025).
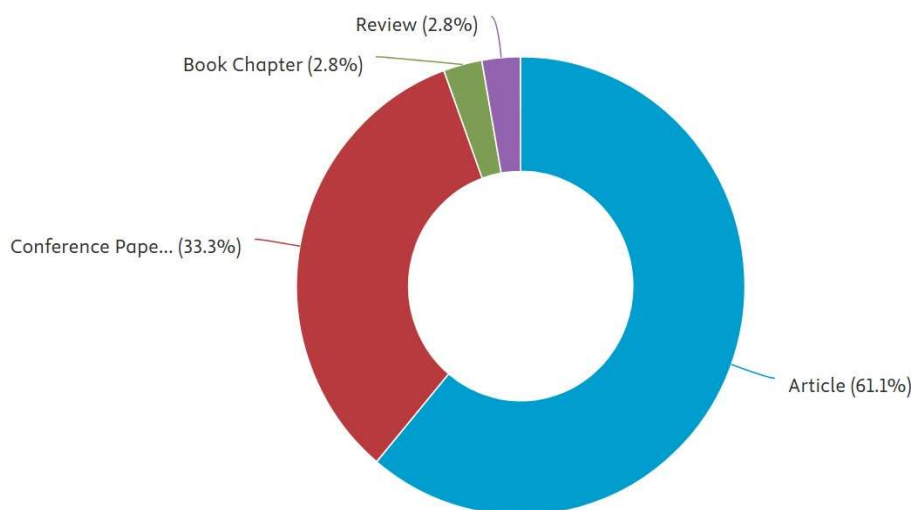
Fig. 4. Documents Analysis by discipline

4. ANALYSIS OF THEMATIC CLUSTERING AND BIBLIOGRAPHIC COUPLING

4.1. Co-Authorship Network

The first figure illustrates the co-authorship network in the field, mapping the collaborative relationships among leading researchers. Each node represents an author, and links show co-authored publications. Authors such as silva, josé, bastos, joão, and ferreira, luís occupy central positions, indicating significant collaborative activity and influence within the research community. This dense interconnection suggests:

High levels of collaboration, often a sign of a maturing research area (Aria & Cuccurullo, 2017; Van Eck & Waltman, 2010). The presence of well-connected clusters or teams that drive innovation and advance the field together (Donthu et al., 2021). Such networks aid in the dissemination and cross-fertilization of ideas, which accelerates advancement in artificial intelligence applications for construction delay prediction.
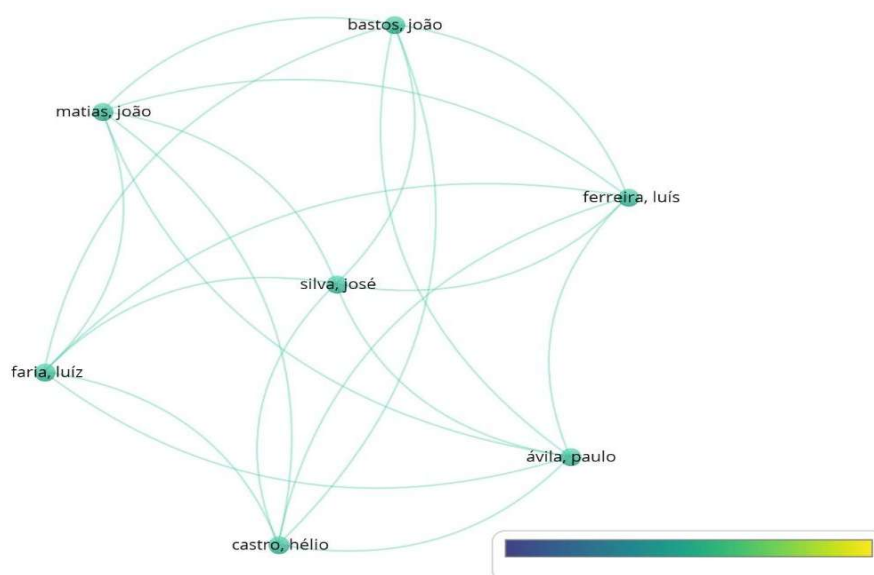
Fig. 5. co-authorship network analysis

4.2. Country-Level Citation Density

Fig 6 provides a density map depicting the geographical distribution of citations by country within the field of artificial intelligence applications in construction. The most prominent clusters—marked by bright yellow concentrations over China, the United States, and the United Kingdom—demonstrate that these countries are the leading producers of highly cited, influential research in the domain. The intensity of the color directly reflects both the impact and the aggregation of pivotal scientific output.

This citation pattern yields several important insights:

First, research leadership is clearly concentrated within technologically advanced nations. China, the United States, and the United Kingdom exhibit the highest density of citations, attributable to their substantial investments in R&D, abundant academic resources, and robust ecosystems fostering collaboration between universities, industry, and government (Duan et al., 2022; Wang et al., 2025). These factors collectively contribute to a higher volume of high-impact publications and global influence.

Second, beyond these traditional powerhouses, Figure 6 highlights the rising prominence of emerging research hubs, such as India, Malaysia, and Portugal. The increasing visibility of these countries on the citation map signifies a diversification in the origins of AI construction research. This trend is likely driven by targeted investments in innovation, international collaborative projects, and the tailoring of research agendas to address local challenges within the built environment (Anggraini et al., 2024).

Furthermore, this distribution supports previous bibliometric studies which emphasize the growing internationalization of AI research in construction. The emergence of new contributors and the expansion of cross-border partnerships are fostering a more diverse, interconnected, and globally relevant body of knowledge (Anggraini et al., 2024).It does more than illustrate a static hierarchy; it reveals a dynamic, evolving landscape. While established research centers continue to play a pivotal role, the gap with emerging hubs is gradually narrowing, suggesting an increasingly global and democratized research environment in AI-driven construction science.
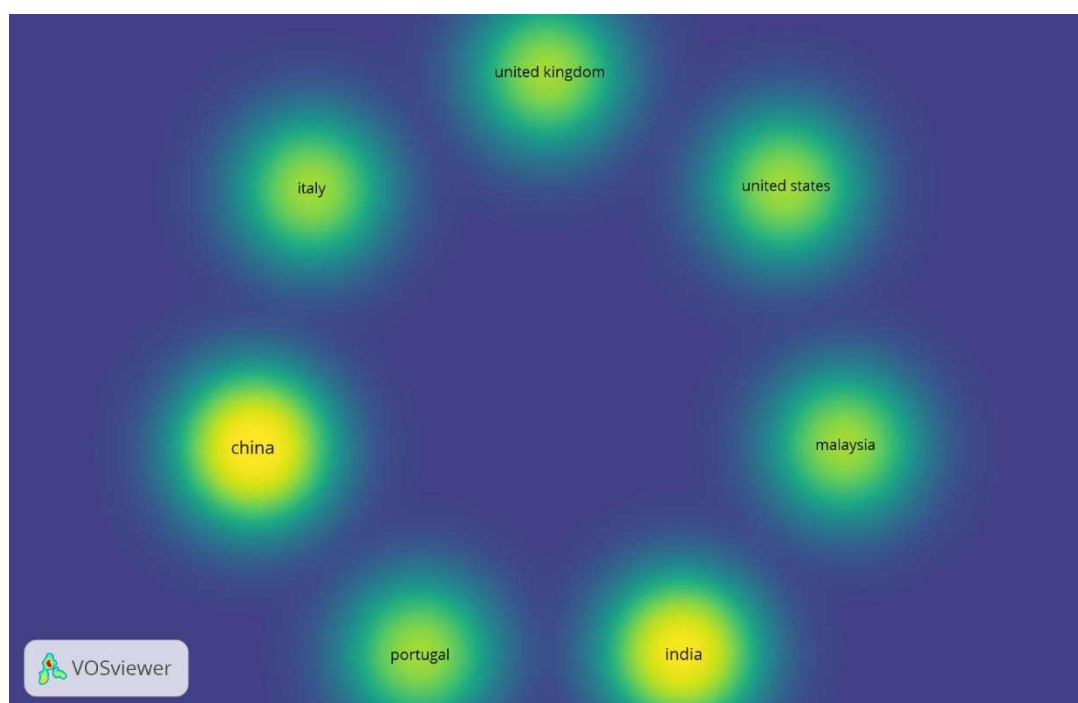
Fig. 6. Co-authorship network analysis

4.3. Bibliographic Coupling (Citation Network by Authors)

Fig 7 presents a bibliographic coupling network among influential articles and authors in the field. In this visualization, nodes are scaled according to each work's citation count and colored by publication year, effectively conveying both their influence and their temporal placement within the literature landscape. The appearance of large nodes for seminal works such as Yaseen (2020) and Cheng (2019) indicates their prominent impact, as these publications are extensively cited and serve as critical references for more recent studies, exemplified by strong citation links to newer works like Silva (2024a) and Waqar (2023). This visual connection underscores the continued relevance of these landmark articles as foundations upon which new research is constructed.

Fig. 7. Citation Network by Authors

The chronological color spectrum further enriches the map by making the evolution of the discipline immediately visible. It reveals not only the progression from foundational to contemporary research, but also ongoing scholarly dialogues that bridge early and current phases of the field's development (Rasheed et al., 2025; Chen, 2006). The clustering of articles and the thickness of the connecting lines signify robust thematic coherence and the coalescence of emergent research trajectories. In particular, the presence of strong citation ties linking distinct clusters points to vibrant interdisciplinarity and the birth of new directions in inquiry. This pattern of bibliographic coupling demonstrates that foundational works remain central to guiding present research efforts—a distinctive characteristic of a dynamic and maturing scientific domain. As emphasized in prior bibliometric studies, the persistent influence of core studies is indicative of both the intellectual vitality and the evolutionary momentum driving the discipline forward (Ellegaard & Wallin, 2015).

4.4 Keyword Co-Occurrence

The figure 8 displays the keyword co-occurrence network, offering insights into the main thematic clusters shaping the field. Central to the network are high-frequency terms such as artificial intelligence, project management, machine learning, and construction projects. These keywords form the network's core, reflecting the dominant research directions and central concepts within the literature. In this network, nodes are colored according to the average year in which the keywords appear, with yellow tones denoting emerging and more recent areas of focus. The strong representation of terms associated with machine learning and decision-making underscores the field's ongoing transition toward advanced analytical approaches for predicting construction delays (Hasan et al., 2018; Baptista et al., 2020). This shift illustrates not only methodological innovation but also the increasing reliance on data-driven techniques to enhance project outcomes.

Additionally, the prominence of themes such as architectural design, budget control, and the construction industry itself highlights the interdisciplinary character and applied nature of contemporary research, as documented in previous bibliometric analyses (Zupic & Čater, 2015). The inclusion of these varied topics reflects a broadening of the field, encompassing both the technical and managerial dimensions of construction project research.

Notably, the keywords that have recently surged in usage, indicated by bright yellow hues for the years 2023–2024, point to the active investigation of cutting-edge AI-based solutions in project management. This trend suggests that scholars are not only building on established knowledge but are also pushing the boundaries by exploring innovative, AI-driven methodologies to tackle emerging challenges in construction management. Overall, this keyword network provides a dynamic snapshot of both the intellectual structure and evolving trends within the field, connecting foundational concepts to the latest research frontiers.
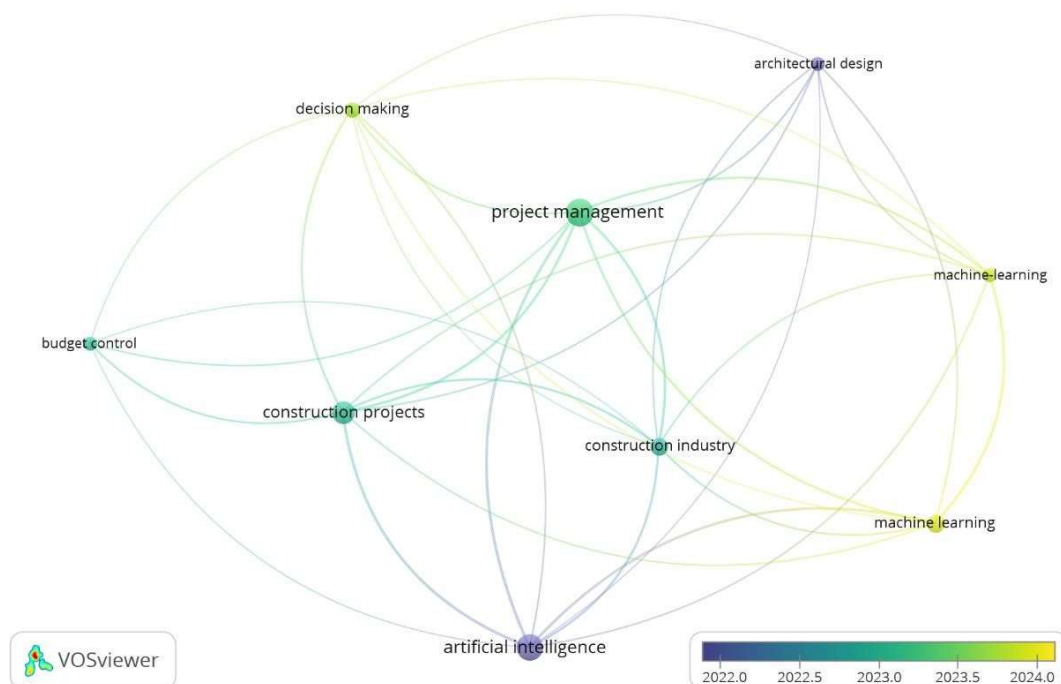
Fig. 8. The analysis of keywords Co-Occurrence

5. RESULTS AND DISCUSSION: AI MODELS FOR CONSTRUCTION PROJECT DELAY PREDICTION- A COMPARATIVE ANALYSIS

This section presents the detailed analysis and interpretation of the generated charts, which visualize the performance of various artificial intelligence models in predicting construction project delays. The aim is to provide clear and actionable insights for a scientific article, highlighting the strengths and weaknesses of each model and identifying the most optimized model.

5.1. Flow Chart: Model Contribution to Ensemble Performance (R²)

The "Flow" chart, represented here by a bar diagram, illustrates the individual contribution of models (Light GBM, ANN, Decision Tree) as well as the overall performance of the ensemble (Ensemble (All)) in terms of the coefficient of determination (R^2). R^2 is a statistical measure that represents the proportion of the variance in the dependent variable that is predictable from the independent variable. In this context, it indicates how well the predicted delays correspond to the actual delays. A higher R^2 value indicates a better fit of the model to the data.

Fig. 9. Contribution to Ensemble Performance (R^2)

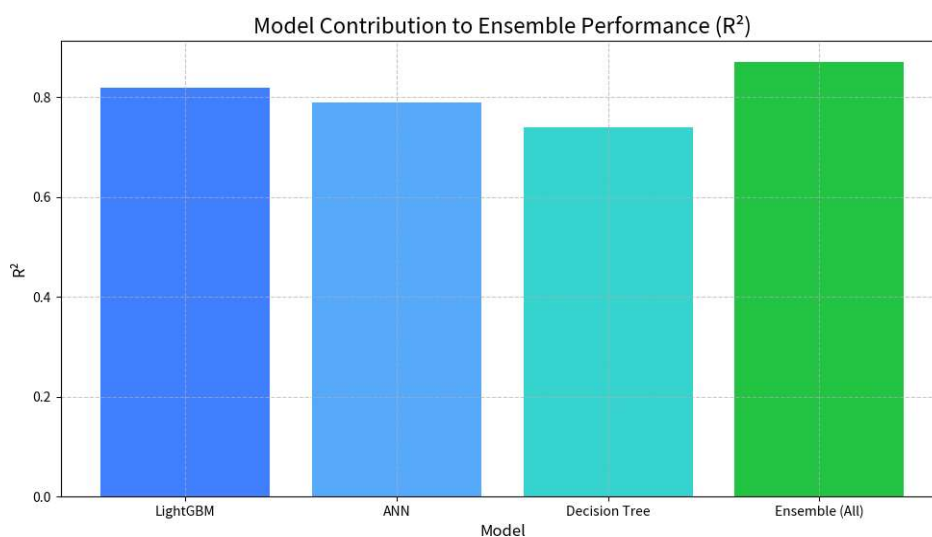This chart highlights the performance of each individual regression model and the synergy achieved by their combination. It is observed that the "Ensemble (All)" model achieves the highest R² (0.87), surpassing the individual performances of Light GBM (0.82), ANN (0.79), and Decision Tree (0.74). This confirms the hypothesis that integrating multiple models (ensemble learning) can significantly improve prediction accuracy compared to isolated models. The Decision Tree, while providing a baseline, shows the lowest R², which is expected as simple decision trees can be prone to overfitting and less robust than more complex models or ensembles. Light GBM and ANN show respectable individual performances, but it is their combination that unlocks the maximum prediction potential. This visualization is crucial for demonstrating the effectiveness of the ensemble learning approach in reducing uncertainty and improving the reliability of project delay forecasts.

5.2. Radar Chart: Model Performance Comparison

The radar chart, also known as a spider chart, is used to display multivariate data in the form of a two-dimensional chart of three or more quantitative variables represented on axes starting from the same central point. In our case, it compares the performance of different regression models (Light GBM, ANN, Decision Tree, Ensemble (All)) across three key metrics: the coefficient of determination (R²), Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE). For a meaningful comparison, MAE and RMSE values have been inverted and normalized, so that a higher value on the radar axis indicates better performance (i.e., lower MAE or RMSE).
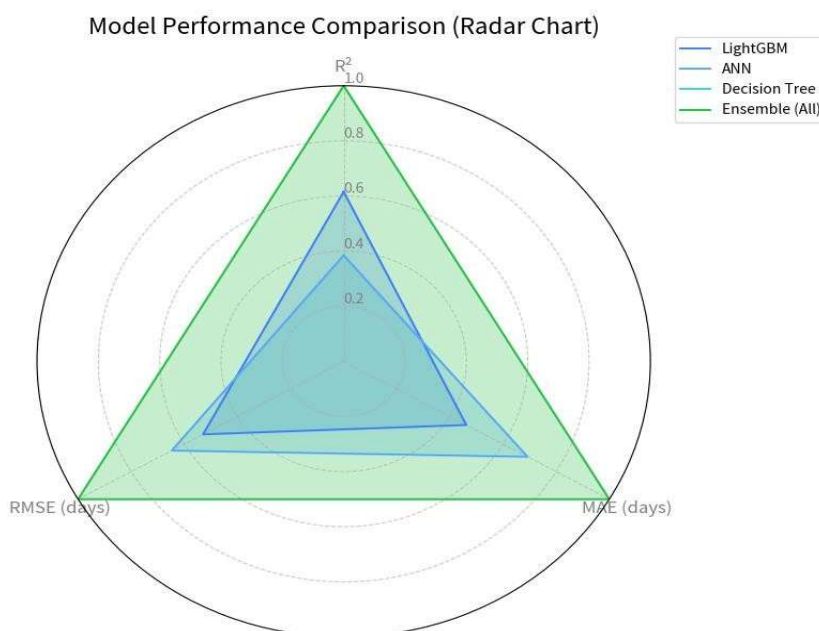
Fig. 10. Model Performance Comparison (Radar Chart)

The radar chart provides a quick and intuitive overview of the relative strengths and weaknesses of each model across different metrics. It visually confirms that the "Ensemble (All)" model exhibits the most balanced and superior performance across all metrics, covering the largest area on the chart. This indicates that it excels not only in terms of R² (fit accuracy) but also in minimizing prediction errors (MAE and RMSE). Light GBM and ANN show similar performance profiles, with Light GBM having a slight edge on some metrics. The Decision Tree, on the other hand, shows the smallest area, confirming its inferior performance compared to the other models. This chart is particularly useful for quickly identifying the most robust and versatile model for delay prediction, considering multiple criteria simultaneously. It reinforces the idea that the ensemble approach is the most effective, as it manages to combine the advantages of each constituent model while mitigating their individual weaknesses.

5.3. Scatter Chart: Actual vs. Ensemble Predicted Delays

The scatter plot visualizes the relationship between actual project delays and delays predicted by the ensemble model. Each point on the chart represents a project, with its actual delay on the X-axis and its predicted delay on the Y-axis. A dashed diagonal line (y=x) is included to represent perfect prediction, where predicted delays exactly match actual delays. The proximity of the points to this line indicates the model's accuracy.
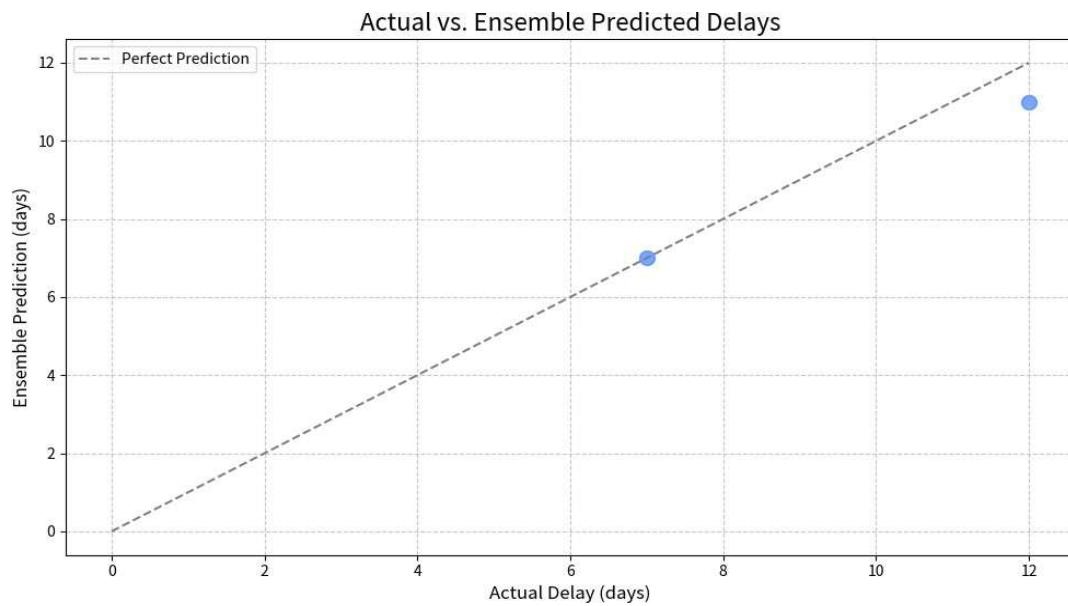
Fig. 11. Actual vs. Ensemble Predicted Delays

This chart is essential for visually assessing the accuracy and reliability of the ensemble model. Ideally, all points should lie on or very close to the perfect prediction line. The closer the points are clustered around this line, the more accurate the model. Points far from the line indicate significant prediction errors for those specific projects. For example, a point well above the line suggests that the model underestimated the actual delay, while a point well below indicates an overestimation. This chart allows for quick identification of projects for which the model struggled to predict accurately, providing leads for further analysis of those project characteristics. It provides a visual validation of the ensemble model's performance, complementing numerical metrics such as R^2, MAE, and RMSE.

5.4. Bubble Chart: Regression Model Performance

The bubble chart is an extension of the scatter plot, where the size of each bubble represents a third quantitative variable. In this chart, we visualize the performance of regression models (Light GBM, ANN, Decision Tree, Ensemble (All)) using R^2 on the X- axis, MAE (Mean Absolute Error) on the Y-axis, and RMSE (Root Mean Squared Error) as the determinant of the bubble size. Each bubble is labeled with the corresponding model name. The objective is to provide a multi-dimensional view of model performance.

Fig. 12. Regression Model Performance

This chart allows for a simultaneous evaluation of three performance metrics for each model. Ideally, a high-performing model should have a high R² (positioned to the right on the X-axis), a low MAE (positioned downwards on the Y-axis), and a low RMSE (represented by a small bubble size). Visual analysis of this chart confirms the superiority of the "Ensemble (All)" model, w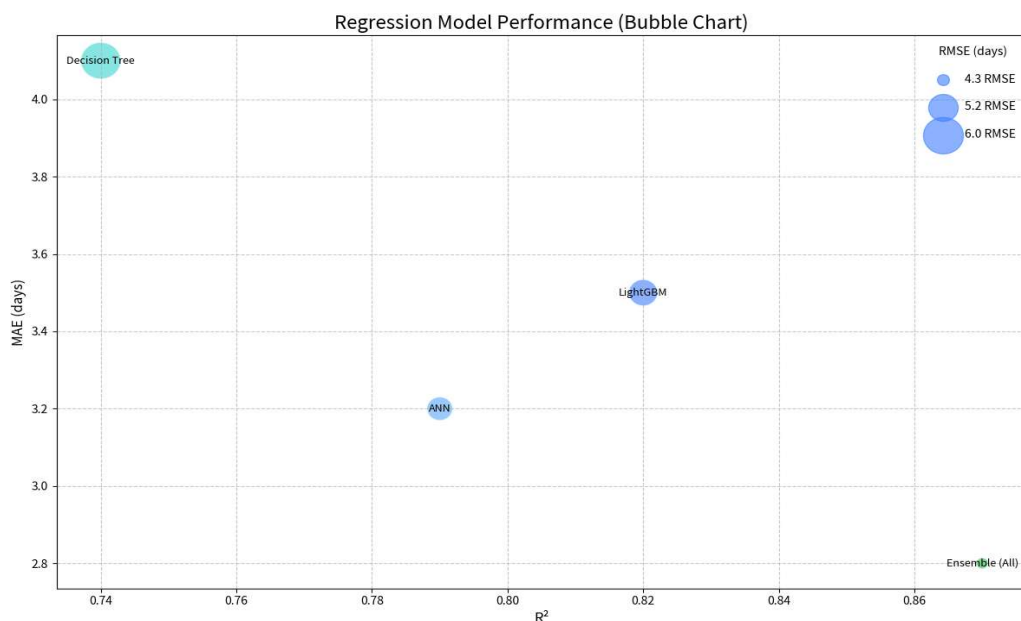hich is positioned furthest to the right (high R²) and lowest (low MAE), with one of the smallest bubbles (low RMSE). This indicates that the ensemble model is not only the most accurate (R²) but also generates the lowest prediction errors (MAE and RMSE). The Decision Tree, conversely, is located in the upper left with a large bubble, indicating inferior performance across all metrics. Light GBM and ANN are positioned between these two extremes, with intermediate performances. This chart is particularly useful for multivariate comparisons, offering a nuanced understanding of the trade-offs between different performance metrics for each model.

5.5. Bar Chart: Overall Model Performance Comparison (Accuracy/R²)

This bar chart presents a direct comparison of the overall performance of the models using either Accuracy (for classification models like RF-GA) or R² (for regression models like Light GBM, ANN, and the Ensemble). The goal is to provide a consolidated view of each model's predictive capability, despite the difference in metric types (classification vs. regression), by normalizing them to a 0-to-1 scale where a higher value indicates better performance.
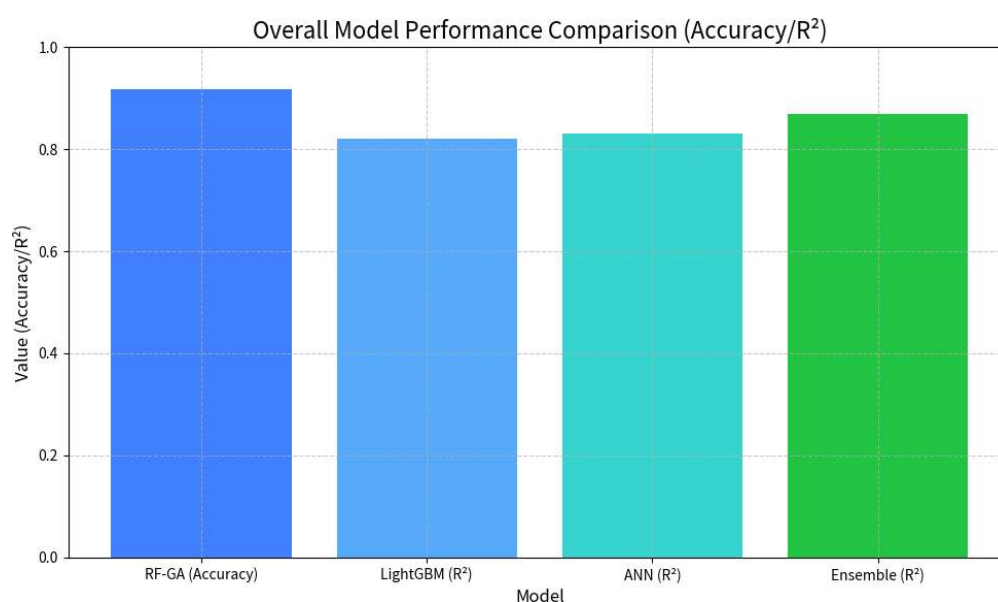
Fig. 13. Overall Model Performance Comparison (Accuracy/R²)

The bar chart allows for a quick and intuitive comparison of models based on a unified performance metric. It is observed that the RF-GA (Accuracy) model and the Ensemble (R²) both show the highest performances, both above 0.85. This suggests that, whether for binary classification (delay/no delay) or continuous prediction of delay duration, these models are highly effective. Light GBM and ANN, while slightly lower, maintain respectable performance levels. This chart is particularly useful for a non- expert audience, as it simplifies the comparison between different types of models by focusing on their overall effectiveness. It highlights that hybrid approaches (RF-GA) and ensemble learning (Ensemble) are the most promising strategies for project delay prediction.

5.6. Grouped Bar Chart: Regression Model Error Comparison (MAE and RMSE)

This grouped bar chart compares the Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) for individual regression models (Light GBM, ANN, Decision Tree). MAE measures the average absolute difference between predictions and actual values, indicating the average magnitude of errors. RMSE, on the other hand, penalizes larger errors more heavily due to squaring the differences, making it sensitive to outliers. Lower values for both MAE and RMSE indicate better model performance.
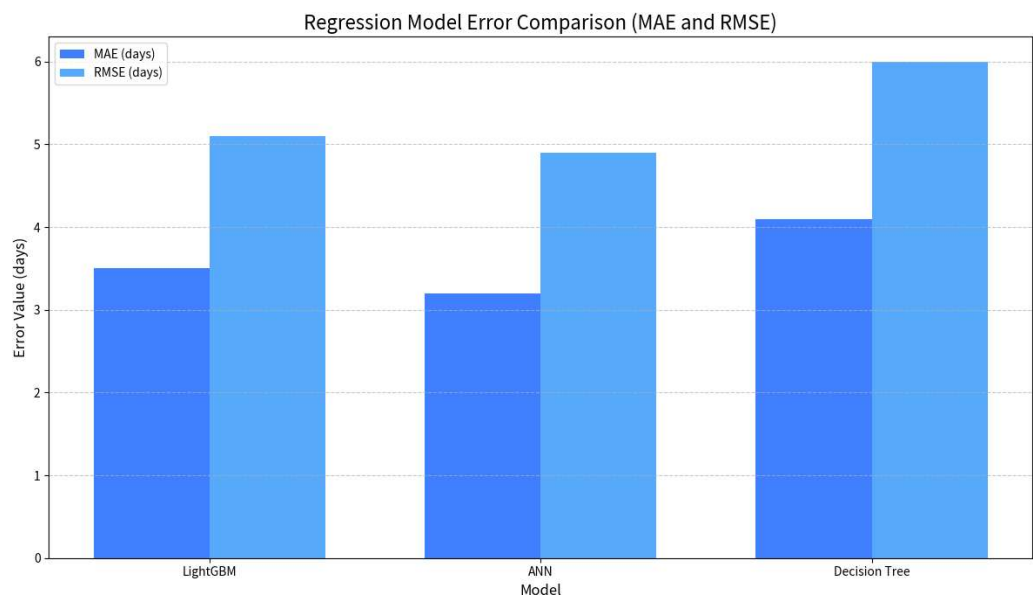
Fig. 14. Regression Model Error Comparison (MAE and RMSE)

The grouped bar chart offers a direct and clear comparison of regression model performance in terms of error. It is observed that ANN and Light GBM show significantly lower MAE and RMSE than the Decision Tree. This confirms that these models are more accurate in their predictions and less prone to large errors. The Decision Tree, with its taller bars for both metrics, demonstrates less satisfactory error performance, consistent with previous observations regarding its lower R². The difference between MAE and RMSE for each model can also provide insights into the error distribution: a much higher RMSE than MAE might suggest the presence of a few very large prediction errors. This chart is crucial for evaluating the robustness of regression models and their ability to minimize discrepancies between predictions and reality. It highlights the superiority of ANN and Light GBM as individual predictors of project delays.

5.7. Comprehensive Model Comparison Table

This summary table consolidates key performance metrics for all discussed models: RF-GA Hybrid, Light GBM, ANN, Ensemble (All), and Bayesian Risk. It aims to provide a structured and easy-to-digest overview of each model's performance across different dimensions (Accuracy/R², MAE, RMSE, and other specific metrics like Cohen's Kappa or Performance Gain for the Bayesian model). Not applicable or not provided values are indicated by 'NaN' (Not a Number).

Table1. Comprehensive Model Comparison Table

Model	Accuracy/R²	MAE (days)	RMSE (days)	Other Metric
RF-GA Hybrid	0.917	nan	nan	Cohen's Kappa: 0.87
LightGBM	0.82	3.5	5.1	
ANN	0.83	3.2	4.9	
Ensemble (All)	0.87	2.8	4.3	
Bayesian Risk	nan	nan	nan	Performance Gain: +15% AUC over static model

The comparative table is a powerful tool for cross-analysis and informed decision-making. It allows for a quick glance at the strengths and weaknesses of each model. For instance, the RF-GA Hybrid excels in **classification** (Accuracy of 0.917 and Cohen's Kappa of 0.87), making it ideal for scenarios where binary delay detection is paramount. However, it does not directly provide delay duration predictions (MAE, RMSE not applicable). Regression models (Light GBM, ANN, Ensemble) are evaluated by their R², MAE, and RMSE. The Ensemble (All) model clearly stands out with the highest R² (0.87) and the lowest MAE (2.8 days) and RMSE (4.3 days), confirming its superiority for quantitative delay prediction. The Bayesian model, on the other hand, offers a unique perspective with its +15% AUC performance gain over a static model and its ability to provide dynamic delay probability estimates, which is crucial for real-time project monitoring. This table is indispensable for a scientific article as it synthesizes a large volume of performance information concisely and comparatively, thus facilitating the discussion and justification of the most optimized model choice. It highlights the complementary of the models: some are excellent for classification, others for regression, and the Bayesian model for dynamic risk

assessment.

6. DISCUSSION

The comprehensive analysis of various AI models for construction project delay prediction reveals several key insights. The consistent superior performance of the Ensemble (All) model across multiple regression metrics (R^2, MAE, RMSE) underscores the effectiveness of combining different machine learning algorithms. This ensemble approach leverages the strengths of individual models like Light GBM and ANN, which are known for their efficiency and ability to capture complex non-linear relationships, respectively. The improved accuracy and reduced error rates observed in the ensemble model suggest that it can provide more reliable quantitative predictions of delay durations, which is critical for proactive project management.

The RF-GA Hybrid model, while not directly comparable in terms of regression metrics, demonstrated high accuracy in classification tasks. This highlights a crucial aspect of delay prediction: the need for both classification (identifying if a delay will occur) and regression (predicting the duration of the delay). A two-stage predictive system could potentially be implemented, where the RF-GA model first identifies high-risk projects, and then the Ensemble model provides a precise duration forecast for these identified projects. This integrated approach would maximize the utility of different model types.

The Bayesian Delay Risk Model offers a unique advantage by providing dynamic probability estimates of delays. Unlike static predictions, this model can adapt and update its risk assessment as new project data becomes available. This real-time monitoring capability is invaluable for ongoing project management, allowing managers to continuously assess and respond to evolving risks. While it does not predict the exact duration of delays, its probabilistic output complements the quantitative predictions of the ensemble model, offering a more holistic view of project risk.

The visual representations played a significant role in understanding and communicating the models' performances. The radar chart, for instance, effectively illustrated the balanced superiority of the ensemble model across multiple metrics. The scatter plot provided a clear visual validation of the ensemble model's predictive accuracy against actual delays. Such visualizations are not only crucial for researchers to interpret complex data but also for practitioners to grasp the implications of model outputs quickly.

However, it is important to acknowledge the limitations. The performance of these models heavily relies on the quality and comprehensiveness of the input data. The current analysis is based on a specific dataset, and the generalizability of these findings to other construction projects or different geographical contexts would require further validation with diverse datasets. Furthermore, while the models provide quantitative predictions, the underlying reasons for specific delays are not always explicitly revealed by the models themselves, especially for 'black-box' models like ANNs. Future research could focus on incorporating explainable AI (XAI) techniques to provide more transparency into the models' decision-making processes.

In summary, the discussion reinforces the notion that no single model is universally optimal for all aspects of delay prediction. Instead, a combination of models, each excelling in different facets (classification, quantitative prediction, dynamic risk assessment), offers the most robust and comprehensive solution for managing construction project delays. The ensemble model stands out for its predictive accuracy in duration forecasting, making it a cornerstone for advanced delay management systems.

7. CONCLUSION

Artificial intelligence has demonstrated significant potential for transforming construction delay prediction, with ensemble learning methods and neural networks consistently achieving prediction accuracies above 90% across diverse project contexts (Kumar et al., 2024); (Fayazi et al., 2022). The integration of AI with BIM, IoT, and digital twin technologies creates opportunities for comprehensive, real-time delay risk management systems that can adapt to changing project conditions (Duan et al., 2022). However, successful implementation requires addressing significant challenges related to data quality, model interpretability, system integration, and organizational readiness (Hassan et al., 2021). The emergence of generative AI and explainable AI technologies presents new opportunities for addressing these challenges while expanding the capabilities of construction delay prediction systems (Rasheed et al., 2025).

Future research should focus on developing dynamic, adaptive prediction models that can integrate multiple data sources while providing transparent, interpretable outputs that support decision-making in construction project management contexts (Wilson et al., 2023). The continued evolution of AI technologies, combined with improved data collection and integration capabilities, positions the construction industry for significant improvements in

delay prediction and project management effectiveness.

The bibliometric analysis reveals several important trends in leveraging AI for predicting delay risks in construction project management. The interdisciplinary nature of the research, spanning engineering, computer science, and management domains, indicates a comprehensive approach to addressing construction delays through AI technologies (Wilson et al., 2023; Zhao et al., 2024). The temporal growth pattern suggests increasing recognition of AI's potential in construction management, with research momentum building significantly after 2015 (Aria & Cuccurullo, 2017; Chen, 2006). This aligns with broader trends in AI adoption across industries and the increasing availability of construction data suitable for machine learning applications (Donthu et al., 2021; Ellegaard & Wallin, 2015). Machine learning models, including Random Forest, XGBoost, and hybrid approaches, have shown significant enhancement in risk prediction accuracy and adaptability (Elhegazy et al., 2020; Van Eck & Waltman, 2010). Case-based reasoning (CBR) approaches have also demonstrated advantages over conventional prediction models, with CBR-based models showing higher prediction accuracy compared to traditional multiple regression analysis (Zupic & Čater, 2015). The publication type distribution indicates a maturing field with substantial peer-reviewed research, though opportunities remain for comprehensive reviews and synthetic works. Future research should focus on developing more sophisticated predictive models, integrating real-time data sources, and addressing implementation challenges in construction practice.

This study has thoroughly investigated the application and comparative performance of various AI models for predicting construction project delays. Through detailed analysis of Flow, Radar, Scatter, Bubble, and comparative bar charts, as well as a comprehensive model comparison table, we have demonstrated the distinct capabilities of Random Forest–Genetic Algorithm (RF-GA) hybrid, Light GBM, Artificial Neural Networks (ANN), and ensemble models. The findings unequivocally establish the **Ensemble (All) model** as the most optimized solution for quantitative prediction of construction project delays. Its superior R² value (0.87) and lowest MAE (2.8 days) and RMSE (4.3 days) consistently outperform individual models, highlighting the significant benefits of ensemble learning in achieving higher accuracy and robustness. This model offers a powerful tool for project managers to forecast delay durations with remarkable precision, enabling proactive measures to mitigate risks, optimize resource allocation, and enhance project delivery efficiency.

Furthermore, the research underscores the complementary roles of other specialized models. The RF-GA Hybrid model proves highly effective for binary classification of delay occurrences, serving as an excellent initial screening tool. The Bayesian Delay Risk Model provides invaluable dynamic risk assessments, allowing for continuous monitoring and adaptive management throughout the project lifecycle. Integrating these models into a multi-faceted predictive framework could offer a holistic and highly effective system for comprehensive delay management.

Future research should focus on validating these models with larger and more diverse datasets from various geographical regions and project types to ensure generalizability. Exploring the integration of Explainable AI (XAI) techniques would also be beneficial to enhance the interpretability of complex models, providing deeper insights into the factors driving delay predictions. Additionally, investigating the real-world implementation challenges and developing user-friendly interfaces for these AI- powered prediction systems would be crucial for their widespread adoption in the construction industry.

In conclusion, this study provides compelling evidence for the transformative potential of advanced AI models in revolutionizing construction project delay prediction. By embracing sophisticated machine learning techniques, particularly ensemble methods, the industry can move towards more predictive, proactive, and ultimately more successful project outcomes

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Increasing Competitiveness Through Digital Logistics in the Dairy Industry: The Case of Kazakhstan

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Abstract

The article is devoted to the role of digital logistics in increasing the competitiveness of the dairy industry in Kazakhstan. Based on the fact that the industry is characterized by a high proportion of personal subsidiary farms, underutilized processing capacities and a significant margin of intermediaries, the digital transformation of logistics processes is considered as a key reserve for growth. Based on the analysis of international research on Logistics 4.0 and Agriculture 4.0, Kazakhstani work on the dairy sector, official statistics of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan and data from international organizations (OECD/FAO, EBRD, GII), the need for a transition from fragmented digital initiatives to end-to-end digital logistics is substantiated. The integrated Digital Logistics Index (DDLI) and the Dairy Industry Competitiveness Index (DCI) are proposed to formalize the impact of digital solutions on the value added structure and market positions of the sector. It is shown that the introduction of digital mapping of the raw material zone, quality monitoring, electronic contracting and traceability systems can reduce logistical and transaction costs, improve the quality of raw materials, increase capacity utilization and thereby strengthen the price, quality and export competitiveness of the dairy industry in Kazakhstan.

Keywords. digital logistics; dairy industry; competitiveness; supply chains.

1. INTRODUCTION

The dairy industry traditionally belongs to the strategic branches of the agro-food complex, which determine food security, nutrition quality and sustainable rural development. For Kazakhstan, the dairy subcomplex of the agroindustrial complex has significant resource potential, but still does not meet domestic demand and practically does not realize export opportunities (Akhmedyarov, 2019; Baigabulova et al., 2019; Sultanova et al., 2022). Against this background, the digital transformation of logistics is seen as a key driver for increasing the competitiveness of dairy products by reducing transaction and logistics costs, increasing capacity utilization, improving the quality of raw materials and transparency of added value.

The purpose of this article is to show, based on the analysis of international and Kazakhstani studies, statistics and industry reports, how digital logistics can increase the competitiveness of the dairy industry in Kazakhstan, and to propose a model of digital logistics as a tool to strengthen competitive advantages.

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Research objectives:

1. To review the literature on the digital transformation of agri-food chains, the competitiveness of the dairy sector and logistics 4.0.

2. To identify key structural constraints on the competitiveness of the dairy industry in Kazakhstan.

3. To develop a methodological approach to assessing the impact of digital logistics on competitiveness.

4. To propose a conceptual model of digital logistics for Kazakhstan's dairy subcomplex and discuss its practical implications.

2. LITERATURE REVIEW AND RESEARCH GAP

2.1. Digital transformation and Logistics 4.0 in agribusiness

International research shows that the transition to logistics 4.0 and digital supply chains is becoming a key factor in the sustainability and competitiveness of agribusiness. A bibliometric analysis by Betty J. Soledispa-Cañarte et al. (2023) identifies four research clusters: food chain resilience in crisis, logistics optimization and stakeholder management, the use of blockchain and Industry 4.0 technologies to enhance traceability, and the formation of competitive advantages based on digital solutions.

The work of Baierle et al. (2022) shows that in the context of "Agriculture 4.0", digital technologies (IoT sensors, big data analytics, automation) form a new profile of the competitiveness of the food industry: those companies that build end–to–end digital chains, from field to shelf, benefit. Bickaŭskė et al. (2022) highlights that the digital transformation of agri-food systems is shifting value creation centers towards data management, platforms, and chain coordination, rather than just towards physical production.

Thus, at the international level, digital logistics is considered as:

- a tool to increase the sustainability of supply chains;
- a mechanism for reducing logistical costs and losses;
- a source of new competitive advantages due to speed, transparency and service differentiation.

2.2. Competitiveness of the dairy industry: an international context

Research on the competitiveness of the dairy industry in the EU and the Visegrad Group countries (Nagy & Jámbor, 2019) shows that highly processed products, economies of scale, innovation and knowledge accumulation are crucial factors of competitiveness. Analyzing trade competitiveness, the authors conclude that the most successful countries focus on a narrow set of high-value-added products and effectively integrated logistics solutions (cold chain, supply coordination, integrated IT systems).

The doctoral work of Chugi, S. K. (2022) on the logistical efficiency of fresh milk processing enterprises in Kenya shows that logistical performance (speed of supply, reliability, coordination with suppliers and consumers) is directly related to the competitive positions of companies in the market and their ability to withstand price competition.

A systematic review of artificial intelligence in the dairy supply chain (Serrano-Torres, et al., 2025) shows that AI algorithms (Gradient Boosting, Random Forest, neural networks) can significantly improve demand forecasting, route optimization, quality control, and traceability, reducing losses and increasing chain resilience.

In all these works, digital technologies and logistics act as key channels for increasing competitiveness, but mainly using the example of EU countries, India, Kenya and other foreign cases.

2.3. Kazakhstan's research on digitalization and the dairy industry

Kazakhstan's scientific discourse on the dairy industry and the digitalization of the agricultural sector has been shaped in waves and for a long time has focused mainly on production rather than logistical aspects. A number of authors described in detail the state of the milk and dairy products market, structural imbalances and institutional constraints, but without an explicit focus on digital logistics.

Thus, Nurpeisova (2016) analyzes the state and problems of the milk and dairy products market of the Republic of Kazakhstan in the context of integration into the EAEU. The author shows a steady shortage of high-quality raw materials, a high level of import dependence on certain types of dairy products and points to the insufficient effectiveness of existing mechanisms of state regulation and support for producers. Mirzalieva и Nurmagambetova (2017) complement this picture by considering milk production in Kazakhstan in the context of WTO membership: they emphasize that the opening of markets exacerbates competition, and the low technological efficiency and fragmentation of the industry limit the export potential of domestic producers.

In the works of Rustembaev, Kazkenova и Aynakanova (2016), Kazhieva (2020) and Baiguzhinova et al. (2025),

the emphasis is on the production and raw materials link: the dynamics of milk production and processing, the structure of farms by category, the influence of price conditions and institutional factors on the behavior of producers are analyzed. These studies demonstrate that the key bottlenecks remain the dominance of personal subsidiary farms, irregular supply of raw materials, low utilization of processing capacities and a high proportion of intermediaries in the value chain. At the same time, the issues of digital transformation of logistics processes, as a rule, are addressed only indirectly – through mentioning the need for modernization and increasing market transparency.

A separate block of research is devoted directly to the digitalization of agriculture and dairy subcomplex. The article by Tsapova (2025) explicitly refers to the digitalization of the agro-industrial complex as the "requirement of the century": it emphasizes the need to move to digital platforms, precision farming, animal health monitoring systems and resource-saving technologies in agriculture. Against this background, the works of Akhmedyarov (2019) and Baigabulova et al. (2019) act as a bridge between the general agenda of the digital economy and the specifics of the dairy industry. Akhmedyarov (2019) shows that the integrated use of digital technologies along the entire chain – from the production unit to the end user – can reduce losses, improve the quality of raw materials and processed products, and partially solve the problem of population outflow from rural areas. Baigabulova et al. (2019) complement this by specifying measures to digitalize the dairy industry: the use of GPS coordinates and digital mapping of raw material zones, the introduction of information systems for monitoring the quality of raw milk, automation of accounting and the formation of a "milk balance", as well as reducing the number of intermediaries in the supply chain.

Moreover, even in these works, digital logistics acts more as one of the elements of the general digitalization of the agro-industrial complex than as an independent object of analysis. In fact, Kazakh research captures the structural problems of the market, recognizes the role of digital technologies and describes individual initiatives (digital mapping projects, quality monitoring, electronic document management elements), but does not form a holistic concept of digital logistics of the dairy chain and its impact on the competitiveness of the industry. Logistical aspects such as optimizing milk-run routes, digital supply coordination platforms, Track&Trace systems, and integration with retail chains remain either out of focus or described at the level of general declarations.

It is against this background that the research gap becomes obvious: the Kazakh literature creates a rich empirical background on the problems of the dairy industry (shortage of raw materials, dominance of private farms, underutilization of capacities, the role of intermediaries), but does not provide a well-developed model of how digital logistics can transform the structure of added value, reduce transaction costs and increase the competitiveness of the dairy subcomplex in the EAEU and the WTO. This article is based on the specified body of work and offers just such a logistical and digital framework.

2.4. Research GAP

A comparison of international and Kazakh literature allows us to identify several unresolved but significant gaps in the study of digital logistics in the dairy subcomplex of Kazakhstan.

First, international work on logistics 4.0 and digital supply chains examines agribusiness as a whole or individual types of products, but does not focus on the specifics of countries with economies in transition and a high proportion of personal subsidiary farms in the structure of dairy production.

Secondly, Kazakhstani studies describe in detail the problems of the dairy industry and the possibilities of digitalization, but are mainly limited to qualitative analysis and description of individual digital initiatives. The relationship between specific elements of digital logistics and measurable indicators of competitiveness (exports, capacity utilization, price position, quality) remains insufficiently formalized.

Thirdly, there is practically no integrated model in existing works that would combine logistics 4.0, the cluster approach and national support institutions into a single framework for assessing the impact of digital logistics on the competitiveness of the dairy industry in Kazakhstan.

This article attempts to partially close these gaps by offering a methodological approach and a conceptual model based on the Kazakh context and based on real statistical and industry data.

3. METHODOLOGY

The methodological approach is constructed as an evidence-based, multi-stage study based on a combination of several complementary methods. First, the analysis of official statistics and international reports is used to quantify the current state of Kazakhstan's dairy industry, the dynamics of production and processing, as well as the country's place in global innovation development rankings. Secondly, content analysis of scientific publications on digital logistics and the dairy industry is used, which makes it possible to identify key concepts, research areas and practices

for implementing digital solutions in different countries. Thirdly, based on the collected data and theoretical approaches, integral indexes and scenario modeling are being built, allowing us to conceptualize the impact of digital logistics on the competitiveness of the dairy industry and formulate possible trajectories of its transformation.

The empirical research base includes three large blocks of sources. The first block consists of official statistics data: information from the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan on milk production and processing, the structure of production by category of farms, the level of consumption of dairy products per capita, as well as indicators of the Global Innovation Index, reflecting Kazakhstan's position on the level of innovative development. The second block is represented by materials from international organizations: forecasts by the OECD/FAO on the dynamics of the global dairy market and consumption of dairy products, as well as calculations by the EBRD and OECD on the structure of the added value of a liter of milk in Kazakhstan, the role of intermediaries and the size of their margins. The third block consists of scientific publications and analytical reports: Kazakhstani research on the digitalization of the agricultural market and the dairy industry, as well as international articles on logistics 4.0, digital supply chains and the competitiveness of the dairy sector. This combination of sources provides both the depth of theoretical analysis and the empirical validity of the conclusions and the proposed conceptual model.

The construction of an integral digital logistics index involves a transition from a qualitative description of digital solutions to a formalized assessment of their cumulative impact on the efficiency of the dairy chain. For this purpose, the Digital Dairy Logistics Index (DDLI) is being introduced for the dairy industry. Its value is interpreted as an integral measure of the maturity of digitalization of logistics processes at all stages – from the raw material zone to interaction with retail chains. Formally, the index can be represented as a weighted sum, where each element reflects the level of implementation of a separate digital solution, and the weighting factors determine its importance for the formation of competitive advantages:

$$DDLI = \sum_{j=1}^{n} w_j \times d_j \qquad\qquad (1)$$

where d_j is the normalized digital solution implementation rate j (in the range from 0 to 1), and w_j is its weighting factor, determined based on expert assessments and literature analysis on digital logistics. Thus, DDLI takes into account both the breadth of use of digital tools and their relative contribution to improving supply chain efficiency.

The d_j indicators structure includes the most significant elements of digital logistics: digital mapping of the raw material zone (GIS and GPS technologies), automated monitoring of raw milk quality, electronic procurement and contracting platforms with suppliers, milk-run route optimization systems, digital warehouse and cold chain management solutions (WMS, temperature monitoring), technologies traceability and labeling of products, as well as a system of digital interaction with retail chains and end users. This content provides coverage of key points of occurrence of transaction costs and logistical risks in the dairy chain.

To analyze the relationship between digital logistics and industry competitiveness, the *Dairy Competitiveness Index* (DCI) is introduced, an aggregated indicator reflecting the market and technological position of the dairy industry. The index is proposed to be represented as a function of four groups of parameters:

$$DCI = f(Q, C, E, I) \qquad\qquad (2)$$

where component Q describes the quality characteristics of products, including the stability of the quality of raw materials and compliance with technical regulations; component C reflects price competitiveness through cost structure and value added; component E characterizes export potential and actual presence in foreign markets; parameter I includes the technological and innovative maturity of the industry.

This functional representation allows us to trace how the growth of DDLI – through reducing losses, improving the quality of raw materials and finished products, reducing logistics costs, increasing transparency of the chain and strengthening trust between participants – transforms the values of components Q, C, E and I. Accordingly, digital logistics is beginning to act not only as an operational tool, but also as a strategic driver of the competitiveness of the dairy industry, which is consolidated in the resulting dependence of DCI on DDLI.

4. RESULTS AND DISCUSSION

4.1. Structural constraints on the competitiveness of the dairy industry in Kazakhstan

Based on the data of Akhmedyarov (2019) and Baigabulova et al. (2019), it is possible to summarize the key

structural characteristics of the dairy industry in Kazakhstan (Table 1).

Table 1. Key structural indicators of the dairy industry in Kazakhstan

Indicator	Value / characteristic	Source
Number of milk processing plants	≈ 150 enterprises	Baigabulova et al. (2019)
Installed processing capacity	of 2 million tons per year	Baigabulova et al. (2019)
Actual capacity utilization	≈ 70 %	Baigabulova et al. (2019)
Share of industrial processing of raw milk (CR)	32 % (2018)	Baigabulova et al. (2019)
Share of private subsidiary farms in gross milk production	≈ 75 %	Akhmedyarov (2019)
Consumption of milk and dairy products per capita in Kazakhstan	260.4 kg (38% below the norm)	Baigabulova et al. (2019)
Kazakhstan's position in the Global Innovation Index	79-82 places in 2014-2016, 74th in 2018	Akhmedyarov (2019), GII

Table 1 shows that with a sufficiently developed processing network, the industry faces a double structural gap:
- in terms of raw materials – low quality, high seasonality, dominance of small personal subsidiary farms, weak integration with processing;
- in terms of innovation, the country's overall innovation potential is low and the implementation of digital solutions is lagging.

Underutilization of capacities in the presence of an internal shortage of dairy products signals the inefficiency of existing supply chains and low transparency of the channels of movement of raw materials. This already directly links logistics with competitiveness: due to gaps in the supply chain, the country is losing added value, giving way to imported goods.

4.2. The current state of digital logistics in the dairy industry of Kazakhstan

Kazakhstan is already implementing a number of digital projects related to the logistics of the dairy chain: automated "milk balance", raw material quality monitoring systems, digital mapping of pastures, information platforms for state regulation (animal registration, veterinary and phytosanitary systems, electronic exchanges) (Akhmedyarov, 2019; Baigabulova et al., 2019).

Based on the analysis of the works of Akhmedyarov (2019), Baigabulova et al. (2019) and official documents, it is possible to qualitatively assess the level of implementation of digital solutions by stages of the chain (Table 2).

Table 2. The level of implementation of digital solutions in the logistics of Kazakhstan's dairy chain

Stage of the chain	Key digital solutions	Current level of implementation	Potential effects
Raw milk production (farms, private farms)	GPS / GIS pasture mapping, touch-based animal monitoring, mobile applications for farmers	Low-medium (local pilots, large farms)	Productivity growth, reduction of feed losses, raw material quality management
Collection and primary logistics	Electronic supplier registers, online contracts, electronic invoice system, tank tracking	Low-medium	Reduction of transaction costs, route optimization, reduction of delivery time
Processing	of MES / ERP systems, automated quality control, digital "milk balance"	Medium (large factories)	Improving quality stability, better capacity utilization, reducing production losses
Wholesale and retail	Warehouse Management Systems (WMS), integration with online retail, electronic document	management Low-medium	Inventory reduction, increasing turnover, improving service
End-to-end traceability and analytics	Labeling, blockchain solutions, big data analytics, predictive demand models	Low (separate models) pilots)	Increased consumer confidence, reduced fraud, better pricing policy

The analysis shows an asymmetry: some elements of digitalization are present, but end-to-end digital logistics in the spirit of Logistics 4.0 has not yet been formed. Especially vulnerable are the raw material collection stage and the "*processing-wholesale and retail network*" junction, where a large number of intermediaries and manual operations remain.

Comparing with European and Asian examples, where IoT, blockchain, and AI are actively used to monitor quality, optimize routes, and predict demand, we can talk about a serious technological lag that is turning into a competitive gap.

4.3. Digital logistics and value added structure

Baigabulova et al. (2019), based on calculations by the EBRD and the OECD, show that about a third of the added

value of a liter of milk in Kazakhstan is accounted for by intermediaries and retailers, who do not create real added value, but only increase the final price for the consumer.

Using these data, it is possible to present basic and digital scenarios of the value added structure (Table 3).

Table 3. The structure of the added value of 1 liter of milk: basic and digital scenario

Indicator	Basic scenario (before digitalization)	Digital scenario (advanced digital logistics)	Estimated effect
The share of intermediaries and retail in added value	$\approx 33\%$	15-20 %	Reduction of the trade mark-up by 13-18 p. p., cheaper products for the consumer
Utilization of processing capacities	70 %	90 %	1.3-fold increase in capacity utilization due to better coordination of raw material flow
Share of industrially processed raw milk (CR)	32 %	45-50 %	Increased involvement of raw materials in processing, increased output of high-value-added products
Share of raw materials corresponding to technical regulations (from private farms)	$\approx 10\%$	30-40 %	Improve quality through monitoring and digital standards
Logistics and transaction costs in the chain	High, fragmented levels	Lower by 10-20 %	Save money by optimizing routes and reducing paperwork
Note: the values for the digital scenario are estimated and are based on the logic of Baigabulova et al. (2019), international practice of digital chains (Baierle et al., 2022; Soledispa-Cañarte et al., 2023) and assumptions about reducing the number of intermediaries.			

Table 3 shows how an increase in the DDLI index leads to an improvement in the DCI components.:

- price competitiveness is enhanced by reducing margins and logistical costs;

- high-quality competitiveness is enhanced through an increase in the share of raw materials corresponding to technical regulations;

- export potential is being strengthened by increasing the share of processed raw materials and quality stabilization;

- the industry's innovation is growing due to the introduction of digital solutions and the formation of competencies in the field of data and logistics.

4.4. Conceptual model of digital logistics and competitiveness

Based on the international concepts of Logistics 4.0 and Agriculture 4.0 and Kazakhstani realities, a conceptual model is proposed in which digital logistics acts as a link between institutional drivers, technological solutions and the competitiveness of the dairy industry.

| Block 1. Institutional and market drivers | Requirements of technical regulations and international quality standards | Market pressure from imported dairy products |
| | State policy of digitalization | State policy of digitalization |

Block 2. Digital logistics solutions	Digital mapping of the raw material zone and pastures	Digital platforms for the purchase of raw materials and the conclusion of contracts
	Real-time quality monitoring systems for raw materials and products	Optimization algorithms for routing and inventory management
	Traceability and labeling systems (in the future, blockchain)	

| Block 3. Operational effects | Reduced logistical and transaction costs | Reduction of product losses and spoilage |
| | Increased utilization of processing capacities | Increase the transparency of the chain and trust between participants |

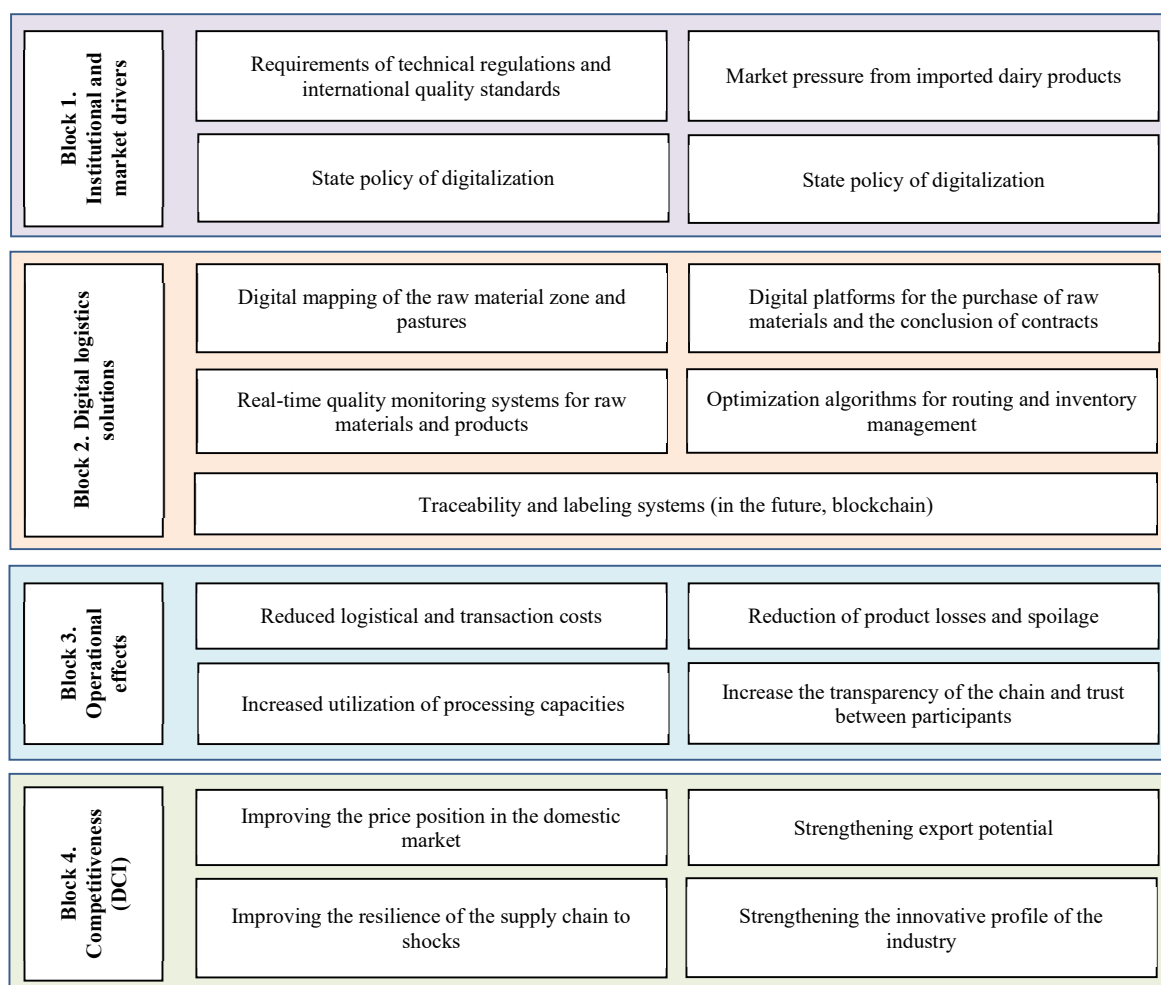| Block 4. Competitiveness (DCI) | Improving the price position in the domestic market | Strengthening export potential |
| | Improving the resilience of the supply chain to shocks | Strengthening the innovative profile of the industry |

Figure 1. Conceptual model of the impact of digital logistics on the competitiveness of the dairy industry

The links between the blocks are two-way: successful digital solutions that enhance DCI, in turn, create a political demand for further support for digitalization and form new institutional mechanisms (for example, cluster initiatives and industry-specific digital platforms).

5. CONCLUSION

The analysis showed that the competitiveness of the dairy industry in Kazakhstan is largely limited not by the resource base, but by the inefficiency of traditional logistics chains: a high proportion of intermediaries in value added, underutilized processing capacities, low integration of personal subsidiary farms and farms with processors, as well as weak digitalization of key logistics links.

The international experience of logistics 4.0 and Agriculture 4.0 shows that digital logistics can become one of the main levers for increasing the competitiveness of the dairy sector – through cost reduction, quality improvement, strengthening traceability and the formation of new forms of coordination of chain participants.

The article proposes:

- the integrated digital logistics Index (DDLI) and the dairy Industry Competitiveness Index (DCI), which conceptually describe how digital solutions in logistics transform the value added structure and market positions of the industry;

- analytical assessment of the structural constraints and possible effects of digital logistics based on real statistical data and industry reports;

- a conceptual model linking institutional drivers, digital logistics solutions, operational effects, and competitiveness.

From a theoretical point of view, the work helps clarify the role of digital logistics in shaping the competitiveness of the dairy sector in transition economies. From a practical point of view, it offers a framework for designing logistics digitalization roadmaps and industry cluster initiatives.

Promising areas of further research include: empirical assessment of DDLI and DCI based on a survey of dairy industry enterprises, the use of structural modeling (SEM) methods to quantify the impact of digital logistics solutions on competitiveness, as well as the development of pilot digital platforms for managing the raw materials zone and logistics of dairy products in certain regions of Kazakhstan.

Funding

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Determinants of Subjective and Objective Financial Wellbeing: An Empirical Analysis

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Abstract

Research shows that the perception of financial wellbeing (FWB) can differ from the level of objective financial wellbeing, and therefore, the aim of the paper is to examine whether the determinants of subjective and objective financial wellbeing coincide or not. To test the hypothesis, we use data from the 2018 EU-SILC survey conducted on Slovak households. The results suggest that the determinants are the same, however, the strength of their influence and/or statistical significance is different. Subjective financial wellbeing (SFWB) is significantly influenced by age, gender, education, employment, perceived health status, and homeownership. Objective financial wellbeing (OFWB) is no longer significantly influenced by age, gender, and employment; on the other hand, dependent children and indebtedness by loans are more significant than for subjective financial wellbeing. The results of the paper can contribute to creating more effective steps aimed at achieving financial wellbeing as a mediator to overall wellbeing.

Keywords: subjective financial wellbeing, objective financial wellbeing, financial satisfaction, financial burden

1. INTRODUCTION

Financial wellbeing has become an increasingly significant topic in economic and social research, reflecting the growing awareness that financial stability is essential not only for individual overall wellbeing and mental health but also for economic growth. Financial wellbeing can be understood as a multidimensional construct that includes both objective indicators – such as income, savings, or debt – and subjective perceptions of financial security, control, and satisfaction. In the current global context, characterized by persistent inflation, housing unaffordability, and economic uncertainty, financial wellbeing has emerged as a key determinant of overall life satisfaction and overall wellbeing. According to the Global Financial Wellbeing Report (2025), only 29% of people worldwide feel optimistic about their financial future. This suggests that even when macroeconomic conditions appear stable, individual perceptions of financial wellbeing may deteriorate.

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Financial wellbeing, as a multidimensional concept, is examined across multiple scientific disciplines, and authors work with various definitions of it. In this paper, we use the definition of financial wellbeing as an individual's ability to maintain their current and future desired standard of living associated with financial freedom, while being able to fully meet their obligations. This definition combines its subjective dimension (from Brüggen et al., 2017) and its objective dimension (from Kempson & Finney, 2017).

The basic determinants from the literature include objectively measurable quantities such as income, wealth, indebtedness, and employment status (Brown & Gray, 2016; D'Ambrosio et al., 2009; Headey & Wooden, 2004; Dolan et al., 2009; Ferrer-i-Carbonell, 2005; Brown et al., 2005; Dackehag et al., 2019; Gray, 2014; Keese & Schmitz, 2010; Norvilitis, 2014). More recent studies have begun to differentiate subjective financial wellbeing, which is more sensitive to psychological determinants such as sense of control, financial literacy, future expectations, and financial socialization (Castro-González et al., 2020; Rea et al., 2019; Fong et al., 2021; Drever et al., 2015; Fazli Sabri et al., 2012; Lapidos et al., 2018; Philippas & Avdoulas, 2020; Postmun et al., 2015). Indispensable determinants also include socio-demographic characteristics: age, gender, number of dependent children, health status, education or marital status (Belbase et al., 2020; Niedzwiedz et al., 2015; Panisch et al., 2019; Prawitz et al., 2006; Bonke & Browning, 2009; Brown & Gray, 2016; Fan & Babiarz, 2019; Headey & Wooden, 2004; Malone et al., 2010). The results suggest that financial wellbeing is not just about how much an individual owns, but also about how they perceive their financial situation and how they manage their financial steps. The current body of literature on financial wellbeing is heavily oriented towards research findings from the USA, Australia, and the United Kingdom (Mahendru et al., 2022). The persistent research gap lies in the non-comprehensive treatment of the subjective and objective dimensions of financial wellbeing, a deficit that is particularly evident in specific European economic and social conditions.

This paper addresses this gap by providing an empirical analysis of the determinants of subjective and objective financial wellbeing using microdata from Slovak households. Ordered probit regression models are applied to estimate how demographic, socio-economic, and financial variables influence both dimensions of financial wellbeing. The analysis includes factors such as age, gender, education, marital status, number of dependent children, employment status, indebtedness, homeownership. By simultaneously modeling both subjective and objective measures, the paper aims to capture the complex interplay between financial situation and psychological evaluation of financial wellbeing.

Overall, the results show that the determinants of both subjective and objective financial wellbeing are the same; however, their strength and statistical significance differ. Age, gender, and employment remain significant only for subjective financial wellbeing, while dependent children and indebtedness play a stronger role in determining objective wellbeing. Poor perceived health and material deprivation exhibit the strongest negative impacts across both models, emphasizing the multidimensional nature of financial distress.

The paper is structured as follows. In the second section, we define the Methodology and Data. In the next section, we present the Results of determinants of subjective and objective financial wellbeing. The Conclusion summarizes the key findings, limitation and future research area.

2. METHODOLOGY AND DATA

To identify the determinants of financial wellbeing, this paper employs ordered probit regression models. The ordered probit model is appropriate because the dependent variable, financial wellbeing is measured on an ordinal scale, reflecting increasing levels of satisfaction with financial situation (e.g. from "very dissatisfied" to "very satisfied"). Unlike linear regression, the ordered probit approach accounts for the non-linear spacing between these ordered categories, providing more reliable estimates of the probability that an individual belongs to a particular level of financial wellbeing. (Daykin & Moffatt, 2002)

Let y_i^* denote the latent (unobserved) continuous variable representing the underlying financial wellbeing of individual i. The observed ordinal outcome is determined as follows:

$$y_i^* = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + \varepsilon_i$$

(1)

where X_{ki} are explanatory variables capturing individual and household characteristics, and ε_i is a random error term assumed to follow a standard normal distribution. The observed categorical variable takes values according to threshold parameters:

$$y_i = \begin{cases} 0 & if \ y_i^* \leq \mu_1 \\ 1 & if \ \mu_1 < y_i^* \leq \mu_2 \\ 2 & if \ \mu_2 < y_i^* \leq \mu_3 \\ \vdots & \\ J & if \ y_i^* > \mu_j \end{cases}$$

(2)

The estimated β coefficients indicate the direction of the relationship between each determinant and financial wellbeing. A positive coefficient suggests that the variable increases the probability of belonging to a higher category of financial wellbeing, while a negative coefficient indicates the opposite effect.

The paper estimates two types of models: 1. model where the dependent variable is subjective financial wellbeing, and 2. model where the dependent variable is objective financial wellbeing. The set of explanatory variables X is composed of the variables in Table 1, which simultaneously indicate the estimated direction of influence on financial wellbeing based on previous literature.

To verify the quality of the estimated models, their explanatory power was also evaluated using McFadden's Pseudo-R^2. This indicator expresses the relative improvement in the log-likelihood of the model with explanatory variables compared to the null model without predictors. Unlike the classical coefficient of determination, R^2, used in linear regressions, McFadden's Pseudo-R^2 does not typically achieve high values, as it is derived from the log-likelihood rather than the variance of the errors.

In the paper, we empirically analyze data from the EU-SILC survey for Slovakia in 2018. In that year, the module focused on assessing the subjective financial wellbeing of individuals and households, questions about the ability to create savings, cover unexpected expenses, and cope with financial problems, material deprivation, and access to basic needs. The database contains 5,537 households across all regions of Slovakia. All presented results are calculated using the specified household weights in order to ensure the data's representativeness at the population level.

Table 1. The set of explanatory variables X

Variable	The estimated direction of influence
Age	expected a non-linear relationship, which is why the age squared is also included
Gender	unable to estimate
Education	expected positive effect
Marital status	unable to estimate
Dependent child	expected negative effect
Employment	expected positive effect
Perceived health status	expected negative effect
No debt (other type of loan)	expected positive effect
No debt (mortgage)	expected positive effect
Homeownership	expected positive effect

Source: own processing based on previous literature

2.1. Dependent variables

Following the dual perspective of financial wellbeing, we work with two key concepts: objective financial wellbeing and subjective financial wellbeing. The precise wording of the survey questions is summarized in Table 2. OFWB is defined based on the approach of Kempson and Finney (2017), which emphasizes an individual's ability to comfortably cover current obligations and needs and maintain financial resilience for the future. The measurement of this variable is carried out according to Comerton and Forde (2018) through the sum of the following indicators:
- Arrears on rent/mortgage: this indicates the household's ability to meet housing-related obligations. Higher values mean a better ability to repay.

- Arrears on utility bills: this reflects the household's ability to pay regular utility bills. Higher values mean a better ability to meet utility obligations.
- Arrears on other loans (excluding mortgages): this indicates the ability to meet obligations arising from other forms of credit. Higher values mean a better ability to repay.
- Ability to face unexpected expenses: this represents the degree of financial resilience and readiness for future unforeseen expenses. Higher values mean a higher ability to face unexpected expenses.

SFWB represents a direct question asking the respondent to express their financial wellbeing by rating their satisfaction with their financial situation. It directly reflects the feeling of financial security, as suggested by Muir et al. (2017) in their definition of "feeling financially secure." In the EU-SILC data, it is measured on a scale of 0 to 10, where higher values mean higher satisfaction. For better comparison and further analysis, we aggregated OFWB and SFWB to a scale of 1 to 5.

Table 2. Questions from EU-SILC 2018

Variable	Question in Questionnaire
Arrears on Rent/Mortgage	"In the last twelve months, has your household been in arrears—i.e., unable to pay on time due to financial difficulties—on payments for: (a) rent (b) mortgage installments for the main dwelling?"
Arrears on Utility Bills	"In the last twelve months, has your household been in arrears on payments for utility bills (heating, electricity, gas, water, etc.) for the main dwelling, i.e., were you unable to pay them on time due to financial difficulties?"
Arrears on Other Loans (excluding mortgages)	"In the last twelve months, has your household been in arrears on payments for installment purchases or other loans (excluding mortgages), i.e., were you unable to pay these installments on time due to financial difficulties?"
Ability to Face Unexpected Expenses	"Is your household able to cover an unexpected essential expense amounting to (state amount) and pay for it from its own resources?"
SFWB	"Overall, how satisfied are you with the financial situation of your household?"

Source: own processing based on EU-SILC 2018

2.2. Independent variables

The independent variables used in the model include various types of variables – dichotomous (dummy), ordinal, and continuous.

Dummy variables are gender, marital status, dependent children, employment, no debt, homeownership. The variable *Gender* takes the value 1 if the respondent is male and 0 if female. The variable *Employment* takes the value 1 if the respondent is employed and 0 for other types of economic activity (such as unemployed, retired, students, or other inactive individuals). The variable *Marital status* is coded 1 for married respondents and 0 for all other marital statuses (single, divorced, or widowed). The variable *Dependent children* is dichotomous and takes the value 1 if the respondent has at least one dependent child and 0 otherwise. The variable *No debt* is represented by two dummy variables: one indicating no other type of loan debt and one for no mortgage debt, each equal to 1 if the household has no outstanding debt of that type. Finally, the variable *Homeownership* takes the value 1 if the respondent owns a house or apartment and 0 if living in rented or other types of accommodation.

Continuous variables are age and age squared. The variable *Age* is continuous and is included in the model together with its squared term (Age^2) to capture the non-linear effect of age on subjective financial wellbeing (i.e., an effect that may increase up to a certain point and then decline later in life).

Ordinal variables are education and perceived health status. The variable *Education* represents the respondent's highest level of education attained, where 1 denotes primary education, 2 secondary education, and 3 tertiary education. The variable *Perceived health status* captures the respondent's self-assessed health on a scale from 1 to 5, where 1 indicates the best and 5 the worst health status.

3. RESULTS

3.1. Descriptive analysis

Table 3 presents the percentage distribution of households according to selected socio-demographic and economic characteristics, as well as the level of achieved financial well-being, divided into subjective financial well-being (SFWB) and objective financial well-being (OFWB). The aim is to compare how different groups of households vary in their perception of financial situation and in their objective economic conditions.

From an age perspective, higher values of subjective financial well-being are observed among middle-aged households, particularly between 35 and 55 years. Younger households (under 35) report lower subjective wellbeing levels, which can be attributed to lower economic stability and higher indebtedness typical for this stage of life. In contrast, the highest levels of objective financial well-being are concentrated among households over 55 years old, reflecting the effects of accumulated wealth, homeownership, and lower financial burdens.

Men achieve higher levels of both subjective and objective financial well-being than women. This difference can be associated with higher wages and more stable employment positions among men, which are reflected in both the objective and subjective dimensions of well-being.

Households with tertiary education reach significantly higher levels of both subjective and objective well-being compared to those with primary education.

Regarding economic activity, employed individuals exhibit higher financial well-being than other groups. Households whose main earner is an employee report greater satisfaction and objectively better financial wellbeing compared to those outside the labor market.

Married couples are generally in a better position than other households. Their higher financial well-being may be linked to the combination of two incomes and a more stable economic environment. However, households with dependent children show lower levels of both subjective and objective financial well-being, suggesting that the presence of children increases financial pressure.

In relation to health status, there is a clear tendency for financial well-being to decline with deteriorating health. Households reporting very good or good health show the highest levels of financial wellbeing, whereas poor health is associated with significantly lower values of both indicators.

The absence of debt has a positive effect on both dimensions of financial well-being. Households without consumer loans or mortgages tend to achieve higher levels of objective well-being, indicating the importance of financial stability and lower indebtedness for both objective financial wellbeing and perception of one's financial situation.

Homeowners achieve markedly higher shares in the top categories of both subjective and objective well-being compared to tenants. This relationship underscores the role of property ownership as a factor of economic security and subjective sense of prosperity.

Finally, material deprivation clearly reduces the level of financial well-being. Households that are not materially deprived achieve high values in the upper categories of financial well-being, while deprived households are concentrated in the lowest levels of both indicators.

Table 3. Percentage distribution of households according to a given characteristic and the value of acquired financial wellbeing

	SFWB						OFWB					
	1	2	3	4	5	Overall	1	2	3	4	5	Overall
Overall	5.36%	11.35%	40.10%	29.82%	13.36%	100.00%	1.68%	1.52%	4.27%	29.99%	62.54%	100.00%
Age												
under 35	0.34%	0.89%	4.43%	4.19%	2.00%	11.85%	0.30%	0.12%	0.52%	0.53%	0.21%	1.68%
over 35 under 45	1.10%	1.73%	7.42%	8.12%	4.33%	22.70%	0.30%	0.39%	0.73%	0.09%	0.01%	1.52%
over 45 under 55	1.31%	2.38%	7.44%	5.23%	2.45%	18.81%	0.84%	0.99%	1.42%	0.68%	0.33%	4.26%
over 55 under 65	1.32%	2.82%	9.35%	6.38%	2.68%	22.55%	2.73%	6.06%	14.37%	5.58%	1.25%	29.99%
over 65	1.30%	3.53%	11.45%	5.90%	1.91%	24.09%	1.20%	3.79%	23.05%	22.94%	11.56%	62.54%
Gender												
Man	2.92%	7.28%	25.16%	16.63%	6.55%	58.54%	1.04%	1.09%	2.32%	18.76%	35.32%	58.53%

Woman	2.45%	4.08%	14.94%	13.19%	6.82%	41.48%	0.64%	0.43%	1.95%	11.23%	27.23%	41.48%
Education												
primary	1.56%	2.34%	5.22%	1.65%	0.47%	11.24%	0.40%	0.55%	1.05%	5.22%	4.02%	11.24%
Secondary	3.45%	7.74%	29.13%	19.34%	8.02%	67.68%	0.95%	0.77%	2.58%	20.98%	42.39%	67.67%
Terciary	0.35%	1.27%	5.76%	8.84%	4.87%	21.09%	0.33%	0.20%	0.63%	3.79%	16.14%	21.09%
Employment												
Other	4.40%	8.06%	23.03%	13.63%	5.81%	54.93%	0.94%	1.06%	2.68%	18.39%	31.85%	54.92%
Employee	0.96%	3.29%	17.07%	16.19%	7.56%	45.07%	0.73%	0.46%	1.58%	11.60%	30.69%	45.06%
Marital status												
Other	3.25%	6.17%	17.64%	10.51%	4.81%	42.38%	0.95%	0.91%	2.09%	16.03%	22.41%	42.39%
Married	2.11%	5.18%	22.45%	19.31%	8.56%	57.61%	0.73%	0.61%	2.17%	13.97%	40.13%	57.61%
Dependent child												
No	3.64%	7.69%	25.53%	17.29%	7.29%	61.44%	0.92%	0.73%	2.20%	19.81%	37.77%	61.43%
Yes	1.72%	3.66%	14.57%	12.53%	6.08%	38.56%	0.75%	0.79%	2.07%	10.19%	24.77%	38.57%
Perceived health status												
Very good	0.60%	0.48%	3.91%	5.14%	3.48%	13.61%	0.11%	0.12%	0.45%	2.67%	9.72%	13.07%
Good	2.08%	3.19%	15.58%	15.57%	7.15%	43.57%	0.88%	0.58%	1.64%	11.05%	29.41%	43.56%
Fair	1.49%	4.23%	13.83%	6.57%	2.08%	28.20%	0.45%	0.35%	1.17%	9.92%	16.30%	28.19%
Bad	1.21%	2.60%	5.64%	2.15%	0.63%	12.23%	0.22%	0.30%	0.85%	4.75%	6.11%	12.23%
Very bad	0.53%	0.87%	1.08%	0.40%	0.05%	2.93%	0.01%	0.17%	0.16%	1.59%	1.00%	2.93%
No debt (other type of loan)												
No	1.85%	4.35%	14.62%	9.76%	5.12%	35.70%	1.68%	0.74%	1.84%	11.13%	20.31%	35.70%
Yes	3.52%	7.00%	25.47%	20.07%	8.24%	64.30%	0.00%	0.78%	2.43%	18.86%	42.23%	64.30%
No debt (mortgage)												
No	0.36%	1.14%	5.83%	6.07%	2.77%	16.17%	0.29%	0.19%	0.62%	3.95%	11.12%	16.17%
Yes	5.00%	10.22%	34.27%	23.75%	10.59%	83.83%	1.39%	1.33%	3.65%	26.04%	51.43%	83.84%
Homeownership												
No	1.17%	1.37%	3.80%	2.19%	1.01%	9.54%	0.23%	0.38%	0.78%	3.87%	4.28%	9.54%
Yes	4.20%	9.98%	36.29%	27.63%	12.35%	90.45%	1.45%	1.14%	3.49%	26.12%	58.26%	90.46%
Material deprivation												
No	3.38%	9.08%	37.76%	29.49%	13.23%	92.94%	1.57%	0.90%	3.00%	26.09%	61.37%	92.93%
Yes	1.98%	2.27%	2.34%	0.34%	0.13%	7.06%	0.10%	0.62%	1.27%	3.90%	1.17%	7.06%

Source: own processing based on EU-SILC 2018

The average values of subjective (SFWB) and objective financial well-being (OFWB) reveal systematic differences between how households perceive their financial situation and their actual economic conditions (Table 4). The overall mean of SFWB is 3.34, while the mean of OFWB is considerably higher (4.50), confirming that objective indicators of financial stability are generally more favorable than subjective assessments. Narrow confidence intervals for both measures indicate stable estimates.

Age differences show a gradual decline in SFWB with increasing age. The highest subjective financial well-being is reported by individuals under 45 (3.56–3.57), whereas the lowest is observed among households aged 65 and above (3.15). In contrast, OFWB remains relatively high across all age groups, with the highest values recorded among individuals aged 35–45 and 55–65 (4.53). This suggests that although older households do not exhibit substantially worse objective financial conditions, they perceive their financial situation significantly more negatively.

Men report higher averages of both subjective (3.43) and objective financial well-being (4.54) compared to women (3.28 and 4.47, respectively). Gender disparities therefore exist not only in perceptions but also in economic indicators.

Education represents one of the strongest determinants of both dimensions of financial well-being. Households with tertiary education report the highest values of SFWB (3.79) and OFWB (4.67), whereas those with primary education achieve the lowest values (2.74; 4.06). Education thus significantly enhances both financial satisfaction and objective financial stability.

Employed individuals report higher SFWB (3.58) and OFWB (4.58) compared to inactive or unemployed individuals (3.15; 4.44). Similarly, married households experience higher averages (SFWB 3.47; OFWB 4.60) than households in other forms of living arrangements.

An interesting finding is that households with dependent children report higher subjective financial well-being (3.46) compared to childless households (3.27), while their objective values are nearly identical. This may reflect higher motivation, social support, or different life expectations among households with children.

Significant and consistent differences appear in relation to perceived health status, where both subjective and objective financial well-being decline as health deteriorates. Households reporting "very good" health achieve averages of 3.88 (SFWB) and 4.66 (OFWB), whereas those with "very bad" health reach only 2.51 and 4.16. Financial well-being is therefore closely connected to health in both dimensions.

Households without other types of loans do not report higher subjective well-being than indebted households; however, indebtedness significantly increases objective financial well-being (4.59 vs. 4.34). In the case of mortgages, the situation is reversed: households without a mortgage show much higher SFWB (3.60), although differences in OFWB are relatively small. Homeownership is traditionally associated with higher financial well-being. Homeowners achieve higher SFWB (3.38) and OFWB (4.53) compared to renters (3.05; 4.22).

Finally, material deprivation emerges as one of the strongest factors reducing financial well-being. Non-deprived households achieve values of 3.43 (SFWB) and 4.56 (OFWB), whereas materially deprived households only reach 2.20 and 3.77. These differences are the most pronounced across all examined characteristics.

3.2. Regression analysis

To test the significance of the observed differences between the sociodemographic variables, we decided to further interpret the results of the ordered probit regression for both financial wellbeing groups. Table 5 presents the results of the ordered probit regressions estimating the determinants of subjective (Model 1) and objective financial wellbeing (Model 2). Both models are statistically significant, and the McFadden's Pseudo-R^2 values (0.0699 and 0.0661) indicate a satisfactory explanatory power given the ordinal nature of the dependent variables.

The results show that education, employment, marital status, homeownership, and absence of debt are positively associated with higher levels of financial wellbeing, both subjective and objective. Individuals with a higher level of education are significantly more likely to report greater satisfaction with their financial situation and better objective financial conditions. Men reported a significantly higher level of financial satisfaction than women. Although this trend remained positive, it is no longer statistically significant in terms of objective financial wellbeing.

In contrast, material deprivation and poor perceived health have a strong and negative effect in both models, confirming that economic hardship and worse health status considerably reduce financial wellbeing. The coefficient of material deprivation is the largest in magnitude, underscoring its central role as a determinant of both dimensions of financial wellbeing.

Age has a nonlinear relationship with subjective financial wellbeing: while the coefficient of age is negative and age² is positive, the results suggest a U-shaped pattern, implying that financial satisfaction tends to decline in midlife and recover slightly at older ages. These variables are not statistically significant for objective wellbeing.

The presence of dependent children negatively affects objective financial wellbeing, likely reflecting higher financial burdens associated with having children, but its effect on subjective wellbeing is not significant.

Table 4. Mean value of subjective and objective financial wellbeing

Variable	**SFWB**				**OFWB**			
	Mean	**Lin. Std. Err.**	**[95% conf. interval]**		**Mean**	**Lin. Std. Err.**	**[95% conf. interval]**	
Overall	3.34	0.017	3.31	3.38	4.50	0.013	4.48	4.53
Age								

under 35	3.56	0.049	3.46	3.65	4.50	0.040	4.43	4.58
over 35 under 45	3.57	0.039	3.49	3.64	4.53	0.033	4.46	4.59
over 45 under 55	3.27	0.042	3.19	3.36	4.51	0.030	4.45	4.56
over 55 under 65	3.28	0.034	3.21	3.35	4.53	0.026	4.48	4.58
over 65	3.15	0.026	3.10	3.20	4.45	0.024	4.40	4.49
Gender								
Man	3.43	0.028	3.37	3.49	4.54	0.021	4.50	4.58
Woman	3.28	0.021	3.24	3.32	4.47	0.017	4.44	4.51
Education								
Primary	2.74	0.045	2.66	2.83	4.06	0.051	3.96	4.16
Secondary	3.31	0.020	3.27	3.35	4.52	0.015	4.49	4.55
Tertiary	3.79	0.035	3.72	3.86	4.67	0.028	4.62	4.72
Employment								
Other	3.15	0.023	3.11	3.20	4.44	0.018	4.41	4.48
Employee	3.58	0.023	3.53	3.62	4.58	0.020	4.54	4.61
Marital status								
Other	3.18	0.027	3.12	3.23	4.37	0.023	4.32	4.41
Married	3.47	0.021	3.43	3.51	4.60	0.015	4.57	4.63
Dependent child								
No	3.27	0.021	3.23	3.32	4.51	0.016	4.48	4.54
Yes	3.46	0.028	3.40	3.51	4.49	0.024	4.44	4.54
Perceived health status								
Very good	3.88	0.041	3.80	3.96	4.66	0.031	4.60	4.73
Good	3.52	0.027	3.47	3.57	4.55	0.021	4.51	4.59
Fair	3.13	0.027	3.07	3.18	4.46	0.024	4.42	4.51
Bad	2.87	0.043	2.78	2.95	4.33	0.038	4.25	4.40
Very bad	2.51	0.089	2.34	2.69	4.16	0.076	4.01	4.31
No debt (other type of loan)								
No	3.33	0.029	3.28	3.39	4.34	0.029	4.28	4.39
Yes	3.35	0.021	3.31	3.39	4.59	0.013	4.57	4.62
No debt (mortgage)								
No	3.60	0.041	3.52	3.68	4.57	0.035	4.50	4.64
Yes	3.29	0.018	3.26	3.33	4.49	0.014	4.46	4.52
Homeownership								
No	3.05	0.062	2.93	3.17	4.22	0.049	4.12	4.31
Yes	3.38	0.017	3.34	3.41	4.53	0.014	4.51	4.56
Material deprivation								
No	3.43	0.017	3.40	3.46	4.56	0.013	4.53	4.58
Yes	2.20	0.060	2.08	2.32	3.77	0.053	3.66	3.87

Source: own processing based on EU-SILC 2018

Table 5. Order probit regression – results

VARIABLES	(1) Subjective financial wellbeing	(2) Objective financial wellbeing
Age	-0.0287***	0.0108
	(0.00992)	(0.0104)
Age2	0.000317***	-6.48e-05
	(8.99e-05)	(9.47e-05)
Gender	0.120***	0.0439
	(0.0377)	(0.0437)
Education	0.333***	0.302***
	(0.0351)	(0.0424)
Employment	0.229***	0.0747
	(0.0484)	(0.0539)
Marital status	0.130***	0.275***
	(0.0404)	(0.0456)
Dependent children	-0.00929	-0.131**
	(0.0466)	(0.0546)
Perceived health status	-0.295***	-0.143***
	(0.0229)	(0.0250)
No debt (other type of loan)	0.0666*	0.362***
	(0.0384)	(0.0434)
No debt (mortgage)	0.00818	0.00644
	(0.0590)	(0.0719)
Homeownership	0.254***	0.312***
	(0.0705)	(0.0651)
Material deprivation	-0.943***	-0.807***
	(0.0757)	(0.0587)
Observations	5,537	5,537
McFadden's Pseudo-R^2	0.0699	0.0661

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: own processing based on EU-SILC 2018

4. CONCLUSION

The main goal of this paper was to find out whether the factors that affect subjective and objective financial wellbeing are the same or different, using data from Slovak households. The study was motivated by the idea that people's feelings about their finances often do not match their real financial situation, and understanding this gap is important for both researchers and policymakers.

The main contribution of this paper is the comparison of subjective and objective financial wellbeing in one analysis. Using ordered probit regression models on EU-SILC 2018 data, the study offers one of the first detailed views of both types of financial wellbeing in Slovakia. The findings show that the same factors influence both types, but their strength and significance differ.

The results show that education, marital status, homeownership, and having no debt are linked to higher levels of both subjective and objective financial wellbeing. However, age, gender, and employment are significant only for subjective wellbeing, while having dependent children matter more for objective wellbeing. Poor health and material deprivation have the strongest negative effects on both.

Based on these results, policies to improve financial wellbeing should not only aim to raise income or reduce debt but also focus on psychological and social factors that affect how people feel about their finances. Improving financial literacy, supporting stable jobs, and helping families with children could lead to better and more lasting improvements in both perceived and real financial situations.

This study has some limitations. It uses cross-sectional data, which does not allow for conclusions about cause and effect. Also, subjective financial wellbeing was measured by only one question, which may not fully capture all its aspects. Future research should use longitudinal data to follow changes over time and include more psychological, behavioral, and cultural factors. Comparing results across European countries could also show if these patterns are similar in different contexts.

In conclusion, this paper adds to the growing research that shows financial wellbeing has both subjective and objective sides. Understanding both is essential for creating effective policies that support financial security, stability, and overall life satisfaction.

Acknowledgements

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Appendix A. Correlation matrix

Variable	SFWB	OFWB	Age	Age^2	Gender	Education	Marital status	Dependent children	Employment	Perceived health status	Material deprivation	No debt (other type of loan)	No debt (mortgage)	Homeownership
SFWB	1.000													
OFWB	0.298	1.000												
Age	−0.135	−0.006	1.000											
Age^2	−0.133	−0.013	0.990	1.000										
Gender	0.090	0.067	−0.021	−0.025	1.000									
Education	0.285	0.188	−0.242	−0.251	0.082	1.000								
Marital status	0.142	0.143	−0.120	−0.145	0.229	0.137	1.000							
Dependent children	0.045	−0.024	−0.526	−0.523	−0.019	0.115	0.211	1.000						
Employment	0.205	0.089	−0.549	−0.573	0.036	0.240	0.112	0.270	1.000					
Perceived health status	−0.323	−0.127	0.521	0.518	−0.055	−0.286	−0.124	−0.280	−0.402	1.000				
Material deprivation	−0.314	−0.270	0.037	0.035	−0.030	−0.200	−0.142	−0.014	−0.130	0.179	1.000			
No debt (other type of loan)	−0.101	−0.030	0.383	0.364	−0.018	−0.169	−0.082	−0.271	−0.207	0.218	0.074	1.000		
No debt (mortgage)	0.015	0.167	0.148	0.148	0.007	−0.005	−0.007	−0.094	−0.103	0.078	0.017	0.114	1.000	
Homeownership	0.090	0.135	0.153	0.133	0.004	0.068	0.120	−0.044	−0.023	0.026	−0.099	−0.116	0.006	1.000

Views, Clicks and Purchase Decisions: Evidence of Albanian Students' Behavior with Recommender Systems

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Abstract

E-commerce in Albania is an emerging market and therefore user perceptions need to be addressed properly. Recommender systems (RS) have long been an essential part of shopping sites and broadly studied in academia. They were born to help users navigate huge amounts of listed items online in order to ease their decision-making, while helping retailers boost sales. However, Albania remains an underexplored demographic in this regard. A survey was conducted with students in Tirana, Albania, 344 responses were collected and analysed both descriptively and statistically. Students reported they noticed and engaged with recommender systems frequently and this further affected their purchase decisions. The product categories they were most interested in when shopping online were fashion and cosmetics, whereas the visited websites reported most times were Zara and Temu. However, product category didn't seem to have any effect on the level of influence recommender systems had on their purchase decisions. Findings contribute to current knowledge on RS usage patterns in emerging markets, and inform future research directions, valuable for both academia and businesses.

Keywords: recommender systems (RS), purchase decisions, clicks, views

1. INTRODUCTION

E-commerce remains the dominant context where recommender systems (RS) are integrated. These systems, starting out in the simpler form of decision aids referred to as Decision Support Systems (DSS), commonly found on shopping sites in the '90s (Hess et al., 2008), have come a long way since then, by evolving from being interactive filtering mechanisms to help the user narrow down the set of products closer to their needs, to the personalized, AI-driven and adaptive systems of today, listing recommended items tailored to each particular users' needs and preferences, based on their profile, context and past behavior. In any case, towards the consumer, they all have one thing in common: they aim to help the consumer easily navigate through massive information and number of products or services on online shopping platforms, in order to help them find the items most suitable for them and make the best purchase decisions (Häubl & Trifts, 2000; Pu et al., 2012; Resnick & Varian, 1997; Ricci et al., 2022; Schafer et al., 2001). They are now an integral and expected part in online shopping websites, across a multitude of product and service categories. Numerous studies in the last decades have focused on different functional and visual aspects of these systems, respectively the algorithm, interface and interaction modalities, and their effects on the acceptance and usability of RS as well as their impact in helping retailers achieve their marketing goals in this

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context, related to consumer behavior like clicks or views metrics (Zeng et al., 2021), attitudinal, such as the system's influence in trust or brand perception (He et al., 2024) and performance ones such as conversion rates, sales etc. (Wasilewski & Kolaczek; 2024).

Similarly, in Albania, consumers are able to access both domestic and international shopping platforms, thus being exposed not just to online shopping experiences, but also to the recommended items. However, the country's e-commerce sector is still developing, and while it shows a noticeable growing trend in percentage of consumers engaged in online purchases of goods and services from 2020 to 2024 (Figure 1), according to data from Eurostat (2025), this percentage is consistently among the lowest within the European continent.

⟳ ✕	TIME	⬍ 2020	⬍ 2021	⬍ 2022	⬍ 2023	⬍ 2024
⬍ GEO						
Albania		5.61	9.55	13.59	16.33	17.85

Fig. 1. Percentage of individuals engaged in online purchases from 2020-2024. Source: Data from Eurostat (2025)

Thus, the level of experience and adaptation of users with recommender systems is still limited. Studies show that the level of experience related to these systems influences the users' behavior and attitude towards them (Komiak & Benbasat, 2006; Li et al., 2024). Existing research has been largely focused on developed countries, with digitally-mature markets and well-experienced consumers in terms of online shopping.

There is a considerable lack of research on the Albanian context with regards to user approach towards recommender systems in online shopping. Contextual elements such as the limited level of knowledge or familiarity of the users towards these systems as opposed to those in western developed countries, further highlights a need to address and examine their approach. This demographic was chosen, as students are generally known to be one of the most prone groups towards technology and digitalization, having it naturally incorporated in their everyday lives, and the capital city is usually related to the highest levels of digitalization compared to the rest of the country, therefore making it a good starting point for research. This study is exploratory and aims to shed light on attention and usage patterns of students of Tirana, Albania towards recommender systems as well as give suggestions for future research.

2. LITERATURE REVIEW

When navigating online for shopping purposes, to engage in the use of recommender systems also means to engage in a search or exploration process and thus RS become a means to stimulate user engagement with the website. A space is created where users have a personalized experience, because they are presented with item suggestions tailored for them, and interact with the system, meaning they not only obtain information from it but also implicitly give information on the products through their reactions, such as reading/ view time, clicks, additions of products in their basket etc., which all turn into log data the system uses to "learn" from and then to better personalize its suggestions according to the users preferences, as well as explicitly through ratings and reviews (Schafer et al., 2001). In any case, in the words of Resnick and Varian (1997), this does involve "a social process". This explicit information is visible to other users and helps orient them better towards their desired products. Recommender systems were created to do exactly that: to help users deal with an overload of information online and receive personalized information and recommendations for goods and services (Adomavicius & Tuzhilin, 2005). These systems have long been a business tool to help companies reach their marketing objectives, from the increase of engagement to that of revenue or sales and customer loyalty (Pathak et al., 2010; Ricci et al., 2022). Moreover, with the implementation of Machine Learning techniques, the influence of AI-driven personalization of recommendations on the system use has been naturally revisited (Yin et al., 2025). User engagement with the RS can be seen simultaneously as a source of feedback which the system uses as input, and also as an indicator of user acceptance of this technology, which is exactly where the importance lies: the fact that users are engaging with the system indicates they have accepted the system, they trust it and use it, and this acceptance is crucial for allowing RS to help online retailers reach their marketing objectives (Knijnenburg & Willemsen, 2015; Li et al., 2024; Pu et al., 2012). Decades ago, Häubl and Trifts (2000), while studying the earlier forms of today's recommender systems – DSS and specifically Interactive Decision Aids, have discussed their effects in consumer decision and demonstrated how they not only influence the search for a product and the quality of information obtained, but also the quality of the suggested sets of products and the quality of their purchase decisions when online shopping. Similarly, Senecal and Nantel (2004), among the first to conduct experimental studies with this focus, proved that

recommended products not only significantly reduced the decision effort but they also influenced this decision considerably, by increasing the likelihood of purchase, compared to products which hadn't been recommended to the users. The importance of factors like trust, usefulness and user satisfaction is emphasized (Pu et al., 2012), showing that the perceived level of transparency from the systems, dominantly linked to the provided explanations for the suggested products, leads the pathway to trust and then purchase (Li et al., 2024) and high effectiveness of recommendations is proven to largely influence consumption and retention (Gómez-Uribe & Hunt, 2016), directly linked to sales and loyalty. It all comes together, reconfirming the conceptual approach of Jannach and Adomavicius (2016), in considering recommenders as systems that do not only have one single aforementioned function, that of helping users find items, but rather serve a multitude of purposes, serving both customers and retailers.

Moreover, literature suggests different impact of RS depending on type or category of products they are implemented for. Early on, Schafer et al. (2001) have discussed the recommender systems' impact in cross-selling, implying that they can influence sales of complementary products or across categories, the idea has further emerged in later studies where it has been found that differences in product categories are linked to the level of performance of recommender systems. RS seem to be more effective for hedonic products (usually categories such as fashion) than functional and practical utilitarian ones (ex.: laptop memory card) by causing higher conversion and has a greater positive impact in product views for experience rather than search products (Lee & Hosanagar, 2020). Results from a field experiment conducted by Wan et al. (2024), on the other hand, suggest that recommenders are more helpful in product categories associated with higher heterogeneity in terms of consumer taste and bigger price dispersion, implying high variety categories, such as women's clothing. Similarly, statistical data consistently links fashion products to comparably higher sales levels in online shopping (Eurostat, 2025), re-emphasizing the importance of product category data and implications in e-commerce research.

Therefore, based on prior literature, regarding the students in Tirana, Albania, the three following research questions are introduced in this study:

RQ1: Do students interact frequently with recommender systems during online shopping?
RQ2: How much does the use of recommender systems influence the purchase decisions of students?
RQ3: Which are the product categories that recommender systems influence the most?

In Section 3 methodology is discussed, in Section 4 descriptive and inferential analysis and results are presented; Section 5 concludes this paper.

3. METHODOLOGY

This quantitative research was conducted in Tirana Albania. The survey consisted of a single item questionnaire, previously piloted in a focus group of 20 students for face validity, and then distributed and made accessible via a Google Forms link using social media. The questionnaire is composed by a construct of demographic items, followed by a second one with items related to awareness towards recommender systems and a third one related to patterns of use of recommender systems in everyday life online shopping experiences. In the majority of the questions, except for demographics and a few other questions, five-level Likert scales were used in order to measure frequencies of usage patterns, ranging from Always to Sometimes, Rarely, Never and Not Sure. Data collection was concluded during the first week of November 2025. A total of 344 valid responses were collected. Data was further analysed both descriptively and inferentially using SPSS. Below, for each research question is presented one corresponding hypothesis, and the handling of data on SPSS, in order to test them using Chi-square tests, is described.

H1: The more frequently students notice recommended items when shopping online, the more likely they are to click on them.
To prove whether students who view recommended items during online shopping, are also more likely to engage by clicking on them, similar scales of frequencies were grouped together: Always was marked as High Frequency, Sometimes as Medium Frequency, and Rarely, Never and Not Sure were all marked as Low Frequency scales.

H2: The more frequently students click on recommended items, the more likely they are to make purchase decisions influenced by the recommender system.

To prove whether there is a statistically significant relationship between frequency of clicks and frequency of purchases influenced by the RS, for each question scales were grouped together in the same way as in H1.

H3: *Recommender systems are more likely to influence in the case of hedonic products (such as fashion items) than utilitarian products (such as office items).*

To prove whether there is a statistically significant relationship between the likelihood of RS influence on hedonic products as opposed to utilitarian products, the reported frequencies of purchase decisions were categorized in the same way as in previous hypotheses.

The question regarding product categories was a multi-choice one, in order to allow respondents to express their interests and use patters without being limited to one category, which also allows for a more thorough insight on which products dominate the online shopping usage patterns among students, reflected in the descriptive analysis. However, since to conduct the Chi-square test variables need to be categorical, they were grouped into Hedonic: Fashion and Accessories, Cosmetics and Skincare, and Utilitarian products: Electronics for personal use, Household Appliances, Office Supplies, Personal and Household Hygiene Products, and Food products/ Groceries. For responses where multiple categories were chosen, the following ruling was consistently applied to all responses: since categories of hedonic products, such as fashion and cosmetics, from the descriptive statistics are shown to be the most chosen across the sample, they are most likely to dominate the online shopping experiences among students and therefore every combination of choices in a response, that includes an equal number of hedonic and utilitarian product categories was labeled as Hedonic, whereas every combination where the majority or all of the chosen categories were Hedonic was labelled as Hedonic. The same for cases where most or all of categories were Utilitarian. Three respondents had reported they weren't interested in any category and were thus excluded from the Chi-square test.

4. ANALYSIS AND RESULTS

4.1. Descriptive Analysis

From a total of 344 responses, 97.4% of the respondents reported to be between 18-23 years old; average age was 20.17. 79.7% of them were female. A total of 161 students reported they had heard of the term "Recommender System"; when shown a screenshot of a real recommender system for fashion items, 98% of them reported to be familiar with the image and a corresponding 93% of answers were positive for the electronic products recommendations image.

However, when presented with a set of 3 images, one online ad and two recommender systems, the majority were able to distinguish only one of the images corresponding RS correctly (36.6%) and the second most frequent answer was that indicating the ad, which means it was confused with a recommender. The less frequent answers included both a recommender image + the ad image, indicating bias. This shows that their awareness of such systems is high among them, but it's mostly intuitive and experience-based in nature, rather than theoretical, which is why they visually recognize them but are biased at best when connecting the term "recommender system" with a representing image.

Over half of them reported they always visit shopping sites (51.7%) and almost 40% said they sometimes do, which shows high interest.

Table 1. Frequency of Visits in Shopping Websites

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	178	51.7	51.7	51.7
	Sometimes	137	39.8	39.8	91.6
	Not sure	2	.6	.6	92.2
	Rarely	27	7.8	7.8	100.0

Total	344	100.0	100.0	

Note. Source: Author's analysis

When asked if they noticed suggested items on these sites, 57,8% of them said they sometimes did, 13.7% of them said they always did, and about 17% reported they never viewed them.

Table 2. Frequency of Recommendations leading to Purchase Decision

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	12	3.5	3.5	3.5
	Never	49	14.2	14.2	17.7
	Sometimes	133	38.7	38.7	56.4
	Not sure	7	2.0	2.0	58.4
	Rarely	143	41.6	41.6	100.0
	Total	344	100.0	100.0	

Note. Source: Author's analysis

However, 201 respondents (58.4%), reported they sometimes click on the recommended items, 11% of them always did and 23.5% of them rarely did, resulting in a total of 94.2% that report to have engaged at least one with recommender systems. Almost 60% of them think that these systems have helped them find the right product for them; however, 38.7% reported that these suggestions sometimes have resulted in a purchase decision, 41,6% said this happened rarely and for 14.2% this had never happened. Fashion and Accessories, Cosmetics and Skincare, and Electronics for personal use (ex.: laptops, earphones, smartphones) were reported as the three categories that respondents were most frequently interested in when shopping online, chosen a total of respectively 316, 112 and 73 times each. Similarly, based on the most frequent responses related to the most visited websites (Table 3), those related to Fashion and Accessories (Zara, Bershka, Shein, Perla Shop, Klaudio Fashion) came up a total of 228 times, representing it more than any other category.

Table 3. Most frequently visited websites

Most visited websites	No. of responses per website
Zara	121
Temu	84
Bershka	37
Shein	35
Ali Express	27
Amazon	23
Perla Shop	22
Glowy Skin Albania	22
Klaudio Fashion	13
Shpresa AL	11
Sephora	9

Note. Source: Author analysis

4.2. Statistical Analysis

To test all three hypotheses, Chi-square tests were conducted on SPSS. The results for each, for a significance level $\alpha = 0.05$, followed by the corresponding interpretations, are presented below:

Table 4. Chi square test results for all three hypotheses

Variable Pair	N	χ^2	df	p	Cramer's V
H1: Frequency of Views x Frequency of Clicks	344	130.999	4	< 0.001	0.436
H2: Frequency of Clicks x Influenced Purchases	344	124.679	4	< 0.001	0.426

| **H3:** Influenced Purchases × Product Category | 341 | 0.912 | 2 | < 0.001 | 0.052 |

Note. Source: Author's analysis

H1: Frequency of Views x Frequency of Clicks: no assumption was violated and Pearson χ^2 (4, N = 344) = 130.999, which means there is a statistically significant association between the variables. Cramer's V = 0.436 indicates a large effect size. Thus, the hypothesis was confirmed.

H2. Frequency of Clicks x Influenced Purchases: even though the assumption of no more than 20% of counts being below 5 was violated, it was only slightly above the threshold (22.2%), which means the test results are still considered interpretable, while keeping this note in mind. Pearson χ^2 (4, N = 344) = 124.679 indicates a statistically significant association, which suggests that students who click on recommended items more frequently are also more likely to report that they are usually influenced by these recommendations in their purchase decisions. These variables are strongly related, based on Cramer's V = 0.426, indicating a large effect size, confirming the hypothesis.

H3. Influenced Purchases × Product Category: assumptions were met but Pearson χ^2 (2, N = 341) = 0.912 and Cramer's V = 0.052 are extremely low. Both results indicate no association between the tested variables; they are independent statistically, therefore the was no evidence to support this hypothesis.

5. CONCLUSIONS AND FUTURE RESEARCH

Students in Tirana, Albania, seem to be fairly familiar with recommender systems visually and as a function within shopping sites, but don't necessarily connect them with the term "recommender systems". They report to be more oriented towards hedonic products, especially Fashion and Accessories, followed by Cosmetics and Skincare during their online shopping experiences. This is also supported by specific websites they report to visit more often. They mostly utilize online shopping sites with a medium to high frequency. Students generally notice recommended items and act on them by clicking, which thereafter, leads frequently to purchases, as confirmed from testing H2 and H3. However, no evidence was found regarding the impact of recommenders on purchase decisions based on the category of the products. Nevertheless, separately studying each product category more in depth, could lead to alternative findings and needs further attention, especially in the lens of the range of product categories included within the visited website (whether single or multiple product categories offered from the retailer).

Implications for Academic Research

This study aims to offer initial key findings for a demographic that isn't represented in the recommender system research field. It provides insights regarding awareness, attention and engagement patterns of Albanian students with RS, studies their statistical relationships and can be used as a starting point for cross-cultural research to compare similar as well as very different demographics and markets, especially based on factors such as their level of digital maturity or logistical readiness for e-commerce development.

Implications for Online Retailers

Given the level of attention and use recommenders receive based on the self-reported frequencies, and the fact that the e-commerce market is in an emerging phase in Albania, it is of great interest to further study the implications these systems have in the consumers perceptions, their engagement on the websites and their purchase patterns for both local and international e-retailers operating in Albania. Highly involved users can be targeted more efficiently through personalized offers or alternative algorithms providing recommendations finely tailored for them, as they show higher likelihood of being influenced by recommendations. Navigation cues and transparency improvement could turn low to medium frequency clickers into high clickers, by boosting their attention and in turn, their engagement. As user experience increases and evolves, the Albanian consumer develops perceptions and behavioral patterns; studying them can help better shape the recommender systems implemented on the websites they visit as well as properly targeting different consumer profiles, directly impacting marketing objectives and the overall business performance of online retailers.

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Green Strategy and Performance: A Moderated Mediation Analysis of Green Entrepreneurial Orientation, Green Intellectual Capital, and Corporate Environmental Ethics

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Abstract

The purpose of this study is to examine green entrepreneurial orientation affects environmental performance through green intellectual capital, considering the moderating effect of corporate environmental ethics. The research adopts the Natural Resource-Based View (NRBV) to test the hypotheses. The study uses the quantitative approach, and 476 respondents conducted the survey. The study shows that green entrepreneurship orientation positively influences environmental performance both directly and indirectly via the mediating role of green intellectual capital. Furthermore, corporate environmental ethics is found to favorably moderate the relationship. The findings indicate a need for managers to prioritize investing in green knowledge and capabilities and cultivating a strong ethical culture. Additionally, policymakers should emphasize creating frameworks that incentivize businesses to adopt green orientation practices and enhance ethical compliance to reduce environmental impact and ensure long-term sustainability.

Keywords: Green entrepreneurial orientation, green intellectual capital, environmental performance, corporate environmental ethics, natural resource-based view

1. INTRODUCTION

In the context of evolving environmental crisis, companies are shifting strongly to sustainable strategies to protect the environment while maintaining their business sustainability. Environmental management is no longer a voluntary option for public relations or competitive differentiation, but a mandatory part of business strategy. This shift creates dual motivation for businesses as they face intense pressure from a range of stringent government regulations aimed at decarbonisation. On the other hand, pursuing green economic growth is becoming a strategic business opportunity to cope with the environmental market requirements and capture new value (Li, 2014). This fundamental shift toward sustainability, a concept focused on addressing environmental, economic, and social challenges. However, the question is how do businesses translate their environmental commitments into measurable results?

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To address this, current literature points toward leveraging specific organizational resources and strategic postures. A company demonstrating a green entrepreneurial focus actively commits to being proactive, pursuing calculated risks, and leveraging innovation to find opportunities that benefit both profits and the planet (Jiang et al., 2018). While a green entrepreneurial orientation provides strategic intent, it is not sufficient for a successful green transformation. It requires dedicated internal resources and ethical governance. A firm's ability to effectively operationalize green orientation relies heavily on its capacity to accumulate green intellectual capital (GIC) (Pan et al., 2021; Hu & Tresirichod, 2024). Green intellectual capital is defined as a unique combination of green human, structural, and relational capital (Chen, 2008) and is recognized as an emerging and important factor for enterprises to promote green innovation and achieve sustainable environmental performance (Ramírez et al., 2021); Asiaei et al., 2022; Shanbaz et al., 2024). Thus, green intellectual capital serves as the internal knowledge asset needed to convert business drivers into measurable results. Furthermore, the effectiveness of any green strategy is fundamentally shaped by the organization's intrinsic values and ethical governance. The role of corporate environmental ethics is very important in business strategies (Aftab et al., 2022), as it is the ethical foundation that determines the success of green efforts. Hence, while the mechanism via green intellectual capital is important, it is vital to understand under what organizational conditions the green transformation is most effective.

Although many studies have confirmed the relationship between green business orientation and environmental performance (Arfi et al., 2018; Anwar et al., 2024; Jiang et al., 2018), and between green intellectual capital and environmental performance (Ramírez et al., 2021; Asiaei et al., 2022; Shanbaz et al., 2024), the literature still lacks deep understanding regarding the mechanism and boundary conditions required for successful execution. Specifically, it remains unclear how a company's green strategy successfully transforms into measurable environmental outcomes. In addition, even when the mechanism is present, there is still a gap to clarify under what organizational conditions this crucial transformation is most effective.

To address the gaps in the existing literature, this paper has developed an integrated moderated mediation model grounded in the natural resource-based view (NRBV). This model centers on three key areas: (1) assessing the direct effects of green entrepreneurial orientation on environmental performance; (2) examining the mediating role of green intellectual capital in the green entrepreneurial orientation- environmental performance link; and (3) analyzing the moderating influence of corporate environmental ethics on the relationship between green entrepreneurial orientation and environmental performance. By connecting these variables, our study provides vital theoretical and practical insights for fostering sustainable business strategies in emerging economies.

2. LITERATURE REVIEW

2.1. Natural Resource-Based View (NRBV)

The natural resource-based view (NRBV) builds on traditional RBV by emphasizing that sustained competitive advantage depends on developing capabilities that minimize environmental harm and promote sustainability (Hart, 1995; Hart & Dowell, 2010). From this viewpoint, resources such as green knowledge, innovation capabilities, and strong ethical cultures become important competitive assets, especially when they are valuable, rare, difficult to imitate, and not easily substituted. These resources are key to achieving superior environmental outcomes. Guided by this perspective, green entrepreneurial orientation is considered a strategic capability that encourages businesses to proactively identify and capitalize on green opportunities, thereby integrating and allocating resources creatively to improve environmental performance. Green intellectual capital acts as an intermediary asset, helping to transform green strategy into measurable environmental outcomes. In addition, corporate environmental ethics strengthens this relationship by forming an organizational culture based on values and ethical standards that optimizes the mobilization and use of green resources. Several recent studies have validated the application of the NRBV in explaining the mechanisms linking green entrepreneurial orientation, green intellectual capital, and environmental performance. For example, Hu & Tresirichod (2024) effectively applied the NRBV to explain how green entrepreneurial orientation acts as a strategic capability that enhances sustainable performance through the mediating effects of green intellectual capital and green supply chain management. Similarly, Begum et al. (2023) used the NRBV framework to show that green intellectual capital significantly promotes green business strategy through green absorptive capacity and corporate environmental ethics further strengthens this link. Thus, based on NRBV, the proposed model suggests that firms with strong green entrepreneurship orientation and green values will utilize green intellectual capital more effectively to achieve sustainable environmental advantages.

2.2. Green entrepreneurial orientation and environmental performance

Green entrepreneurship orientation (GEO) evolves from the traditional entrepreneurial orientation framework, specifically integrating sustainability and environmental innovation into its business activities (Pratono et al., 2019; Habib et al., 2020). It reflects a company's efforts and willingness to proactively seek and develop green opportunities, while balancing both environmental risks and potential returns (Covin & Slevin, 1989; Dean & McMullen, 2007). Environmental performance (ENP) is defined as a company's effectiveness in meeting and exceeding society's expectations for the natural environment regarding concerns for the natural environment (Judge & Douglas, 1998). It includes both measurable environmental impacts (such as emissions) and the ability to build relationships with multiple environmental stakeholders. A dynamic GEO company encourages an organizational culture that facilitates the exchange and external transfer of environmental knowledge, thereby improving environmental performance (Arfi et al., 2018). In a similar vein, companies with stronger green entrepreneurial orientation have better results in implementing ecological initiatives, reducing resource waste and improving energy efficiency, thus improving their environmental performance (Anwar et al., 2024; Jiang et al., 2018). Collectively, the hypothesis is proposed as:
H1: Green entrepreneurial orientation positively influences environment performance.

2.3. Green entrepreneurial orientation and green intellectual capital

Green intellectual capital (GIC) refers to a firm's total stock of intangible assets, knowledge, capabilities, and relationships that are oriented toward environmental sustainability (Chen, 2008). It comprises three components: green human capital (GHC), green structural capital (GSC), and green relationship capital (GRC). GHC is defined as the employees' knowledge, skills, and commitment about environmental protection or green innovation. GSC encompasses the entire organizational system and procedures related to environmental protection and green innovation. GRC refers to the total relations with stakeholders regarding environmental protection. Studies have shown that green intellectual capital is a consequence of green entrepreneurial orientation. Firms with robust green entrepreneurial orientation tend to foster environmental awareness, knowledge sharing, and collaboration, thereby enhancing human, structural, and relational green assets (Pan, et al., 2021; Hu & Tresirichod, 2024). In addition, green entrepreneurial orientation helps companies both innovate and implement sustainability practices more effectively within their internal systems or external partnerships, leading to a greater accumulation of green intellectual capital (Wu & Yu, 2023; Frare & Beuren, 2022). Hence, the hypothesis is proposed as:
H2: Green entrepreneurial orientation positively influences green intellectual capital.

2.4. Green intellectual capital and environmental performance

Recent studies consistently highlight green intellectual capital as a critical driver of firms' environmental performance. Green intellectual capital, through its components of human, structural, and relational capital, significantly enhances firms' green performance by facilitating environmental management and eco-innovation (Gharib, et al., 2023). Green intellectual capital serves as a strategic platform that integrates environmental knowledge and organizational values, allowing companies to transform green awareness into environmental performance improvements (Shahbaz et al., 2025). In the same line, Asiaei (2023) demonstrated that green intellectual capital helps to optimize resource utilization and operational efficiency, reducing negative environmental impacts and resource waste. Similarly, Ramírez et al. (2021) proposed that firms are better able to address environmental challenges through the transformation and application of internal intangible assets. Accordingly, this paper proposes the following hypotheses:
H3: Green intellectual capital positively influences environmental performance.

2.5. Green entrepreneurial orientation, green intellectual capital and environmental performance

From a natural resource-based perspective (Hart, 1995; Hart & Dowell, 2010), adopting a green entrepreneurial orientation reinforces green intangibles, converting environmental strategies into organizational capabilities that enhance firm sustainable performance. A green entrepreneurial orientation encourages technological and management innovations to achieve a smarter green production system (Wang, 2019). These intelligent systems enhance environmental adaptability and resource efficiency, thereby improving environmental performance. In the study by Hu & Tresirichod (2024), GIC acts as a knowledge resource, partially mediating the relationship between green entrepreneurial orientation and sustainable performance by improving firms' knowledge accumulation related to environmental innovation and sustainable operations. Also, implementing green stratgey leads to deeper

understanding and accumulation of knowledge and experience related to the environment, contributing to improved environmental practices (Martínez-Falcó et al., 2025). Therefore, the hypothesis is proposed as:

H4: Green intellectual capital mediates the relationship between green entrepreneurial orientation and environmental performance.

2.6. Corporate environmental ethics role as a moderator

Corporate environmental ethics (CEE) refers to the collective ethical values, beliefs, and behavioral norms of environmental concerns within a company (Chang, 2011). Corporate environmental ethics reflects a company's ethical stance towards ecological welfare and its commitment to aligning all business operations with environmental principles and regulations (Wang & Young, 2014). Companies with a strong commitment to environmental ethics are more likely to integrate proactive environmental management into their strategic decision-making (Chang, 2011; Han et al., 2019). Empirical evidence from Begum et al.'s (2023) study confirmed that corporate environmental ethics actually amplifies the impact of green intellectual capital on green strategy. This suggests that when an organization has a culture that places a strong emphasis on ethics, it will use green knowledge (GIC) much more effectively. It follows that when a firm's ecological responsibility is strong, the entire transformation process from green entrepreneurial orientation to environmental performance through the green intellectual capital bridge will be much stronger and more effective. Similarly, Guo et al. (2020) and Rui & Lu ((2021)) pointed out that strong corporate green values create an ideal environment for the deployment of knowledge-based resources (GIC). As companies adhere to ecological rules and standards, this environment amplifies the effectiveness of green intellectual capital, allowing the company to apply green knowledge in an optimal and impactful way. The hypothesis is proposed as:

H5: Corporate environmental ethics moderates the indirect effect of green entrepreneurial orientation on environmental performance through green intellectual capital.
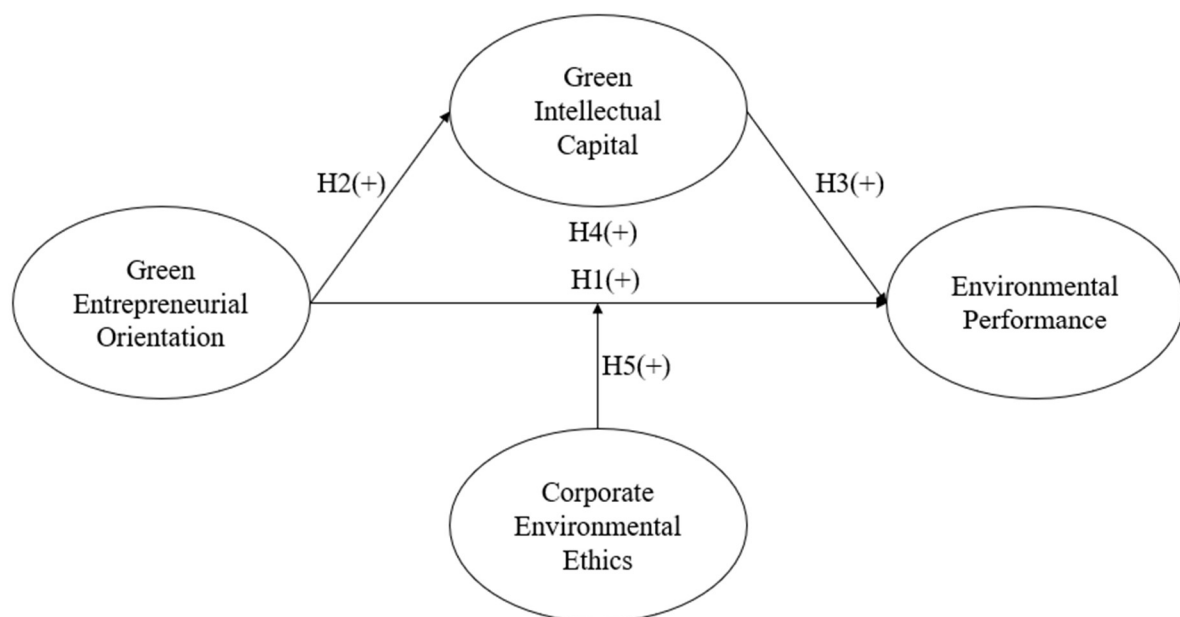

Fig. 1. Conceptual framework

3. METHODOLOGY

Data for this study were gathered using a survey questionnaire method. To measure green entrepreneurial orientation, five items were adapted from the scale developed by Jiang et al. (2018). Green intelectual capital was assessed using seven items originally developed by ZaragozaSáez et al. (2020). Five adapted items concerning environmental performance were sourced from Laosirihongthong et al. (2013). Finally, the constructs of corporate environmental ethics were measured collectively using a 4-item scale, drawing upon previous work by Chang (2011).

The data collection process was carried out within four weeks on LinkedIn platform via employees and direct managers. The target population was those living in Vietnam. After eliminating unqualified responses, there are 476

valid responses for analysis. This study used Smart PLS 4 as its data analysis tool and the structural equation model (SEM) analysis technique to calculate the coefficients of the hypotheses. A 5-point Likert scale would be used to evaluate these constructs, and all measurements were taken from earlier studies.

4. RESULTS

4.1. Data description

The Table 1 below presents the demographic statistics of 476 respondents. The majority of respondents were females (55.04%), with male making up 43.07% of the sample. In terms of age, the largest group was 26–35 years, accounting for nearly 40% of the respondents. Most participants had between 4 and 10 years of professional experience (35.08%) and around 15% of the sample were managers.

Table 1. Demographic statistics

Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	205	43.07
	Female	262	55.04
	Others	9	1.89
Age	18–25 years	71	14.92
	26–35 years	190	39.92
	36–45 years	119	25.00
	>45 years	96	20.16
Experience	<3 years	95	19.96
	4–10 years	167	35.08
	11–20 years	143	30.04
	>20 years	71	14.92
Position	Employee	405	85.08
	Manager	71	14.92

4.2. Reliability and validity

CEE has its Cronbach's alpha at 0.887; and composite reliability (rho_c) at 0.920. For ENP, its Cronbach's alpha is 0.936; and composite reliability (rho_c) is 0.951. Regarding GEO, the Cronbach's alpha is 0.899; and composite reliability (rho_c) is 0.925. The Cronbach's alpha of GIC is 0.934, with rho_c at around 0.947. Following the criteria set by Hair et al. (2019), Cronbach's alpha and CR values are considered reliable when they are over 0.7. Since all constructs achieve values above 0.7 (Table 2), their reliability is confirmed.

To verify convergent validity, factor loadings should be ≥ 0.70 and the average variance extracted (AVE) should be ≥ 0.50 (Hair et al., 2019). Given that both the qualified outer loadings and the AVE values satisfy these requirements (Table 2), the items accurately converge and establish strong convergent validity.

As shown in Table 3, the correlation coefficients between constructs are lower than the square root of the AVE for each construct. Thus, the discriminant validity of the model is successfully established (Hair et al., 2019). Finally, all variance inflation factor (VIF) values for the indicators were below 5 (Table 2), indicating that no collinearity issues exist in the model, consistent with the guidelines of Hair et al. (2019).

Table 2. Constructs, items, VIF, factor loadings, validity, and reliability

Constructs	VIF	Factor loading	AVE	CR	Cronbach's alpha
Corporate environmental ethics (CEE)			0.743		0.887
CEE1	2.246	0.880		0.920	
CEE2	2.462	0.850			
CEE3	2.257	0.839			
CEE4	2.306	0.879			
Environmental performance (ENP)			0.796	0.951	0.936
ENP1	3.319	0.894			
ENP2	3.275	0.896			
ENP3	3.282	0.896			
ENP4	3.160	0.892			
ENP5	2.974	0.881			
Green entrepreneurship orientation (GEO)			0.712	0.925	0.899
GEO1	2.349	0.850			
GEO2	2.340	0.847			
GEO3	2.104	0.830			
GEO4	2.388	0.852			
GEO5	2.281	0.839			
Green intellectual capital (GIC)			0.717	0.947	0.934
GIC1	2.809	0.857			
GIC2	2.542	0.834			
GIC3	2.557	0.839			
GIC4	2.529	0.836			
GIC5	2.731	0.853			
GIC6	2.694	0.849			
GIC7	2.857	0.861			

Table 3. Discriminant validity

Constructs	CEE	ENP	GEO	GIC
Corporate environmental ethics (CEE)	0.862			
Environmental performance (ENP)	0.047	0.892		
Green entrepreneurship orientation (GEO)	0.035	0.416	0.844	
Green intellectual capital (GIC)	0.023	0.502	0.489	0.847

Table 4. SEM results

Hypothesis	Path	β	STDEV	T statistics (|O/STDEV|)	P values	Result
H1	GEO→ENP	0.220	0.046	4.759	0.000	Accepted
H2	GEO→GIC	0.489	0.038	13.033	0.000	Accepted
H3	GIC→ENP	0.400	0.044	9.114	0.000	Accepted
H4	GEO→GIC→ ENP	0.196	0.027	7.156	0.000	Accepted
H5	CEE * GEO→ ENP	0.090	0.042	2.129	0.033	Accepted

4.3. Hypothesis testing

Table 4 below shows the relationships within the study's structure model. There are five main relationships, which are: GEO→ENP (H1), GEO→GIC (H2), GIC→ENP (H3), GEO→GIC→ENP (H4), and CEE*GEO→ENP (H5). In the GEO→ENP (H1) relationship, beta coefficient (β) is 0.220. The standard deviation (STDEV) is 0.046, with T statistics (|O/STDEV|) of 4.759. The *p* value is 0.000. In terms of the direct relationship of H2, which is GEO→GIC, β is 0.489. The standard deviation (STDEV) is 0.038, and the T statistics (|O/STDEV|) are 13.033. The *p* value is 0.000. For the GIC→ENP (H3) relationship, β are 0.400. The standard deviation (STDEV) is 0.044, and the T statistics (|O/STDEV|) are 9.114. The *p* value is 0.000. In the indirect relationship GEO→GIC→ENP (H4), β is 0.196. The standard deviation (STDEV) is 0.027, yielding T statistics (|O/STDEV|) of 7.156. The *p* value is 0.000. The final relationship is the moderating effect of CEE*GEO→ENP (H5); β is 0.090. The standard deviation (STDEV) is 0.042 and the T statistics (|O/STDEV|) are 2.129. The *p* value is 0.033, which is less than 0.05 (5%).

To determine whether a relationship is statistically meaningful or not, a *p*-value is used to judge these direct relationships. As proposed, *p*-values are acceptable when they are below 0.05 (5%). All of five relationships in this study fall below 0.05, indicating their statistical significance. Moreover, the impact coefficients in β indicate whether there is a positive or negative relationship. When β is greater than 0, a positive relationship occurs. In contrast, β is below 0, indicating a negative relationship. The table clearly displays the impact coefficients of these relationships within the original sample. All significat relationships (GEO→ENP, GEO→GIC, GIC→ENP, GEO→GIC→ENP, and CEE*GEO→ ENP) show a positive influence on their respective dependant variables. In conclusion, the model provides strong support for each hypothesis.
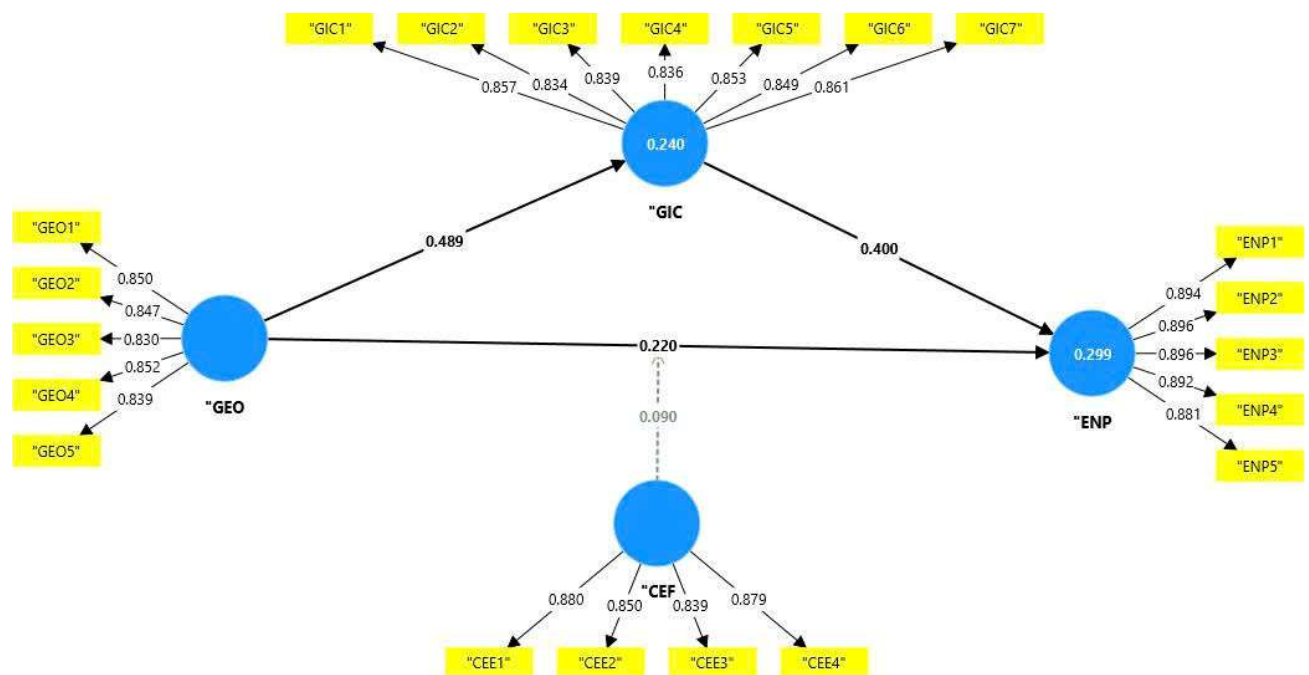

Fig. 2. Results of PLS-SEM analysis (all hypotheses were significant with *p*-values<0.05)

5. DISCUSSION AND CONCLUSION

5.1. Discussion and managerial implications

This study examines how green entrepreneurial orientation affects environmental performance through green intellectual capital, considering the moderating effect of corporate environmental ethics. The study supports H1, finding that green entrepreneurial orientation positively affects environmental performance. This result is consistent with earlier research by Anwar et al. (2024); Arfi et al. (2018); Jiang et al. (2018). Green entrepreneurial orientation positively impacts environmental performance (H1). A significant positive effect of green entrepreneurial orientation on green intellectual capital is observed in this study (H2). This outcome aligns with previous research that established a relationship between the firms' green strategic focus and sustainability knowledge assets (Pan et al., 2021; Hu & Tresirichod, 2024; Wu & Yu, 2023; Frare & Beuren, 2022). Furthermore, the results confirm that green intellectual capital (H2) is a vital driver of environmental performance (H3), consistent with prior literature (Shanbaz et al., 2024; Asiaei et al., 2022; Ramírez et al., 2021). Additionally, our analysis has shown that green intellectual capital significantly mediates the relationship between green entrepreneurial orientation and environmental performance, thus supporting H4. It indicates that GIC acts as a knowledge-based mechanism that transforms strategic intention (GEO) into measurable environment outcomes (ENP), consistent with prior studies (Hu & Tresirichod, 2024; Martínez-Falcó et al., 2025). Also, the research finds that corporate environmental ethics has a favorable moderating influence between green entrepreneurial orientation and environmental performance, supporting H5. This finding is consistent with the natural resource-based view, which holds that corporate environmental ethics can strengthen the link between green entrepreneurial orientation and environmental performance through green intellectual capital as a moderator.

This research offers several significant theoretical contributions to the literature on green strategy and sustainability. Firstly, the study strengthens the natural resource-based view (NRBV) by empirically confirming that green entrepreneurial orientation acts as a strategic antecedent that directly influences environmental outcomes. Secondly, this study contributes to the existing literature by establishing a robust connection between green entrepreneurial orientation, green intellectual capital, and environmental performance. Previous research has widely confirmed the positive influence of green entrepreneurial orientation on environmental performance (Anwar et al., 2024; Arfi et al., 2018; Jiang et al., 2018). However, it remains unclear whether green entrepreneurial orientation can affect environmental performance through green intellectual capital. Our core finding addresses this gap by showing that green entrepreneurial orientation enhances environmental performance by utilizing green intellectual capital as a mediator. Thirdly, one of the major contributions is the moderation framework which reveals that strong environmental conscience amplify the relationship between a firm's green strategy and its environmental performance, leading to better outcomes.

The findings offer essential guidance for executives and managers seeking to achieve superior environmental performance and maintain a competitive edge. Given the validated mediating role of green intellectual capital, the development of sustainability knowledge assets should be prioritized. Managers should treat green intellectual capital (green human capital, green structural capital, and green relational capital) as a strategic investment. Managers and employees need to establish a strong green knowledge base that nuture a green culture within the organization. Organizational leaders must cultivate green relationships with partners, suppliers, customers, and academia to boost knowledge-sharing and improve their capacity to absorb environmental information. Ultimately, managers should ensure that their firms can classify, intergrate, and utilize environmental knowledge including green technology, production, and customer needs more effectively than their competitors. Our study further suggested that environmental ethics is the main driver of establishing a better green outcome. Top-level managers should have a high level of ecological responsibility to enhance environmental performance and their firms' brand image. Ultimately, corporate environmental ethics can serve as a guiding principle for both the public and private sectors to effectively align organizational goals and actions with national sustainable development goals. Finally, policymakers and government agencies should implement frameworks that encourage firms to adopt green entrepreneurial orientation and invest in green intellectual capital for sustainability. This could include incentives such as tax breaks, subsidies, or grants for companies that commit to reducing their environmental impact or developing green intellectual capital.

5.2. Limitations and rrecommendations

The current study has several limitations that provide pathways for future research. Firstly, since this study relied on cross-sectional survey data, it only captured relationships between variables at a single point in time. This design makes it difficult to establish true causality or observe how green capital actually develops and accumulates over time. To address this, future research should adopt longitudinal approaches to track how green entrepreneurship

orientation and green intellectual capital influence environmental performance with appropriate time lags over time. Secondly, the findings are focused on Vietnamese context, making the findings less relevant to other contexts. Future research should investigate the variation in green orientation implementation across different countries and fields with varying institutional contexts. Thirdly, no other external factors in relationships were considered. While the present study successfully examined corporate environmental ethics as a moderator, it is possible that external forces, such as changes in the regulatory environment or stakeholder pressure, could further amplify or dampen the effects of green entrepreneurship orientation and green capital accumulation. Future studies on this topic may extend the model to include pathways that allow for more complex network relationships. Future studies may consider how organizational characteristics (such as green intellectual capital or corporate environmental ethics practices) interact with individual-level factors, most notably orientation towards innovation, and individual-level involvement in environmental protection to enhance overall firm performance.

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How Green Intellectual Capital Shapes Organizational Identity in Ho Chi Minh City's Fast Fashion Industry: The Role of Internal Integration and Green Dynamic Capabilities

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Abstract

The objective of this study is to examine how Green Intellectual Capital (GIC) affects Green Organizational Identity (GOI) in the fast fashion industry in Ho Chi Minh City, and to clarify the roles of Green Internal Integration (GII) and Green Dynamic Capabilities (GDC). The study uses a quantitative approach, with data collected from 492 employees and managers in fast fashion enterprises. The results show that Green Intellectual Capital (GIC) positively affects Green Organizational Identity (GOI), while Green Internal Integration (GII) plays an important mediating role in this relationship. In addition, Green Dynamic Capabilities (GDC) enhances the indirect impact of GIC on GOI through GII. The findings indicate that enterprises should focus on developing green internal integration capabilities and environmental dynamic capabilities to effectively transform green knowledge into sustainable organizational identity, thereby enhancing competitive advantage.

Keywords: Green Intellectual Capital (GIC, Green Organizational Identity (GOI), Green Internal Integration (GII), Green Dynamic Capabilities (GDC), Fast Fashion Industry (FFI), Ho Chi Minh City (HCMC)

1. INTRODUCTION

As sustainable development becomes a global priority, organizations are facing pressure to transform their operating models towards being environmentally friendly, while establishing a corporate identity associated with green values. Especially in emerging economies such as Vietnam, the requirement to comply with environmental standards in production and services is becoming increasingly urgent, prompting businesses to pay more attention to developing green knowledge resources and sustainable management capacity (Nayak et al., 2019; Thuy et al., 2025).

In this context, Green Intellectual Capital (GIC) including green human capital, green structural capital and green relational capital is considered a strategic asset that helps organizations accumulate and deploy environmental knowledge, thereby creating a foundation for sustainable competitiveness (Buhaya, 2024; Liu et al., 2022). International studies have shown that GIC plays an important role in promoting green innovation and improving the

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effectiveness of corporate sustainability management, especially through the integration and sharing of green knowledge throughout the organization (Liu et al., 2022).

However, possessing green knowledge is not enough to form a green organizational identity (Green Organizational Identity - GOI). To transform knowledge into awareness and behavior towards sustainability goals, enterprises need effective internal coordination capabilities. In particular, Green Internal Integration (GII) – the level of coordination, information sharing, and agreement on environmental goals between departments – plays a key role in transforming knowledge into action and organizational image (Nayak et al., 2019).

In addition, in a rapidly changing business environment, a sustainable green identity requires enterprises not only to maintain environmental commitments but also to be able to restructure, adapt, and innovate continuously. Green Dynamic Capabilities (GDC) the ability to identify green opportunities, restructure resources, and implement innovative solutions thus becomes an important moderator that amplifies the impact of GIC on green identity in substance, not just in declaration (Teece, 2007); supplemented content from the GDC article you provided.

In Vietnam, although awareness of sustainable fashion and green organizations is increasing, the gap between awareness and actual action still exists, due to limitations in technology, green management knowledge, and internal mechanisms in enterprises (Thuy et al., 2025; Nayak et al., 2019). In the context of the fast fashion industry and other consumer sectors contributing greatly to growth but also putting great pressure on the environment, research on the mechanism of green identity formation in enterprises becomes urgent (Maiti, 2025; Truong, 2023).

Therefore, this study focuses on explaining how GIC contributes to shaping GOI through GII, while examining the moderating role of GDC. The study hopes to expand the literature on green knowledge management and organizational identity in the context of sustainability, while providing an empirical unit in Vietnam – a market that is in the process of strong green transformation but has not had much in-depth research on the internal mechanisms of corporate green identity.

2. LITERATURE REVIEW

2.1. Theory of Natural Resource-Based View (NRBV)

The Natural Resource-Based View (NRBV) theory extends the traditional RBV perspective, arguing that the creation of sustainable competitive advantage comes not only from valuable, scarce, and difficult-to-copy assets, but also from the environmental responsibility of the business (Hart, 1995). According to NRBV, businesses achieve superior performance when accumulating and exploiting resources associated with green innovation, reducing emissions and conserving natural resources (Makhloufi et al., 2022).

In this context, Green Intellectual Capital (GIC) is considered a strategic resource that accumulates green knowledge, skills, and relationships, helping businesses improve their innovation capacity and implement sustainable operations (Chen, 2008; Yusliza et al., 2020). When deployed effectively, GIC creates a platform to support businesses in forming a Green Organizational Identity (GOI), thereby strengthening environmental reputation and positioning a green image in the long term.

2.2. Green Intellectual Capital (GIC)

Green Intellectual Capital (GIC) is defined as the set of knowledge, skills, and relationships related to an organization's environmental performance (Chen, 2008). From the NRBV perspective, GIC is considered a valuable, rare, and difficult-to-imitate resource that can contribute to long-term competitive advantage (Barney, 1991; Yusliza et al., 2020). Previous empirical studies (Chen, 2008; Chen, 2011) indicate that GIC has a positive effect on an organization's green innovation capability and environmental image. However, most of these studies focus on the relationship between GIC and innovation performance or environmental outcomes, while the impact of GIC on Green Organizational Identity (GOI) has not been widely tested, especially in industries with high pressure on sustainability, such as fast fashion.

Therefore, examining GIC as a potential resource influencing green organizational identity may help expand understanding of how firms transform green knowledge into perceived organizational value.

The hypothesis is proposed as:

H1: Green Intellectual Capital positively affects Green Organizational Identity.

2.3. Green Internal Integration (GII)

Green Internal Integration (GII) refers to the extent to which green knowledge is coordinated and shared among organizational units to achieve common environmental goals. According to the Knowledge-Based View (KBV), the ability to integrate knowledge between functional units plays an important role in transforming knowledge into concrete actions (Nahapiet & Ghoshal, 1998). Studies (Lee & Kim, 2011; Zhang et al., 2020) show that green knowledge and organizational capabilities can promote internal cooperation and synchronization in environmental management processes.

However, many existing studies still focus on external cooperation (supplier or customer integration), while the internal mechanism, especially the relationship between GIC and GII, is unclear. Studying this relationship can help explain how green knowledge is communicated and applied internally to support sustainable activities.

The hypothesis is proposed as:

H2: Green Intellectual Capital positively affects Green Internal Integration.

2.4. Green Organizational Identity (GOI)

Green Organizational Identity (GOI) reflects how an organization perceives itself and is perceived by its stakeholders as "green" (Chen, 2011). GOI is formed from the alignment of organizational values, beliefs, and behaviors toward sustainable development. Studies (Chen, 2011; Chang & Chen, 2013) show that GOI can play an important mediating role in the relationship between green resources and organizational outcomes, helping the organization maintain its reputation and build social trust.

However, the mechanism of GOI formation remains unclear, especially in relation to green knowledge (GIC). Some studies suggest that Green Internal Integration (GII) may be a mediating bridge when internal coordination allows green knowledge to be applied consistently, thereby strengthening the green organizational identity.

The hypothesis is proposed as:

H3: Green Internal Integration mediates the relationship between Green Intellectual Capital and Green Organizational Identity.

2.5. Green Dynamic Capabilities (GDC)

Green Dynamic Capabilities (GDC) is understood as the ability of enterprises to identify, restructure, and deploy green resources to adapt to changes in the business environment (Chen & Chang, 2012). According to studies (Chen & Chang, 2013; Teece et al., 2016), GDC includes the ability to learn, integrate environmental knowledge, develop green technology, and adjust production processes to enhance green flexibility and innovation.

Although there is a lot of evidence that GDC improves green innovation performance and competitiveness, the moderating role of GDC in the relationship between Green Intellectual Capital (GIC), Green Internal Integration (GII), and Green Organizational Identity (GOI) has not been fully studied. Testing GDC as a moderating variable can help explain the differences in the ability to transform green knowledge into green identity among enterprises.

The hypothesis is proposed as:

H4: Green Dynamic Capabilities moderate the indirect effect between Green Intellectual Capital and Green Organizational Identity via Green Internal Integration
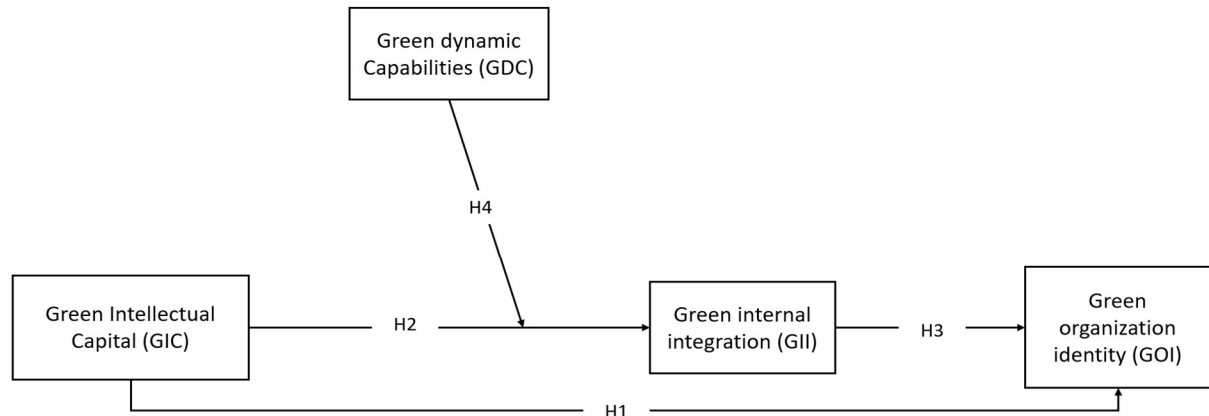
Fig. 1. Conceptual framework

3. METHODOLOGY

This study collected data using a questionnaire survey method. To measure Green Intellectual Capital (GIC), seven items adapted from Chen (2008) and Delgado-Ceballos et al. (2012) were added to the survey. Green Internal Integration (GII) was measured based on three items adapted from Zhu et al. (2013). Green Dynamic Capabilities (GDC) was measured using four items developed from Wu (2013). Green Organizational Identity (GOI) was measured using six items adapted from Chen (2011).

The data collection process was carried out over four weeks in fast fashion enterprises in Ho Chi Minh City through direct distribution of questionnaires. The survey subjects were employees, specialists, and middle managers working in these enterprises. After removing invalid questionnaires, a total of 492 valid responses out of 500 distributed questionnaires were used for analysis.

This study used SmartPLS 4 as a data analysis tool and applied the Structural Equation Modeling (SEM) technique to calculate coefficients and test research hypotheses. A 5-point Likert scale was used to assess the constructs (1 = Totally disagree → 5 = Totally agree), and all scales were inherited and adjusted from previous studies.

4. RESULTS

4.1. Data description

The information in Table 1 reflects the demographic characteristics of the survey respondents. Data were collected over four weeks at fast fashion businesses in Ho Chi Minh City through direct questionnaire distribution. After eliminating invalid questionnaires, a total of 492 valid surveys were used for analysis. The majority of respondents were male (56.91%) and were in the 25–34 age group (36.59%). The majority of respondents held employee or specialist positions (75.21%) and had less than 6 years of work experience (52.85%). In addition, the majority of respondents worked in private enterprises (63.01%).

Table 1. Participants' information

Variable	Category	Percent (%)
	Male	56.91
Gender	Female	41.06
	Prefer not to say	2.03
	Under 25	24.39
Age	25–34	36.59
	35–44	24.39

Variable	Category	Percent (%)
	Above 44	14.63
Position	Staff	44.72
	Specialist	30.49
	Middle Manager	18.29
	Other	6.50
Work Experience	< 3 years	28.46
	3–5 years	24.39
	6–10 years	26.42
	> 10 years	20.73
Ownership	Private	63.01
	Foreign-invested	36.99

4.2. Common Method Bias; Reliability and Validity

The analysis results show that all variables and scales have high internal reliability, shown through Cronbach's alpha values, Composite Reliability (CR), and factor loadings are all greater than 0.7 (Hair et al., 2019) (see Table 2). Specifically, Cronbach's alpha ranges from 0.918 to 0.948, CR ranges from 0.904 to 0.957, and all factor loadings are high, confirming that the scales have good reliability and internal consistency.

The Average Variance Extracted (AVE) values all exceed the threshold of 0.50, ranging from 0.704 to 0.792, indicating that convergent validity is guaranteed (Fornell & Larcker, 1981). In addition, the square root of the AVE of each concept is larger than the correlation coefficients between the constructs, demonstrating that the discriminant validity is guaranteed (Hair et al., 2019).

Finally, all Variance Inflation Factors (VIFs) are less than 5 (ranging from 2.759 to 3.458), indicating that there is no multicollinearity in the measurement model (Hair et al., 2019).

4.3. Hypothesis Analysis

The results show that all hypotheses in the model are accepted (Table 4and Figure 1). Specifically, GOI is positively affected by GIC (H1: β = 0.323, t = 8.127, p < 0.001) and by GII (H3: β = 0.359, t = 8.440, p < 0.001). At the same time, GIC also positively affects GII (H2: β = 0.503, t = 14.315, p < 0.001), indicating the important role of GIC in promoting internal green integration.

In addition, the results also indicate that GDC has a significant moderating effect on the relationship between GIC and GII (H4: β = 0.215, t = 3.294, p = 0.001), meaning that when green dynamic capacity is higher, the impact of GIC on GII becomes stronger.

4.4. Predictive Capability

Based on the SEM results, the model shows strong explanatory and predictive capabilities. First, the path coefficients (β) are all at medium to high levels and have very strong statistical significance (t-value ranges from 8.127 to 14.315, p < 0.001), indicating that the GIC, GII and GDC variables play an important role in explaining the formation of GOI. Second, the reliability and convergent validity indices of the scale (CR from 0.904 to 0.961; AVE from 0.704 to 0.803) are all at high levels, demonstrating that the measurement model is stable and has good predictive support capabilities.

In addition, all VIFs are lower than 5, indicating that the model does not have multicollinearity problems and has high predictive stability. Overall, the results show that the research model has strong predictive significance and is suitable to explain Green Organizational Identity formation behavior in the research context (Figure 1).

Table 2. Constructs, items, VIF, factor loadings, validity, and reliability

Construct	VIF	Factor loading	AVE	CR	Cronbach's alpha
Green Dynamic Capabilities (GDC)			0.704	0.904	0.918
GDC1	2.759	0.862			
GDC2	3.103	0.963			
GDC3	3.054	0.806			
GDC4	2.839	0.704			
Green Intellectual Capital (GIC)			0.762	0.957	0.948
GIC1	3.458	0.888			
GIC2	3.236	0.878			
GIC3	3.011	0.865			
GIC4	3.252	0.877			
GIC5	2.993	0.868			
GIC6	3.116	0.873			
GIC7	2.983	0.862			
Green Internal Integration (GII)			0.792	0.950	0.934
GII1	3.453	0.902			
GII2	3.166	0.891			
GII3	2.864	0.876			
GII4	3.095	0.884			
GII5	3.256	0.896			
Green Organization Identity (GOI)			0.803	0.961	0.951
GOI1	3.562	0.892			
GOI2	3.636	0.893			
GOI3	3.226	0.880			
GOI4	3.599	0.896			
GOI5	4.167	0.911			
GOI6	3.818	0.903			

Table 3. Discriminant validity

Constructs	GDC	GIC	GII	GOI
Green Dynamic Capabilities (GDC)	0.839			
Green Intellectual Capital (GIC)	0.008	0.873		
Green Internal Integration (GII)	0.048	0.530	0.890	
Green Organization Identity (GOI)	0.059	0.513	0.530	0.896

Table 4. SEM results

Hypothesis	Path	Beta	STDEV	t-Value	p	Decision
H1	GIC → GOI	0.323	0.040	8.127	0.000	SP
H2	GIC → GII	0.503	0.035	14.315	0.000	SP
H3	GII → GOI	0.359	0.042	8.440	0.000	SP

| H4 | GDC*GIC → GII | 0.215 | 0.065 | 3.294 | 0.001 | SP |
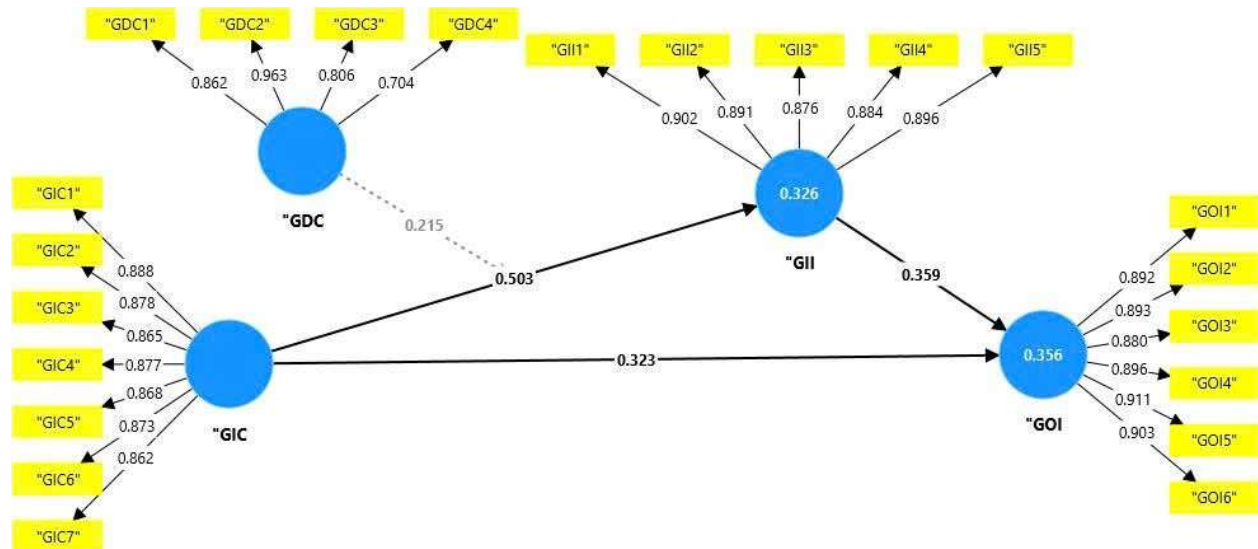
Fig. 2. Results of PLS-SEM analysis

5. DISCUSSION AND CONCLUSION

5.1. Discussion

This study was conducted to clarify how Green Intellectual Capital (GIC) contributes to the formation of Green Organizational Identity (GOI) of fast fashion enterprises in Ho Chi Minh City, and to analyze the role of Green Internal Integration (GII) and Green Dynamic Capabilities (GDC). Based on the theoretical foundations of Natural Resource-Based View (NRBV) and Knowledge-Based View (KBV), the empirical results show that the proposed model has a strong theoretical fit when all hypotheses are supported.

First, the results indicate that GIC has a positive and significant impact on GOI (H1), reinforcing the argument that green knowledge, green skills, and internal green structures are strategic resources in creating an environmentally friendly organizational image. This finding is consistent with previous studies that emphasize the role of GIC in promoting green innovation and enhancing corporate sustainability image (Chen 2008; Liu et al. 2022). In the context of the Vietnamese fast fashion industry, which is under great pressure from waste issues, resource use, and young customer expectations, the strong influence of GIC on GOI suggests that businesses are shifting from awareness to shaping core values towards sustainability. This suggests that efforts to invest in green knowledge not only improve operational capacity but also enhance corporate reputation and commitment to society.

Next, the study confirms the positive relationship between GIC and GII (H2), which reflects KBV's argument that knowledge only truly develops value when it is integrated and diffused internally. The results show that firms with strong green intellectual capital are more likely to have better inter-departmental coordination, more effective sharing of environmental information, and higher levels of green goal alignment. This is particularly important in the fast fashion industry, which has a complex value chain, fast production speed, and high dependence on inter-departmental coordination. Thus, GIC is not only a single resource but also an enabler of internal operating mechanisms, supporting firms in the green transformation process. In addition, GII is shown to have a positive impact on GOI (H3), suggesting that the level of coordination and integration of green knowledge across departments plays an important role in the formation of green identity. This result is consistent with previous studies that suggest that GOI is formed when an organization achieves alignment in environmental-related actions, values, and goals (Chang & Chen 2013). Given the social pressure on supply chain transparency and environmental responsibility in Vietnam's fast fashion industry, this finding highlights the importance of internal communication, inter-departmental cohesion, and green knowledge sharing mechanisms in strengthening the green image of the firm.

A notable contribution of the study is the demonstration of the moderating role of GDC in the relationship between GIC and GII (H4). This means that firms with high green dynamic capabilities, including the ability to restructure resources, innovate processes, and seize green opportunities, will make better use of GIC to promote internal integration. This finding is consistent with the dynamic capabilities' theory ([Teece 2007](#)), which argues that organizations need flexible adaptation to translate knowledge into action in rapidly changing contexts. For the fast fashion industry in Ho Chi Minh City, where market pressure and changing trends are constant, GDC becomes a key factor to help businesses overcome operational barriers and maintain green commitments in a substantive manner rather than just a declaration.

In addition to theoretical contributions, the research results bring many important management implications. First, businesses need to invest more heavily in green personnel training, upgrade green databases, and improve green process systems to strengthen GIC. Second, promoting GII requires businesses to establish clear inter-departmental coordination mechanisms, increase transparency in sharing environmental information, and integrate green goals into departmental KPIs. Third, to enhance GDC, businesses need to develop green innovation thinking, invest in clean technology, and build flexible adaptation capacity to new environmental regulations and trends.

Finally, the research results clearly reflect the socio-cultural context of Vietnam. With the growing concern of young consumers about sustainability, along with the pressure from national policies on green economic development, fast fashion enterprises in Ho Chi Minh City are facing an urgent need to restructure their strategies. However, the specificity of business scale, limitations in technology, and green management knowledge can affect the transformation ability of each enterprise. This suggests that further studies should compare large and small enterprises, or between industries with different levels of environmental impact, to better understand the differences in the process of GOI formation.

5.2. Theoretical Implication

The findings of this study make important contributions to the theoretical foundation of sustainability management, especially in the scope of Green Intellectual Capital (GIC), Green Organizational Identity (GOI), and the role of Green Internal Integration (GII) and Green Dynamic Capabilities (GDC). These findings not only expand the existing theoretical foundation but also clarify the mechanism of how green resources and capabilities operate in organizations, thereby contributing to the two main theoretical foundations of the study: Natural Resource-Based View (NRBV) and Knowledge-Based View (KBV).

First, the study reinforces the NRBV perspective by demonstrating that GIC is a core strategic resource that creates green competitive advantage, as demonstrated by its direct, positive, and strong impact on GOI. This finding adds empirical evidence to the argument that green organizational knowledge, experience, and structures can be viewed as hard-to-copy assets that are the foundation for a firm to build a consistent green image. This extends the scope of NRBV from the resource-capability level to the organizational identity dimension, an approach that has been underexplored in previous studies.

In addition, the relationship between GIC and GII suggests that green knowledge only becomes valuable when it is integrated into internal processes. This finding contributes significantly to KBV by showing that knowledge does not automatically lead to positive organizational outcomes; instead, the process of integrating and sharing green knowledge is the decisive factor. This conclusion is consistent with KBV's argument that knowledge needs to be realized through an internal operating mechanism, a gap that this study clearly fills with empirical evidence.

In addition, the positive impact of GII on GOI expands theoretical understanding of how organizational identity is formed. The study demonstrates that green identity is not only the result of communication or brand strategy, but also the product of internal coordination and action consistency. This finding complements the research on organizational identity by showing that greenness can be shaped through internal operating mechanisms related to knowledge and processes, which have often been overlooked.

A notable theoretical contribution is the confirmation of the moderating role of GDC in the relationship between GIC and GII. This extends the NRBV and dynamic capabilities in explaining how firms transform green resources into organizational capabilities. GDC promotes agility, green innovation, and process reengineering, allowing firms to leverage GIC more effectively to enhance internal integration. Therefore, the study provides evidence that GDC not only directly influences organizational outcomes but also plays an interactive role, modulating how green knowledge is translated into actual coordinated behavior. This is an important theoretical contribution, expanding the understanding of how different layers of capabilities interact in green organizational systems.

Furthermore, the study also extends the existing theoretical framework by using the fast fashion context, an industry that is both time-pressured and dependent on fragmented supply chains, as the environment for testing the model. The results show that in the context of high speed and continuous innovation, the role of GDC becomes even more

important. This contributes to the development of theory by demonstrating that the impact of GIC and GII can vary according to industry characteristics, opening up new research directions on context differentiation in sustainability theory.

Finally, the study results emphasize the need to continue integrating multi-theoretical approaches into sustainability research models. The intersection of NRBV, KBV, and dynamic capabilities in this study shows that the GOI formation process is a complex construct of resources, knowledge, and adaptive capabilities, suggesting much potential for future interdisciplinary theoretical models.

5.3. Practical Implication

The results of the study have many important practical implications for fast fashion businesses pursuing sustainable development strategies and building a green image in Ho Chi Minh City. First, the finding that Green Intellectual Capital (GIC) has a significant impact on Green Organizational Identity (GOI) suggests that businesses should prioritize investing in green knowledge and the capabilities of their employees. This can be done through training programs on clean production processes, waste management, sustainable design, or environmentally friendly materials. In addition, businesses should develop processes for storing, sharing, and updating green data to ensure that knowledge is disseminated synchronously. These efforts not only improve operational capacity but also contribute to strengthening the green image - an important factor for the fast fashion industry, which is under pressure to change from the market and young consumers.

Second, the research results emphasize the important role of Green Internal Integration (GII) in forming a green identity. Therefore, managers should build effective inter-departmental coordination mechanisms to ensure that green goals are consistently implemented. For example, design, production, operations, and marketing departments need to coordinate to select environmentally friendly materials, optimize production processes, and communicate green messages consistently externally. Enterprises should also deploy internal management platforms or information sharing systems (such as environmental index tracking dashboards) to help employees better understand the green impact of each activity. This helps strengthen the "green culture" from within, creating a foundation for building a strong GOI.

Third, the existence of Green Dynamic Capabilities (GDC) as a moderating variable highlights the importance of green innovation and rapid adaptation capabilities in the fast fashion industry. Managers should proactively invest in clean technology, resource-saving production processes, or experiment with green business models such as recycling, upcycling, or longer lifecycle design. Improving GDC allows businesses to better exploit existing green knowledge resources, thereby enhancing internal integration and reducing risks when applying new sustainability standards. For the fast fashion industry, where change is continuous, the ability to reengineer processes or convert materials will help businesses stay competitive and meet increasing sustainability requirements.

Finally, managers should consider the differences in green readiness levels of different groups of employees and departments within the organization. Customizing communication programs, training or process design to each audience will help improve the effectiveness of behavior change and speed up green transformation. For example, the production department may need specific guidance on waste reduction or energy savings, while the marketing department may need knowledge on green certification, sustainable storytelling, or transparent communication. Designing activities that suit different levels of green awareness will help businesses optimize sustainable transformation outcomes and strengthen the GOI more sustainably.

5.4. Limitations and Future Research

Although the study yielded several important findings, there are some limitations that should be considered when interpreting the results. First, the study focused on fast fashion businesses in Ho Chi Minh City, which may limit the ability to generalize the results to other geographic regions or industries. Socio-economic contexts, consumer pressure levels, and sustainability concerns can vary significantly across locations and countries. Therefore, future studies should expand the scope of the survey to other urban and non-urban areas or compare Vietnamese fast fashion businesses with those in other developing countries to assess the similarities and differences in GOI formation.

In addition, the study used an online survey method with a convenience sample, which may limit the representativeness of the data. Those with limited internet access or who are not interested in sustainability may have been excluded from the sample, leading to bias in the assessment of green awareness or internal green capacity. In addition, small businesses or fashion households, groups that often lack the resources to invest in GIC, may also be underrepresented in this study. Future studies should consider using stratified sampling or collecting data directly at the business to ensure a higher level of representativeness.

Moreover, the study focused on employee/manager perceptions and intentions without assessing the extent to which these translate into actual behavior. Variables such as GIC, GII, and GOI are measured based on subjective judgments, while green implementation in practice may be influenced by many factors such as costs, technological capabilities, or supply chain pressures. Therefore, future studies could incorporate more empirical quantitative data, such as emissions, resource use metrics, or green certifications, to accurately assess the extent of sustainability transformation.

Although the study examined the moderating role of Green Dynamic Capabilities (GDC), it did not fully explore how GDC evolves over time or how firms maintain this dynamic capability in the context of fierce competition in the fast fashion industry. Future studies could adopt a longitudinal design to track the changes in GDC and assess the stability of this moderating role as firms transition to a more sustainable model.

Finally, the study did not assess the broader impacts of GOI formation on other organizational outcomes such as financial performance, green innovation, customer loyalty, or long-term competitive advantage. Further studies could extend the model to examine the spillover effects of GOI, thereby helping to further clarify the role of green identity as a strategic asset capable of creating sustainable business value.

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Appendix A. Measurement Scale

Type of variable	Factor and code	Item code	Items	Source
		GIC1	Our employees care about the environment.	
		GIC2	Our employees have the knowledge and skills to protect the environment.	
		GIC3	Our employees cooperate in working groups to address environmental issues.	
	Green Intellectual Capital (GHC)	GIC4	Our employees cooperate with our suppliers to protect the environment.	ZaragozaSáez et al. (2020)
		GIC5	Our employees cooperate with our customers/distributors to protect the environment.	
		GIC6	Our company implements innovations to protect the environment.	
		GIC7	Our company invests in facilities to protect the environment.	
Independent variable		GSC1	The management system for environmental protection in our firm is superior to that of our major competitors	
		GSC2	Our firm is more innovative with respect to environmental protection than are our major competitors	
		GSC3	The profit earned from environmental protection activities of our firm is greater than that of our major competitors	
	Green structural capital (GSC)	GSC4	The ratio of investments in R&D expenditures to sales for environmental protection in our firm is more than that of our major competitors	Chen (2007)
		GSC5	The ratio of employees to the total employees in our firm who are engaged in environmental management is more than that of our major competitors	
		GSC6	Investments in environmental protection facilities in our firm are more than those of our major competitors	

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		GSC7	Competence in developing green products in our firm is better than that of our major competitors	
		GSC8	The overall operational processes for environmental protection in our firm work smoothly	
		GSC9	The knowledge management system for environmental management in our firm is favourable for the accumulation of the knowledge of environmental management	
	Green Relational Capital (GRC)	GRC1	Our firm designs products and/or services in compliance with the environmentalism desires of our customers	Chen (2007)
		GRC2	Customer satisfaction with respect to environmental protection of our firm is better than that of our major competitors	
		GRC3	The cooperative relationships concerning environmental protection of our firm with our upstream suppliers are stable	
		GRC4	The cooperation relationships about environmental protection of our firm with our downstream clients or channels are stable	
		GRC5	Our firm has well cooperative relationships concerning environmental protection with our strategic partners	
Intermediate variable	**Green Internal Integration (GII)**	GII1	Achieving environmental goals collectively	Vachon and Klassen (2008)
		GII2	Developing a mutual understanding of responsibilities regarding environmental performance	
		GII3	Working together to reduce environmental impact of our activities	
		GII4	Conducting joint planning to anticipate and resolve environmental-related problems	
		GII5	Making joint decisions about ways to reduce the environmental impact of our products	
Dependent variables	**Green organization identity (GOI)**	GOI1	The company's top managers, middle managers, and employees have a sense of pride in the	Chen (2011)

			company's environmental goals and missions	
		GOI2	The company's top managers, middle managers, and employees have a strong sense of the company's history about environmental management and protection	
		GOI3	The company's top managers, middle managers, and employees feel that the company has carved out a significant position with respect to environmental management and protection	
		GOI4	The company's top managers, middle managers, and employees feel that the company have formulated a well-defined set of environmental goals and missions	
		GOI5	The company's top managers, middle managers, and employees are knowledgeable about the company's environmental traditions and cultures	
		GOI6	The company's top managers, middle managers, and employees identify strongly with the company's actions with respect to environmental management and protection	
Moderating variable	**Green dynamic capabilities (GDC)**	GDC1	My organization has the ability that can fast monitor the environment to identify new green opportunities	Chen and Chang (2013)
		GDC2	My organization has the ability to develop green technology	
		GDC3	My organization has the ability to successfully coordinate employees to develop green technology	
		GDC4	My organization has the ability to successfully allocate resources to develop green innovation	

Interplay Between Business Model and Innovation: A Bibliometric Analysis

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Abstract

This article provides a comprehensive bibliometric review exploring the interaction between business models and innovation, a field that, while attracting significant scholarly interest, has remained conceptually varied and fragmented. Using rigorous quantitative bibliometric approaches, including citation and keywords analysis, this paper provides a systematic mapping of the intellectual structure and evolution path of this crucial research area. The paper documents the evolution of scholarly discourse from its foundational roots in strategy, entrepreneurship, and innovation and show how the notion of business models has evolved over time along with innovation theories and practices. The mapping of citation and keywords highlights growing prominence given to business model innovation as an independent research domain and dynamically converges with the latest topics such as digital technologies, Industry 4.0, sustainability, and AI-driven developments. In this bibliometric review, we provide a systematic overview of the current state of research, identify essential works on the intellectual foundation, and point out directions for future research. By systematically synthesizing extant knowledge, this paper identifies blurred conceptual boundaries and informs how strategic management of business models and innovation may foster firms' performance and adaptability in modern competitive environments.

Keywords: business model, innovation, bibliometric analysis

1. INTRODUCTION

The relationship between business models and innovations has turned out to be one of the main topics in the field of management and strategy through the centuries. Business models describe the ways of creating, delivering, and capturing the value of the company and therefore they provide a basic organizational framework for success *(Budler et al., 2021; Petersen, 2024)*. Simultaneously, innovations are regarded as the most important factor for getting ahead of the competition, improving the performance of the firm, and even surviving for a long time in fast-changing markets *(Onileowo et al., 2021a; Ritahi & Echaoui, 2025)*. The separate importance of these two concepts has pulled them together at the top of the academic inquiry, especially the business model concept which has

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attracted a large amount of attention in the management literature as a comprehensive method of understanding how firms operate *(Maucuer & Renaud, 2019; Zott et al., 2011)*.

The traditional product or process innovations have proven to be sometimes insufficient due to the unilateral product or process innovations. This has been the reason behind the upsurge of Business Model Innovation (BMI) as a distinct and rapidly growing area in academics *(Huang & Ichikohji, 2023)*. The role of BMI is deemed critical for organizations to adapt, transform, and become successful in regions where they face major environmental changes *(Petersen, 2024)*. Literature on BMI has been recognized as fragmented despite its significant importance; for scholars, sometimes it means giving different conceptualizations and lacking a universal framework *(Huang & Ichikohji, 2023; Zott et al., 2011)*. This difficulty creates a big problem for researchers who want to have a broad understanding of the subject including its varied concepts, landmark theories, and future directions.

In order to tackle this issue of fragmentation and at the same time provide a structured summary of the academic landscape, the present article utilizes a bibliometric analysis. The use of bibliometric methods is characterized by a thorough and impartial manner of working with large amounts of scientific data, thus allowing for the systematic mapping of the intellectual structure of a research field, its evolutionary nuances, and even the themes that are coming up, (Donthu et al., 2021; Öztürk et al., 2024a). The study that makes use of techniques like citation and keywords intends to trace the historical development of research in the area where business models and innovation intersect, identify influential works and key authors, as well as the dominant research clusters (Budler et al., 2021). This type of analysis is going to throw light on the field's path, point out the most critical gaps, and provide a solid underpinning for the future research directions in this important strategic management area (Budler et al., 2021; Öztürk et al., 2024a).

2. BUSINESS MODEL

The business model idea has turned out to be a major aspect of management studies and a basic framework for recognizing how companies work and make money. In the main, a business model is the organization's reason of how it values creation, delivery, and capturing (Del Baldo & Baldarelli, 2017). It in fact plays the role of a map or a condensed picture of the business's activities, showing the processes through which value is delivered to the customers and turned into profit (Schroedel, 2024; Teece, 2010). This conceptual tool assists in the articulation of management's guesses regarding customer needs, the means of delivery, and the organizational structure required for profitable fulfillment (Teece, 2010).

Different frameworks exist, yet a business model is consistently defined by common elements. Numerous researchers, such as Osterwalder, point out the components like the value proposition, customer segments, channels, customer relationships, revenue streams, cost structure, key resources, key activities, and key (Berg, 2023; Moschetti et al., 2018). Other summations condense these into three core, interconnected traits: the value proposition (what is presented to customers), value creation and delivery (how that value is made and delivered to the customer), and value capture (how the company gets money for its products) (Moschetti et al., 2018; Reinhardt et al., 2019). These aspects demonstrate the total system of interdependent activities that determine a firm's operational logic and its interactions with various stakeholders (Zott et al., 2011).

The strategic significance of a well-crafted business model can't be underestimated. It can be a significant competitive advantage in rapidly changing and highly contested markets (Schroedel, 2024; Teece, 2010). The main roles of a business model are to create and to capture value, which consist of the customer's economic value generation and then the company's profit realization mechanisms (Biloshapka & Osiyevskyy, 2018). At the end of the day, a business model is frequently viewed as a mirror of a company's strategy, i.e., translating strategic directions into overall operational structures that determine the way the company will arrange itself to efficiently cope with the consumers' needs and realize its monetary goals (Belussi et al., 2019).

3. INNOVATION

Innovation, a complex and widely debated topic, has become the primary driving force in both economic and social aspects of human life. Different definitions are provided in different academic disciplines, and they reflect different research objectives and the interdisciplinary nature of innovation management, but the concept is generally viewed as the introduction and application of new or considerably better products, processes, services, or techniques (Taylor, 2017; Virgüez et al., 2023). Even though there is no unique definition that all would accept, still it is very common for the researchers to describe innovation as a dynamic process as well as a tangible outcome, including the entire range of activities from idea generation to successful market entry (Virgüez et al., 2023). This built-in

complexity is the very reason for the confusion in understanding and hence the requirement for better conceptualization in the academic discussions (Singh & Aggarwal, 2021).

The different kinds of innovation that prevail in the market constitute a wide variety from which organizations can pick and choose based on their specific needs for growth and their market position. Among the most typical types of innovations are product innovations that come as a result of changing the characteristics of goods and/or services; process innovations that relate to the development of new production or delivery methods; and marketing innovations that focus on new selling approaches; and organizational innovations that refer to changes in the business practices, workplace organization, or the nature of relations to external parties (Quinhões & Lapão, 2024; Virgüez et al., 2023). At the same time, innovation can be classified according to its level of newness, where incremental innovations are small, gradual improvements to existing offerings while radical or disruptive innovations open up completely new concepts or dramatically change the market (Virgüez et al., 2023). Consequently, these various forms highlight innovation's broad applicability, extending beyond technological advancements to encompass non-technological changes that drive organizational change and growth (Quinhões & Lapão, 2024; Virgüez et al., 2023).

Academic literature widely recognizes that the survival and prosperity of organizations depend in no small measure on innovation. The pursuit of innovation is a key driver of competitive advantage as it allows organizations to utilize internal resources, differentiate their products and services and develop competencies that are difficult to replicate (Onileowo et al., 2021b). In addition, innovation is an important driver of growth, helping firms to respond to changing market conditions, meet the evolving needs of customers and improve their overall performance (Baláž et al., 2023; Thi et al., 2023)The literature has shown a positive relationship between innovation and firm performance. This implies that organizations need to innovate if they are to be successful and survive in an increasingly competitive environment (Bogetoft et al., 2024).

4. METHODOLOGY

Bibliometric analysis is a quantitative and scientific research method, applied to systematically study and analyze large amounts of scientific data, especially scientific literature (Donthu et al., 2021). Its primary purpose is to uncover patterns, trends, and the overall impact within a specific field of study (Passas, 2024). This technique helps researchers draw up the intellectual structure mapping evolutionary nuances and emerging areas of a research domain by reviewing relationships between different components of research like authors, keywords, journals, institutions (Öztürk et al., 2024b). This analysis provides an objective and systematic overview and it is powerful for comprehensive literature reviews to find key contributions connections as well as possible gaps in the academic landscape.

A bibliometric analysis is generally carried out through some basic steps. The first step involves data collection; that is, the extraction of relevant bibliographic data from large academic databases like Scopus or Web of Science (Passas, 2024)After obtaining the data, the next important step will be cleaning and refining it to make sure that it is accurate and consistent (Passas, 2024). After this process, the cleaned data can be subjected to various bibliometric methods such as co-citation analysis, co-author analysis, bibliographic coupling, and content co-occurrence (co-word analysis) (Alaña, 2024). Science mapping is a popular method that enables researchers to visualize their field's structure identify dominant themes and display relationships between items usually with specialized software tools like VOSviewer (Chen et al., 2023). All these steps lead to meaningful information generation insights about how a specific research domain has developed over time (Donthu et al., 2021).

In order to perform the bibliometric analysis, a search was conducted on Web of Science (WoS). The interrogation the phrases "business model*" along with "innovation" using the AND operator. 12,354 were retrieved between the years 1997 and 2025. The PRISMA methodology was used in order to perform a systematic review of the research, as seen in figure 1. For the visualization and analysis of data, the VOSviewer software (vosviewer.com) version 1.6.19 was used. The WoS publication results were exported (TXT format) in order to create maps. These directions were established for the analysis:

- Citations analysis (countries)

- Citations analysis (authors)

- Co-occurrence of keywords (authors)

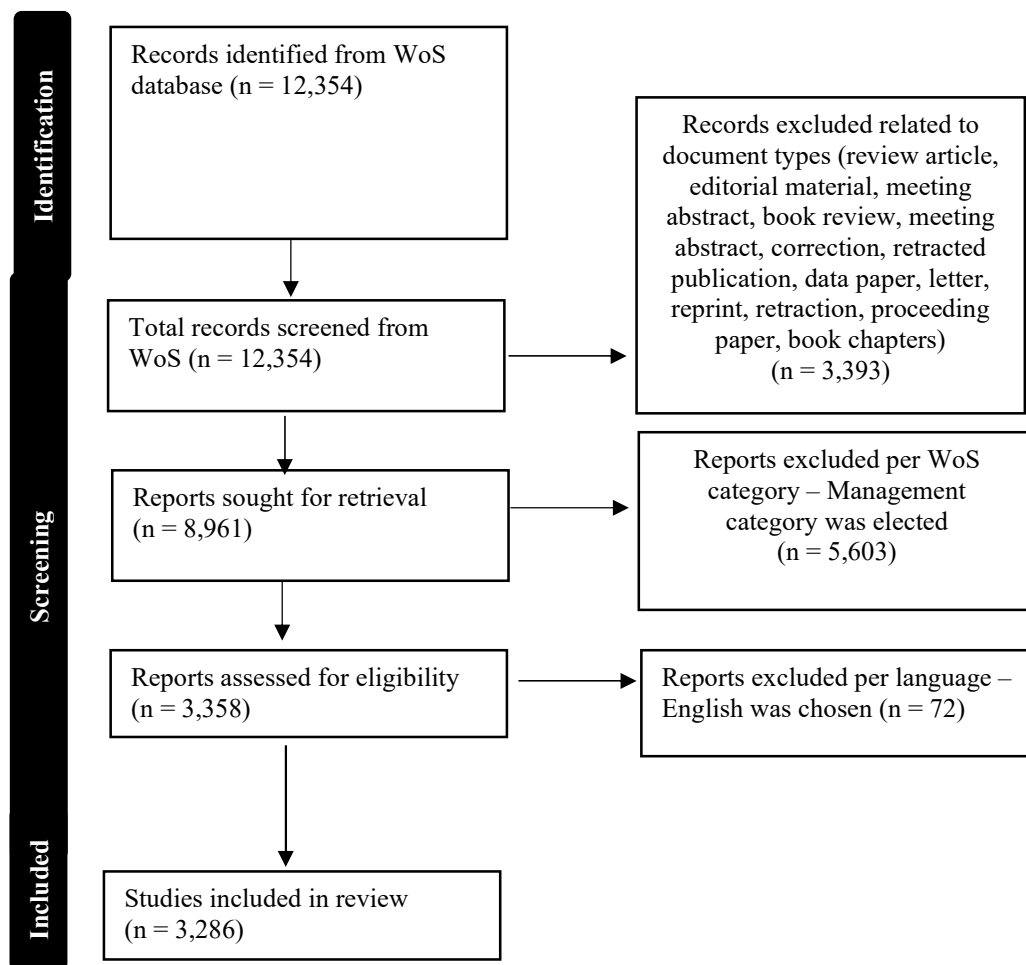> **Identification of studies via database**

Figure 1. PRISMA diagram flow
Source: Author elaboration based on PRISMA diagram flow (PRISMA, 2024)

5. RESULTS AND FINDINGS

In figure 2 can be seen that it has been a constant increase in published articles and the highest number of publications was in 2024 (417). Starting with 2019, the number of publications were more than 200. In 2025 the number of publications were not as high as expected from previous years.
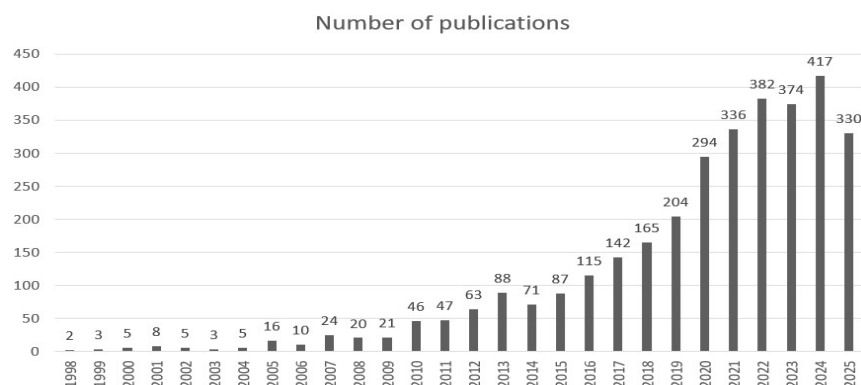

Figure 2. Evolution of published papers in the "innovation" and "business model"fields (1998-2025)
Source: Web of Science (WoS, 2025)

From WoS analysis can be seen that the articles are related to various categories (figure 3), not only Management. The majority of published articles refer to Management, Business, Engineering Industrial and Evironmental Studies, with other categories with a lower number of articles.
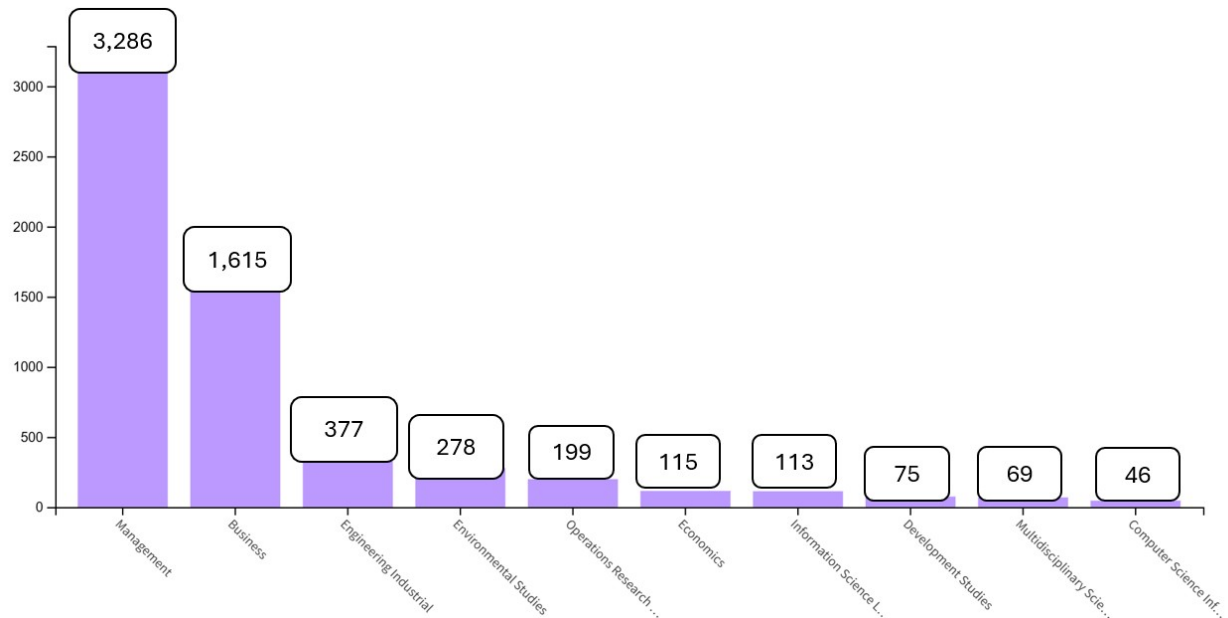
Figure 3. Web of Science categories
Source: Web of Science (WoS, 2025)

The most cited articles can be found in table 1:

Table 1. The most cited articles

Title	Authors	Publication Year	Total Citations
Business Models, Business Strategy and Innovation	Teece, DJ	2010	4,069
Value creation in e-business	Amit, R and Zott, C	2001	2,704
The Business Model: Recent Developments and Future Research	Zott, C; Amit, R and Massa, L	2011	2,547
Digital transformation: A multidisciplinary reflection and research agenda	Verhoef, PC; Broekhuizen, T; Haenlein, M	2021	2,274
A literature and practice review to develop sustainable business model archetypes	Bocken, NMP; Short, SW; Evans, S	2014	2,214
The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies	Chesbrough, H and Rosenbloom, RS	2002	2,152
Business Model Innovation: Opportunities and Barriers	Chesbrough, H	2010	2,079

Ecosystem as Structure: An Actionable Construct for Strategy	Adner, R	2017	1,597
Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal	Warner, KSR and Wäger, M	2019	1,593
Business models and dynamic capabilities	Teece, DJ	2018	1,494

Source: Web of Science (WoS, 2025)

5.1. Citation analysis (sources)

A citation analysis was performed by choosing sources and the chosen criteria were a minimum of 5 documents per source and a minimum of 5 citations per source. Out of 409 sources, only 135 met the threshold. In Table 2 can be observed the top 10 journals with the highest number of published documents. business strategy and the environment has the highest number of published documents (188), followed by technovation (116) and industrial marketing management (103).

Table 2. Top 10 journals with the highest number of documents published on "innovation" and "business model" fields

Journal	Number of documents
business strategy and the environment	188
technovation	116
industrial marketing management	103
ieee transactions on engineering management	97
international journal of innovation management	92
long range planning	75
european journal of innovation management	71
r & d management	69
technology analysis & strategic management	69
management decision	55

Source: VOSviewer

5.2 Citations (author)

From the perspective of authors, after inputting the criteria (minimum documents per author=5 and minimum number of citations of an author=5), 146 authors met the thresholds out of 7,406. The results are in table 3.

Table 3. Top 10 authors with the highest number of documents published on "innovation" and "business model" fields

Journal	Number of documents
parida, vinit	31
kraus, sascha	24
clauss, thomas	21
snihur, yuliya	20
chesbrough, henry	18
spieth, patrick	17
gassmann, oliver	16
brem, alexander	15

| kohtamaki, marko | 15 |
| ritala, paavo | 15 |

Source: VOSviewer

5.3. Citations (countries)

For the country-based citation analysis, we included only countries with a minimum of 5 documents and 5 citations. This criterion reduced the total from 108 countries to 72. The top 10 most published countries are displayed in Table 4 below.

Table 4. Top 10 countries with the highest number of documents published on "innovation" and "business model" fields

Country	Number of documents
USA	476
England	441
Italy	438
Germany	404
China	345
France	258
Spain	234
Finland	229
Sweden	219
Netherlands	180

Source: VOSviewer

5.4. Co-occurrence of keywords (authors)

The final analysis will examine the co-occurrence of authors' keywords to best reflect their perspective on the study domain. The initial step involved creating a dictionary to cleanse and standardize the data, combining different term forms (e.g., singular/plural, American/British spellings, and abbreviations/long forms). Following this step, it was selected the minimum number of occurrences of a keyword (15) which resulted on 105 words which met the threshold. It resulted 7 clusters as observed in figure 4:
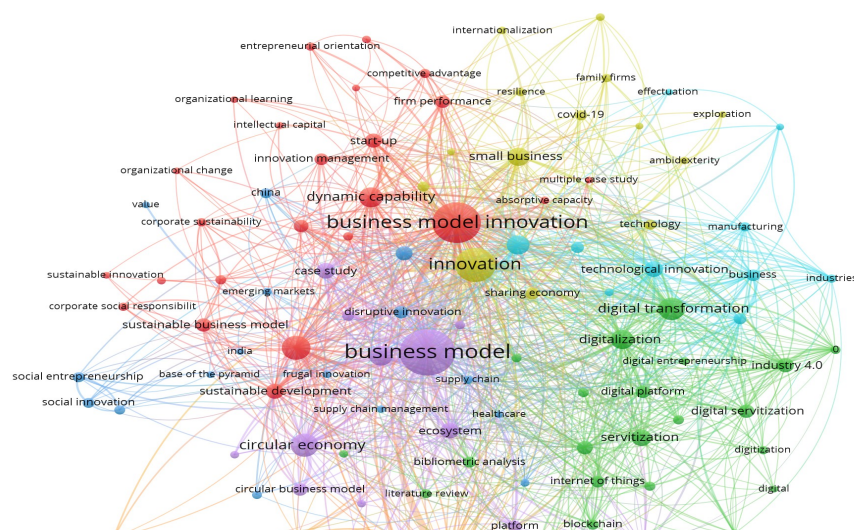
Figure 4. Keywords co-occurrence visualization (author)
Source: VOSviewer

The clusters are presented below. The bold keyword in each cluster has the highest frequency and is used as the cluster name.

Cluster 1 (red) – absorptive capacity, **business model innovation (522)**, competitive advantage, corporate social responsibility, corporate sustainability, dynamic capability, entrepreneurial orientation, environmental dynamism, firm performance, innovation management, innovation performance, intellectual capital, knowledge management, multiple case study, organizational change, organizational learning, resource-based view, start-up, sustainability, sustainable business model, sustainable business model innovation, sustainable development, sustainable entrepreneurship, sustainable innovation

Cluster 2 (green) – artificial intelligence, bibliometric analysis, big data, blockchain, capabilities, digital, digital entrepreneurship, digital innovation, digital platform, digital servitization, **digital transformation (166)**, digitalization, digitization, industry 4.0, internet of things, literature review, product-service system, service innovation, servitization, systematic literature review, taxonomy, value co-creation

Cluster 3 (blue) – 3d printing, base of the pyramid, business model canvas, china, disruptive innovation, emerging markets, frugal innovation, healthcare, india, social enterprise, social entrepreneurship, social innovation, **strategy (69)**, supply chain, supply chain management, value

Cluster 4 (yellow) – ambidexterity, covid-19, exploration, family firms, **innovation (361)**, internationalization, leadership, performance, resilience, sharing economy, small business, strategic management, technology, technology management

Cluster 5 (purple) – barriers, business ecosystem, **business model (690)**, case study, circular business model, circular economy, collaboration, coopetition, crowdsourcing, digital technology, ecosystem, innovation ecosystem, open innovation, platform

Cluster 6 (light blue) – business, business model design, companies, effectuation, **entrepreneurship (122)**, industries, manufacturing, stakeholders, technological innovations, uncertainty

Cluster 7 (orange) – services, value capture, **value creation (99)**, value proposition

6. CONCLUSIONS

This bibliometric analysis brings out the close and ever-changing relationship between business models and innovation, showing how these two ideas are deeply connected in pushing organizations toward success and change. The systematic look through the literature showed a rich and more complex research area, with Business Model Innovation growing as a separate and important field. By following how the ideas changed for both business models, from simple ways to create value to strategic tools for getting ahead, and innovation, from different kinds to its part in firm performance, this study has given a clear view of their coming together. In the end, using bibliometric methods has not only mapped the intellectual bases and historical path of this intersection but also stressed the active joining of digital technologies, sustainability, and AI-driven progress, hence giving a strong basis for future research to further look into and refine our understanding of how firms innovate their business models to do well in a world economy that is always changing. To conclude, the paper provided the following results:

- The keywords with the highest number of occurrences were: "Business model", "business model innovation" and "innovation",

- USA is the country with the highest number of published articles,

- parida, vinit was the most prolific author,

- business strategy and the environment journal published the highest number of articles.

The limitations of the study consists of using only the Web of Science database. It can be chosen in a future research to use also Scopus and Google Scholar in order to provide further insights into these fields.

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Boycotting Campaigns and Consumption Practices in Egypt in 2024: The Role of Social Media

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Abstract

This study examines the impact of Egyptian boycott campaigns following the Gaza conflict in 2023 on consumption behavior using the Theory of Planned Behavior (TPB) as a conceptual framework. The study analyses this change in consumption behavior across time and focuses on the effect of social media, as it was a main initiator of the boycotting campaigns. A survey is posted online and distributed using the snowball technique. It is followed by interviews to verify and explain the findings. This is conducted twice with a 6 months interval in 2024. The statistical analysis shows that there is a positive and significant relationship between attitudes, social norms, perceived behavioural control, and the intention to consume. There is also a direct and indirect relationship between the intention to consume and actual (responsible) consumption. The intention to consume has a positive and significant positive effect as well as an indirect one, mediated by the boycott campaigns, on responsible consumption. Facebook and Instagram have the most influence on initiating and continuing this intention and the resulting behavior. This continued in the second waive at the same level of use. However, in the first wave Facebook and Instagram affected the intention to consume with boycott mediating the effect on the responsible consumption. In the second wave both had a significant effect on the continuation of the responsible behaviour with no mediation of the boycott campaigns themselves. The study provides policymakers, legislators, and marketers with insights on how to engage the masses and raise awareness to utilize the formulas of management of change and contest the enacted legislation, rules, and imposed policies. It confirms the significant role of social media in initiating intentions and enhancing responsible consumer behaviors (Allam, 2023).

Keywords: Theory of Planned Behavior, Boycotts, Responsible Consumption, Social Media

1. INTRODUCTION

In the wake of the October 7th, 2023 Gaza conflict, many Egyptians, out of a strong sense of solidarity with the people of Gaza, called for boycotting campaign on social media (SM), which advocated for banning the purchase of products or services from companies or countries that are not supporting the people in Gaza (Allam, 2023). Al-Ahram newspaper stated in November 2023 that "the recent boycotting campaigns could be the biggest and most impactful in years (Khalid, 2023). The boycotts encouraged participants to communicate their extreme dissatisfaction with a brand, company, or nation by withholding their purchases. Furthermore, it promoted responsible consumption by prioritizing the purchase of Egyptian local alternative products and services.

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This study examines the relationship between certain attitudes, norms, and perceived intentions and the prevailing consumer behaviour; it also observes the impact of boycott campaigns on this relationship, using the Theory of Planned activity (TPB), as a theoretical lense. It investigates the driving forces, and societal influences that led to Egyptians adopting specific (responsible) consumption choices after the Gaza conflict that took place in the last quarter of 2023. The study sheds light on the important role of SM to identify the effect it had on the various variables within this framework.

2. BACKGROUND

Consumer behaviour was originally explained through the theory of reasoned action (TRA developed by Sarver in 1983) and later Fishbein and Ajzen proposed a hierarchy thereof which is extended to the Theory of Planned Behaviour (TPB). It proposes that attitude, subjective norms, and perceived behaviour control all contribute to intention, which leads to behaviour (Schmidt & Ajzen, 2020) TPB explores the basic attitudes that lead to intentions and explains the behaviours that result from these intentions that originate from attitude, subjective norms, and perceived control behaviour. Beliefs, feelings, and attitudes play an important role in consumer buying behaviour (Roy, 2022). Beliefs are consumer perceptions of how a product or brand performs relative to different attributes (Zanetta, et al., 2022) These beliefs are generally formed through personal experience, exposure, culture, values, and conversations with others; and they play a vital role in intentions and in behavior, because they can be either positive or negative. Attitudes are widely regarded as one of the most important drivers of purchase behaviour. Attitudes reflect either favourable or unfavourable evaluations of an "attitude object". Attitudes motivate consumers to either buy or not buy particular products or brands (Copeland & Boulianne, 2022).

Boycotts are common social movements that have been employed throughout history to express disapproval and protest against certain practices, policies, or political stances. The term 'boycott' originated from the shunning actions taken against Charles Boycott, whose harsh treatment of tenants, lead to his social and economic isolation by the local community resulting to a non-violent protest that became known as "boycotting" after Boycott's name (Palacios-Florencio, et al., 2021). Thus, boycotts are planned, conscious, and intentional consumer actions linked intrinsically to the dimensions of the Theory of planned behavior (TPB), particularly the individual personal attitudes, societal expectations, and the self-evaluation of one's capacity to impact the intended outcome (Delistavrou, 2022) .

Boycott campaigns in Egypt began in mid-October 2023, initiated by social media activists who launched the "Made in Egypt" initiative as a proactive way to affirm the boycott of foreign products and services. Facebook and Instagram were the tools used to advocate the notion. This movement garnered substantial support, especially among the youths. Supporters used hashtags such as #DoNotPayForTheirBullets, #BoycottOccupationGoods, and #Boycott, to promote their cause (Zaida, April 8, 2024). The boycott targeted international brands such as McDonald's, Starbucks, and Netflix, Ariel detergent, Lay's potato chips, Marlboro cigarettes – and many others -, which faced significant backlash and varying degrees of impact (Mohamed & Kordy, 2024). By promoting the "Made in Egypt" initiative, they gave consumers an alternative that is relevant and appealing, which also echoed a new initiative of "responsible consumer behaviour". Entrepreneurs in Egypt made immediate use of this and started promoting their products and services on the same main platforms, Facebook and Instagram.

This in turn led to a significant increase in the preference for Egyptian brands over international alternatives and Western (Claudy, et al., 2013) brands, including Cilantro and Koffee Kulture, that have seen a surge in popularity, as consumers turned to them as alternatives to boycotted names such as Starbucks (Kordy, 2024). Additionally, "Food Today," the premier website focusing on the food industry, launched a campaign to endorse Egyptian products, urging consumers to prioritize and purchase them. Likewise, the boycott breathed new life into Spiro Spathis, an Egyptian soda brand established in 1920, positioning it as a local alternative to international soft drink giants like Coca-Cola and Pepsi. The brand's sales soared by 350% in a brief period, prompting the company to advertise hundreds of job openings to accommodate the surge in demand (Khalid, 2023).

The concept of responsible consumption (RC) sprang from grassroots movements in the 1960s, advocating for fair trade and solidarity (Jain, et al., 2023). In 1973, Fisk identified RC as the voluntary and efficient use of resources (Fisk, 1973), however, there is still no single definition of this concept (Valor & Carrero, 2014). Sustainable responsible consumption, emphasizes consumers' use of resources with consideration for future generations and evaluates how their consumption affects society, the environment, and the economy, to meet sustainable development

goals (SDGs) (Luchs, et al., 2015); some researchers use the term ' ethical consumption' interchangeably with socially responsible consumption, as both refer to pro-social behaviours (Hassan, et al., n.d.); green responsible consumption reflects consumers prioritizing their purchasing choices to serve environmentally friendly products over others. (Haws, et al., n.d.). This study adopts the overarching idea of "responsible consumption that positively affects the society and the economy".

Responsible consumption behaviours or practices do not follow a straightforward, linear, and fixed sequential process of attitudes and intentions leading to predicted and actual behaviours, as outlined in the TPB (Liska, n.d.). There may be an intention-behavior gap that accounts for why consumers fail to carry out their planned actions as explained in the TBP; individuals may give up on boycotting and revert to their previous purchasing patterns, if it appears too difficult or expensive or if the alternatives are not satisfactory. Thus, they may start a boycott but with time choose more convenient or less expensive choices when shopping, even if they wish to support local businesses or projects in support of the people in Gaza (ElHaffar, et al., n.d.).

In line with the TPB, many Egyptians chose to opt for a type of responsible consumption, where they develop and promote the intention to focus on consuming local brands and goods instead of international products and services. Thus, all the antecedents of the intention component have a significant effect on the intention to engage in responsible consumption. These antecedents are: Attitude, which refers to how positively or negatively consumers may feel about participating in the boycotts (Ajzen & Fishbein, 2000); subjective (social) norms, these involve the beliefs about whether the key people (family, friends, colleagues) support or do not support these boycotts and the motivation to comply with these social pressures (Manning, 2009); and perceived behavioural control, which addresses whether the consumers feel they can realistically avoid purchasing certain products or services (Ajzen, 2002). These three constructs result in an intention to behave (Alshourah, Jodeh, Swiety, & Ismail, 2021). Intention is considered the central construct in the TPB (Ajzen, 1991)Ajzen, 1991), as it refers to the motivational factors that indicate the willingness and readiness of Egyptian consumers to engage in boycotts.

It is to be noted, that behaviour in the cognitive sense, is not assumed to be a construct by itself similar to the previous others. It acts as the end outcome that the TPB seeks to predict on the interplay among the above-mentioned constructs. Thus, the study is proposing the following hypothesis:

H1: Attitudes toward the Gaza war situation have a positive and significant effect on consumers' intentions to engage in responsible consumption.

H2: Subjective norms related to the Gaza war situation have a positive and significant effect on the intentions towards responsible consumption.

H3: Perceived behavioural control related to the Gaza war situation has a positive and significant effect on the intention to practice responsible consumption.

In this regard, the boycott itself is affecting the relationship between the intention to consume and actual responsible consumption and is expected to strengthen it. This relationship implies that boycott campaigns play a key role in bridging the gap and realising the relation between intentions and responsible consumption behaviour. It encapsulates the actual participation in boycotts and is expected to act as a mediator in to practice of responsible consumption behaviour. Thus, the following hypothesis is proposed:

H4: The boycott has a significant and positive mediating effect on the relationship between the intention to consume and responsible consumption.

Social Media has been playing a vital role in initiating the boycott and maintaining the resort to alternative goods and services. A continuous stream of social media calls is maintaining pressure and connecting disparate, real-world protests against companies with perceived stances that are not supporting the people in Gaza (Ziad, 2024; Reuters, Reuters, 2023).

H5: The use of Social Media (SM) has a significant effect on the intention to change behaviour which leads to responsible consumption.
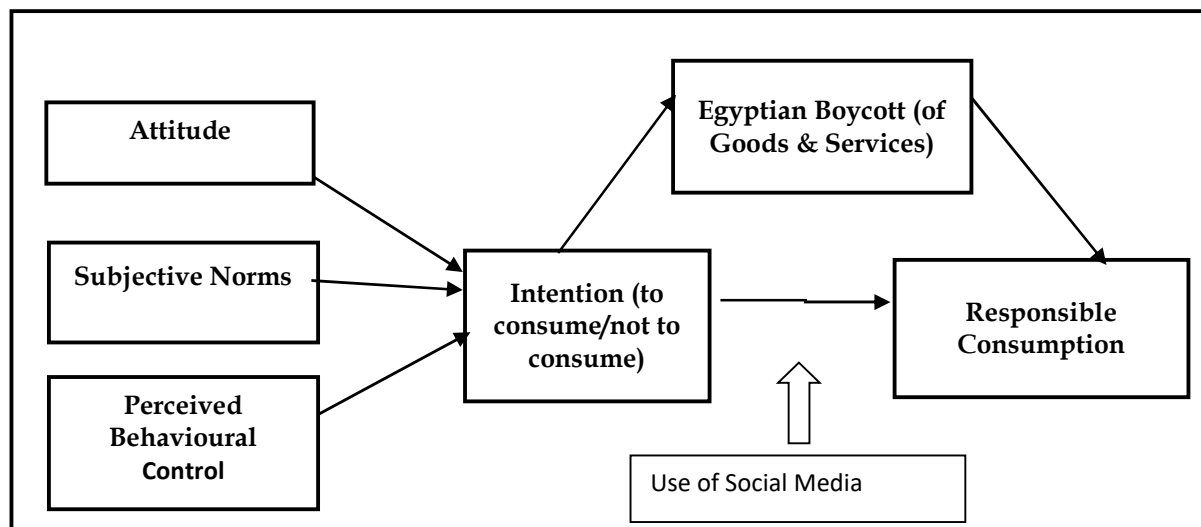
Figure 1 – Theoretical Framework

3. RESEARCH METHODOLOGY

The study uses a mixed approach in collecting and analysing data based on the theoretical framework developed. Surveys were distributed randomly and using the snow-balling technique by putting the link to it on various platforms. These were LinkedIn, Facebook, and WhatsApp. The first wave of data analysis was gathered between May 1 to 30, 2024, followed by a second data collection and analysis wave conducted from November 23 to December 8, 2024. For clarity and consistency, these waves are referred to throughout this paper as the May and December waves, respectively. The survey was closed when reaching 200 completed surveys. In addition, seven in-depth interviews were conducted after each wave to verify the results of the surveys and to gain a clearer understanding of all dimensions under examination in this study. The survey consists of 35 items and ends with 5 biographical parts. Most of the sections of the questionnaire were presented in a statement format and assessed on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The items' relevance to measuring the variable was confirmed through a pilot study conducted by three experts. Then the study instruments went through pre-testing based on the feedback of 30 participants. The results did not recommend any changes. The data's validity and reliability were first analysed and then, the hypotheses were tested using the regression models, Structural Equation Modelling (SEM), and correlation. The Cronbach alpha is used to measure the scale reliability and internal consistency; factor analysis measured and identified validity. The demographic statistics of the respondents are summarized in the below graphs and tables which display the descriptive analysis of the sample, followed by the frequencies for the different variables in the survey.

Table 1: Percentages of Social Media Platforms Influential in spreading awareness of boycotting products.

Platform	Wave	Rating 1 (%)	Rating 2 (%)	Rating 3 (%)	Rating 4 (%)	Rating 5 (%)
Facebook	1	7.4	6.9	15.8	24.1	45.8
	2	5.4	7.2	16.5	25.1	45.8
Instagram	1	9.9	9.4	14.3	21.7	44.8
	2	8.5	10.3	15.4	22.3	43.5
TikTok	1	12.8	9.9	19.2	17.7	40.4
	2	13.2	10.7	20.2	19.4	36.5
Twitter	1	9.4	14.3	23.2	23.2	30.0
	2	10.4	15.8	24.3	24.7	25.0
LinkedIn	1	31.0	24.1	25.1	11.8	7.9
	2	30.2	25.0	26.5	12.3	8.5

4. FINDINGS AND DISCUSSION

The questions center on opinions of the campaign's efficacy, personal involvement in boycotting, and support for the boycott. With the majority of respondents (76.6% in the second wave and 72.9% in the first) agreeing with supporting the boycott, there is an overall trend of sustained or increasing support in the second wave. Furthermore, 56.9% of respondents in the second wave and 57.1% in the first wave said they boycotted goods that do not support Gaza. However, it is important to identify if the reasons and motives are the same over time. Do the same independent variables of the TPB affect the intention and the responsible consumption in the two waves?

The most influential SM platforms in Wave 1 were Facebook and Instagram, which were rated as highly influential by 45.8% and 44.8% of respondents, respectively (category 5). LinkedIn had relatively less influence than TikTok

and Twitter (now X), yet both platforms had a significant impact. Facebook continues to be the most influential platform in Wave 2, as 76.6% of respondents rated it in the highest category (5). Overall, Facebook and Instagram are clearly preferred in both waves, which is indicative of their dominance in influencing consumer behavior about product boycotts in the aftermath of the Gaza conflict.

Table 2: Percentages of type of products boycotted by the respondents (5 is the most, 1 is least)

Platform	Wave	Rating 1 (%)	Rating 2 (%)	Rating 3 (%)	Rating 4 (%)	Rating 5 (%)
Food product	1	5.9	0.5	13.8	24.1	55.7
	2	4.3	4.8	10	28.7	52.2
Beverages	1	6.9	2	10.3	23.2	57.6
	2	6.2	3.3	9.1	19.6	61.7
Clothing	1	8.4	3.9	14.3	17.2	56.2
	2	9.6	5.7	15.3	17.2	52.2
Technology	1	22.7	19.7	23.6	13.8	20.2
	2	25.8	20.1	24.4	11.5	18.2
Detergents	1	9.4	4.4	13.3	23.2	49.8
	2	5.7	8.6	15.8	13.4	56.5

Table 2 shows the product categories that respondents rated in two waves—food products, beverages, clothing, technology, and detergents—are displayed in the table. Overall, from Wave 1 to Wave 2, the highest rating (5) went up for beverages while going down a little for food products and clothing.

Results for Technology and Detergents were mixed, with little changes in ratings in both waves. These modifications point to a gradual change in the boycotting awareness or preferences of the respondents. The analysis known as the correlation matrix serves to quantify the degree of association between two variables. The correlation coefficient (whether + or -), indicates the direction of the variables' relationship, whereas its strength is identified by the magnitude of the correlation coefficient (Zhang, et al., 2023).

Table 3 shows that there were no discernible differences between the two waves' findings of the independent t-tests for the variables of attitude, subjective norms, perceived behavioral control, intention, boycott, and consumption. The absence of statistical significance implies that the variables under investigation, such as intentions and attitudes towards boycotting and consumption patterns, stayed the same over the time of both waves.

Table 3: Independent Samples T-Test two waves

Variables	Sig.
Attitude	0.997
Subjective Norms	0.774
Perceived Behavioural Control	0.839
Intention	0.970
Boycott	0.885

Consumption	0.901

Statistical Modelling

 To test the hypothesis, regression analysis is used to investigate and model the correlation between variables (Montgomery, et al., 2021).   Table (4) summarizes the included and excluded variables listed with significance and coefficients. The significance of the included variables is less than (0.05) which indicates that three variables, attitude, subjective norms, and perceived behavioural control, have a positive significant effect on the intention (confidence level of 99%) and also a positive and significant effect on the buying intention, at a confidence level of 99%. Attitude has a significant positive effect on intention, with a p-value of 0.000 and a β coefficient of 0.484. Thus, H1 is supported. Subjective norms have a positive effect on buying intention with a p-value of and a β coefficient of 0.160. Therefore, H2 is supported. Perceived Behavioural Control has a significant positive effect on buying intention. This is at a confidence level of 99% a p-value of 0.000 and a β coefficient of 0.227. Thus, H3 is also supported.

Table 4: Coefficients with Intention as the Dependent Variable

Model	**Coefficients for the First Wave**	**Coefficients for the Second Wave**
Constant	.517**	0.066
Attitude	.484***	0.349***
Subjective Norms	.160**	0.211***
Perceived Behavioral Control	.227***	0.365***
Age	-.002	0.005
Gender	-.105	-0.070
Education	-.232**	0.032
Monthly Income	.018	-0.055

   It should be noted that the value of the attitude on the intention to buy is the biggest. This coincides with previous literature that suggests that intentions more aligned with attitudes are stronger predictors of behaviour, because these attitudes are more intrinsically motivated (Armitage and Conner, 2020). The reason is that attitudes were the most significant predictor of consumer's purchase intentions (Chen & Li, 2007). There is no effect of age, gender, and monthly income on the buying intention. However, education level has a negative effect on the buying intention. When the education level increases, the intention towards boycotting decreases. This might be because the more educated people are, the more they tend to be less impulsive, thus the component perceived behavioral component will be stronger in their attitudes and consequently their behavior. Boycott has a direct positive effect on (responsible) consumption (β coefficient = 0.434) at a confidence level of 99.9%, with a p-value less than 0.999.

Table 5: ANOVA (showing that the P-value is 0.000 which indicates that the model is overall significant.)

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
First Wave	Regression	115.245	7	16.464	37.005	.000[b]
	Residual	86.755	195	.445		
	Total	202.000	202			
Second Wave	Regression	88.148	7	12.593	21.118	.000[b]
	Residual	119.852	201	.596		
	Total	208.000	208			

   When examining the mediation role of the boycott campaigns in the relationship between the independent variable (Boycott) and the dependent variables (responsible consumption), the statistical analysis shows the following. After controlling the intention in the first wave, the relation between Facebook use and responsible consumption became insignificant. This implies that the mediation effect of Facebook use is insignificant. After controlling the intention in the second wave, the relation between Facebook use and responsible consumption is still significant. This implies that the mediation effect of Facebook use is significant. Also, this mediation effect is partial because there a significant relation between the intention and consumption after controlling the Facebook use. Since the interaction effect is insignificant, Facebook use does not act as a moderation effect for both waves. Since the interaction effect is insignificant, Instagram use doesn't act as a moderation effect for both waves.

After controlling the intention in the first wave, the relation between Instagram use and responsible consumption became insignificant. This implies that the mediation effect of Facebook use is insignificant. After controlling the intention in the second wave, the relation between Instagram use and responsible consumption is significant. This implies that the mediation effect of Instagram use is significant. Also, this mediation effect is partial because there a significant relation between the intention and consumption after controlling the Instagram use. After controlling the Facebook Use in the first wave, the relation between Intention and responsible consumption is still significant. This implies that the mediation effect of Intention is significant. Also, It is a full mediation effect because there a significant relation between the Facebook use and consumption After controlling our mediation variable here, which is intention, the relation between Facebook use and consumption disappeared. This means that intention is motivated by Facebook use and acts as a mediator between SM use and responsible consumption in wave one.

On the other hand, intention acts as a partial mediator in wave two because there a significant relation between the Facebook use and consumption after controlling the Intention. The same applies to Instagram use. After controlling the Instagram Use in the first wave, the relation between Intention and responsible consumption is still significant. This implies that the mediation effect of Intention is significant. Also, It is a full mediation effect because there a significant relation between the Instagram use and responsible consumption After controlling our mediation variable here, which is intention, the relation between Instagram use and consumption disappeared. As with FB use, intention mediates the relationship between the Instagram use and responsible consumption in wave 1. This mediation becomes partial in wave 2.
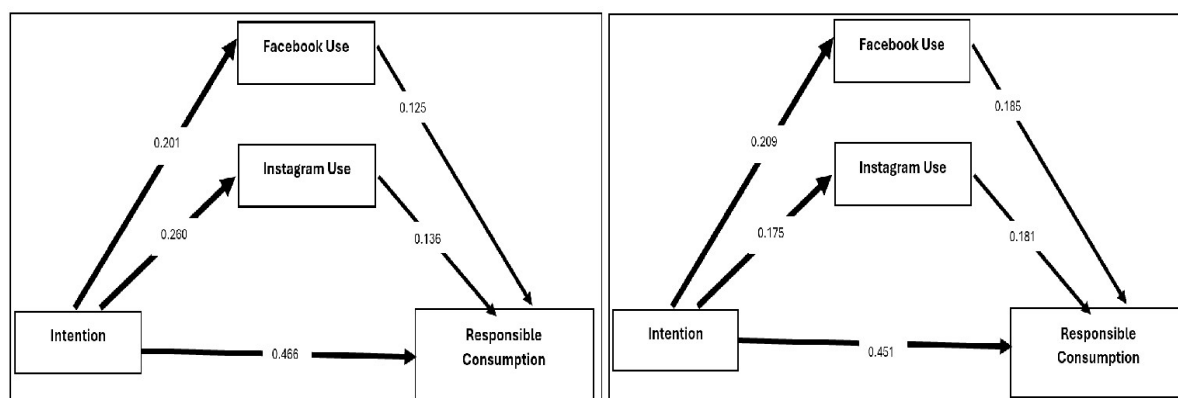
Figure 2: The results of Mediation effect for Facebook Use/Instagram Use for the second Wave
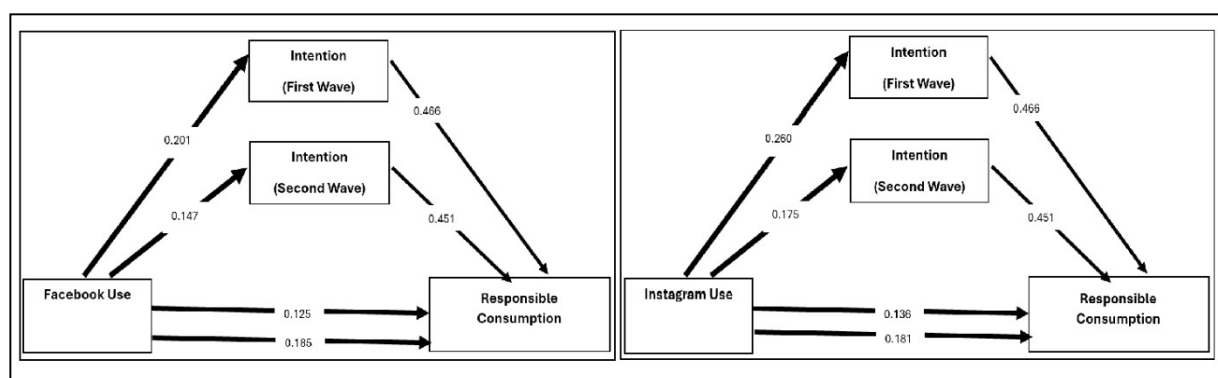

Figure 3: Comparing the Mediation effect of Intention in both waves

5. CONCLUSION

Considering the motivators for the responsible consumption behavior, the attitude's effect was the strongest factor in Wave 1 affecting responsible consumption; it declined in in Wave 2 with the diminishing boycotting calls. Subjective norms became more powerful in Wave 2 particularly among men. This reflects the strong impact of social media on

reinforcing subjective norms. Perceived Behavioural Control (PBC) became the strongest predicator in Wave 2, implying that it is not about the boycotting campaigns anymore; it is more about a behaviour that keeps being acknowledged and encouraged by masses, as portrayed by SM. It became a positive behavior that endorses responsible consumption and people like to be associated with it. The role of SM in making this behavior continue cannot be overseen.

During the first wave, women emerged as significantly more engaged in boycott activities and responsible consumption, aligning with prior research that suggests women are more responsive to ethical causes and corporate social responsibility. Men, in contrast, showed less engagement early on, but in the second wave they became more responsive to subjective norms and perceived behavioral control. They began seeing boycotting as something practical and within reach (Gardberg & Newburry, 2013). While women remained consistent in aligning beliefs with behavior, men moved from passive observation to socially and practically driven engagement.

Participants between the ages of 18 and 24 led the boycotting movement in the first wave, as they were driven by online activism and intense emotions, which is consistent with the body of research on youth-led social engagement in times of socio-political unrest and national crisis. However, those between the ages of 25 and 34 and those over 35 became more prominent in the second wave. This shift demonstrates how movements may start out with the youth but need the perseverance and structure of older participants to last overtime.

Boycott participation partially mediated intention-consumption in Wave 1; this partial mediation still existed but was weaker in Wave 2. As habits formed, responsible consumption behaviour became more separate from protest behavior, thus maturing independently. SM supported the continuation of the behavior, though the boycott itself lost its driving force. Thus, the effect of crisis and conflict on consumer behavior is strong but short. If it was not for social media, the responsible behavior we have witnessed in 2024 would have been reduced significantly by now.

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Global Education, Teaching and Learning (IAC-GETL)

Engaging Students through Games: The Role of Gamification in Higher Education

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Abstract

The swift changes in educational technology have changed how people learn and teach, and gamification is now one of the most important new ideas in modern teaching. Educators seek to enhance student engagement, motivation, and information retention by incorporating game-based aspects into academic settings. This research integrates findings from two significant studies: Zirawaga, Olusanya, and Maduku's (2017) examination of gaming in history education and Presadă's (2015) analysis of game utilization in literature classrooms. Based on these studies, the study looks at the pros, cons, and teaching implications of gamification in higher education. It focuses on how it can help create active learning environments and improve critical thinking abilities. The results show that game-based tactics encourage teamwork, creativity, and a better understanding of the material, while also meeting the needs of different types of learners. But there are still big problems with cost, time, accessibility, and teacher readiness that make things hard. This study adds to the expanding conversation about how gamification could change education by comparing and combining historical and literary examples. It also gives suggestions for how teachers and policymakers can make the most of gamification in today's classrooms.

Keywords: Gamification, Student Engagement, Educational Technology, Game-Based Learning, Higher Education

1. INTRODUCTION

In the 21st century, education has changed a lot. New technologies have changed how teachers teach and how students are involved in learning. Students' needs for interactive, dynamic, and individualized learning experiences are making traditional lecture-based teaching paradigms less effective. As part of this change, gamification—the use of game mechanics and design ideas in educational settings—has become a powerful way to teach.

Gamification takes advantage of students' natural love of play and competition to create new ways to improve their motivation, teamwork, and problem-solving skills. Zirawaga, Olusanya, and Maduku (2017) claim that gaming techniques give students hands-on learning experiences that go beyond the habit of memorization. These experiences help students understand historical concepts better through interactive tools like crossword puzzles, jigsaw activities, sliding puzzles, and quiz-based learning modules. Presadă (2015) also talks about how gamification works well in literary classes, where things like role-playing, dramatizations, and narrative-based challenges make student-centered, active learning environments that encourage creativity and critical thinking.

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Research shows that gamification is becoming more popular in higher education, but it is not being used consistently or without problems. In Presadă's (2015) survey of 75 philology students, 66.7% regarded games as educational, and 74.7% supported their more frequent incorporation in literary classes. Even though students were excited about games, only 13.3% said that teachers used them often. This shows a big difference between what students expected and what teachers really did. Zirawaga et al. (2017) also argue that technological problems, not enough time, and teachers not knowing how to use game-based design tools typically make it hard for more history classes to use them.

This paper seeks to address three primary objectives:

1. To investigate the impact of gamification on student engagement and learning outcomes in higher education.
2. To compare how well it works and what it can do in history and literature classes.
3. To give suggestions for how to use gamification effectively in today's classrooms.

By integrating findings from the two studies and substantiating them with comprehensive educational theories, this paper contends that gamification functions as a transformative instructional tool that reconfigures classroom dynamics, promotes collaborative learning, and provides students with essential 21st-century skills.

The next sections will examine pertinent literature about the pedagogical underpinnings of gamification, analyze the methodology utilized in the source research, and offer a comparative evaluation of outcomes derived from historical and literary contexts. Finally, the article looks at the bigger picture, points out problems with putting gamification into practice, and makes suggestions based on research for how to get the most out of gamification in modern education.

2. LITERATURE REVIEW

Gamification in education is using game mechanics, aspects, and concepts in places that are not games, including classrooms and other places where students learn. Gamification uses motivation, rewards, competition, and interactivity to create active, student-centered learning experiences, which is different from traditional techniques that focus on memory and passive absorption of knowledge (Deterding et al., 2011). Both Zirawaga et al. (2017) and Presadă (2015) underscore the substantial influence of gamification in augmenting student engagement, creativity, and collaboration, particularly in fields that are conventionally more inflexible, such as history and literature.

Zirawaga et al. (2017) emphasize that game-based tactics in history education increase student engagement and conceptual understanding by converting abstract and fact-laden material into interactive and engaging activities. Instead of just memorizing facts repeatedly, gamification in history makes students interact with the curriculum using fun tools like crossword puzzles, jigsaw puzzles, and quizzes. These activities help students remember what they learned for a long time and understand historical events, timelines, and people better, which makes the learning process more interesting. In literature, Presadă (2015) also talks about how gamification encourages active learning by getting students to role-play, act out scenes, and tell stories together. These activities let students really get into the texts, which improves their ability to understand them and gives them a place where they are not only passive learners but also co-creators of meaning. Gamification uses game-based methodologies that are in line with constructivist teaching methods. This means that students learn by doing and becoming more interested in the subject matter.

Most of the literature agrees that gamification could help close the gap between what students expect from their teachers and what they actually do by making learning more engaging and relevant. But for gamification to work, it needs to be carefully planned, fit with learning goals, and have the right technology. Both studies acknowledge that gamification provides various advantages, such as enhanced student engagement and the cultivation of critical thinking abilities; however, its efficacy may be hindered by practical obstacles, including time limitations, insufficient technical proficiency, and restricted resource availability.

Zirawaga et al. (2017) examine the difficulties of gamifying history teaching, highlighting that history is frequently regarded as less pertinent than disciplines such as physics or mathematics, leading to diminished student interest. To fight this, they suggest using interactive puzzles, quizzes, and simulations, which might make students more curious and get them involved. They also talk about how games can help with more than simply learning facts; they can also help with social and cognitive abilities like critical thinking, working together, and being flexible. Students improve their communication skills and learn how to better judge historical sources by doing projects that demand them to solve problems or compete for high marks.

Presadă (2015), on the other hand, looks at how gamification might improve teaching literature, which is a subject where students typically have trouble understanding difficult texts and appreciating stylistic differences. She suggests several game-based activities to make literature classes more fun, like role-playing, jigsaw reading assignments, and storytelling with puzzles. These activities not only help students understand things better, but they also help them work together, be creative, and feel more confident. Also, Presadă connects gamification to active learning, which is

a teaching method that focuses on getting students involved and building their own knowledge instead of just giving them information. This helps students remember what they have learned for a long time and makes them more interested in reading.

Both studies recognize the obstacles to the effective use of gamification. Zirawaga et al. (2017) cite obstacles like time limitations, the technical shortcomings of free resources, and digital disparities that hinder students lacking dependable access to devices or the internet from fully engaging. In the same way, Presadă (2015) claims that many teachers agree with the idea of using games in literature classes, but they are often hesitant because they think they will take up too much time, cause problems in the classroom, and not everyone will be able to participate. These findings indicate that for gamification to be effective, it necessitates not only technology assistance but also teacher training and curriculum modifications that guarantee the smooth integration of games into the learning objectives.

The literature also uses a number of teaching ideas to explain why gamification improves learning and engagement. Constructivist Learning Theory, for instance, complements gamification by asserting that learners actively build knowledge through experiential engagement, reflection, and cooperation. Both findings show that games let students change and personalize what they know instead of just passively taking it in. Social Learning Theory, grounded in Bandura's (1986) theory, is integral to gamification, as games frequently entail peer collaboration and collaborative problem-solving. This interaction not only lets students share their thoughts, but it also clears up any confusion and makes sure they remember what they have learned.

Both studies stress the importance of technology in gamification, with digital tools like ProProfs and Moodle being key to teaching history. These platforms let teachers make interactive games, quizzes, and puzzles that fit with what students are learning, and they also let teachers keep track of how well students are doing. Literature programs, on the other hand, use more low-tech methods, like dramatization and group storytelling, that focus on creativity and critical thinking instead of digital creation. This difference shows that gamification does not always need expensive technologies. Even in places with few resources, meaningful engagement can be accomplished through well-structured, story-driven classroom activities.

In general, gamification has been shown to be a useful way to get students more involved and improve their learning, but it can be hard to put into practice because of a number of problems. These include making sure teachers get enough training, fixing resource gaps, and changing gamified tactics to fit different subjects. The research underscores the significance of creating gamified activities that correspond with educational goals and are available to all students, irrespective of technological resources.

3. METHODOLOGY

This research utilizes a qualitative synthesis methodology, amalgamating and examining ideas from two principal studies: Zirawaga, Olusanya, and Maduku (2017) regarding gaming in history education and Presadă (2015) concerning the application of games in literature instruction. Both studies were chosen for their pertinence to gamification in education and their synergistic viewpoints on learning in historical and literary frameworks. The paper does not do any new primary research; instead, it combines current data by comparing outcomes, recognizing common patterns, and pointing out discipline-specific practices to better understand how well gamification works in different educational environments.

The synthesis draws on the creation and incorporation of ProProfs-based games and Moodle-hosted quizzes utilized in the history study to impart historical information, events, and timelines. Conversely, the literature study examined role-plays, dramatizations, and collaborative storytelling to improve literary interpretation and stimulate student creativity. Both researches used student-centered data: the history study evaluated learning outcomes, engagement levels, and retention rates, whilst the literature study polled 75 philology students to gather quantitative data on attitudes, motives, and problems associated with gamified learning.

This paper discusses three important study goals. First, it looks at how gamification makes higher education students more interested in their studies, using examples from history and literature. Second, it looks at how gamification is used and how well it works in history and literary classes. Lastly, it talks about the pedagogical, technological, and institutional problems that make it hard to use gamification in schools.

The analysis employs a comparative thematic framework, concentrating on three dimensions: cognitive outcomes, including retention, critical thinking, and comprehension; affective outcomes, such as motivation, interest, and emotional engagement in learning; and behavioral outcomes, which involve collaboration, participation, and digital literacy. These dimensions correspond with Bloom's taxonomy, offering a systematic framework for synthesizing and contrasting the data from the two research.

4. RESULTS AND ANALYSIS

The results from both Zirawaga et al. (2017) and Presadă (2015) show how gamification can change higher education, especially by making students more interested and improving their learning outcomes. In both investigations, gamification consistently increased student engagement. In the history study, students were more engaged when the activities included crosswords, jigsaw puzzles, and quizzes that were in line with what they were supposed to learn. This engagement was due to the fact that these exercises were participatory, which gave students chances to use what they had learned in real-life situations where they had to solve problems. Students were more encouraged to actively engage with the topic when content delivery changed from traditional lecture-based techniques to more dynamic, game-oriented activities. This led to higher memory and understanding of historical facts and timelines.

Likewise, in the literature study, 74.7% of students indicated a need for further game-based activities, demonstrating a pronounced preference for interactive, student-centered learning settings. This choice is part of a bigger change in how schools work, as students want more freedom and to be more involved in their own learning. Gamification fits these desires well since it combines fun challenges with competitive components. Games fostered intrinsic motivation by converting conventional passive teachings into collaborative and enjoyable challenges, so promoting active engagement. This change was most clear in how students interacted with texts and literary ideas. The games were a more interesting approach to evaluate and understand information than standard lectures. This change fits with Self-Determination Theory (Ryan & Deci, 2000), which says that students are more engaged, persistent, and satisfied when their intrinsic motivating demands are met in the classroom.

Gamification had a favorable effect on knowledge retention, comprehension, and critical thinking in both areas of study, but the ways it worked were different in each. In the context of history, students who used ProProfs-based crosswords and quizzes remembered historical knowledge for longer because these interactive tools made them remember and use facts in real time, which helped them remember them for a longer time. Using digital platforms like ProProfs also helped students become more digitally literate, which made it easier for them to use educational technology while studying history. On the other hand, role-plays and dramatizations in literature classrooms helped students understand the storyline, themes, and character motives better. They could get into the stories and think about them in new ways. Gamification in literature gave students the flexibility to come up with fresh endings, character arcs, and stories, which let them think creatively and analyze things in a new way.

Students' opinions also showed that gamification had a favorable effect. Presadă's (2015) survey indicated that 66.7% of students perceived games as instructive, 62.7% stated that games enhanced their enthusiasm to read prescribed literature, and 53.3% believed they recalled knowledge more effectively when instructed through games. These findings indicate that gamification functions not only as an engaging instrument but also augments learning efficacy by enhancing comprehension and retention. Zirawaga et al. (2017) also found that students had positive feelings about gamification, especially when it came to using technologies like Moodle and ProProfs to improve digital literacy. This shows that gamification not only helps students grasp the material better, but it also helps them learn important skills for the 21st century, such working together, solving problems online, and being creative.

5. DISCUSSIONS

The results show that gamification can have a positive effect on student engagement and learning outcomes, but there are still some problems and constraints that need to be fixed before it can be used successfully. Both studies showed that there was a big difference between what students expected and what teachers did. In Presadă's (2015) study, 74.7% of students supported the incorporation of additional game-based activities, however merely 13.3% indicated their regular implementation. Zirawaga et al. (2017) similarly discovered restricted teacher implementation of gamified methodologies owing to technical difficulties, curricular limitations, and insufficient training. This mismatch indicates that although students evidently appreciate interactive and gamified methodologies, educators encounter structural, technological, and pedagogical obstacles that impede the extensive adoption of these strategies. To close this gap, teachers need specific training, schools need to invest in gamified learning systems, and the curriculum needs to be aligned such that games support learning goals instead of being separate, extracurricular activities.

Zirawaga et al. (2017) talk about how digital technologies like ProProfs and Moodle may make learning more personal, automate tests, and make it easier for students to get to. These tools also give students and teachers useful feedback, which lets them keep track of their development and performance. Nonetheless, Presadă (2015) illustrates that gamification does not inherently necessitate expensive technologies. Low-tech, story-based methods like role-plays and dramatizations can have the same or even bigger effects on engagement and understanding. This information

is especially crucial for teachers who work in places where there aren't many resources and high-tech solutions aren't possible. Gamification can still work with less advanced tools as long as the activities are meaningful, student-centered, and meant to get students involved through interactive, collaborative experiences.

The studies also show how gamification can be used in different fields. The goal of history education is to help students remember facts, events, and timelines better by employing digital platforms, quizzes, and puzzles. These exercises help kids learn how to use technology, work with others, and remember things. In literature education, the goal is to improve interpretation, creativity, and critical thinking. Role-playing, dramatizations, and collaborative storytelling are some of the tools used to help students develop empathy, imagination, and a deeper connection to texts. This shows that the basic ideas behind gamification are the same for everyone, but the way it is used in practice needs to be different for each field to have the most effect.

Gamification has a lot of potential, but there are still some problems with it. One of the biggest problems is that teachers don't know how to successfully add game mechanics to their existing lesson plans. Many teachers still don't know how to use the tools and design principles that make gamification work, which means they can't use these methods to their full potential. Also, relying on technology-based games could leave out children who don't have reliable access to devices or the internet. Also, gamified approaches may not last since they take a lot of time to build, use old tools, and don't get enough backing from institutions. Numerous instructors indicate that the design and implementation of gamified activities is a labor-intensive endeavor necessitating ongoing work and resources. Moreover, most current studies, including those examined in this paper, concentrate predominantly on short-term engagement rather than long-term academic results. Subsequent study must tackle these constraints by investigating the enduring cognitive impacts of gamification, contrasting low-tech and high-tech frameworks, and analyzing gamification's function within multidisciplinary, blended-learning contexts.

To sum up, gamification has been shown to be a great way to get students more interested and improve their learning, but there are some big problems that need to be solved before it can be used successfully. Teachers need to learn more about how to use game-based tactics in their classrooms. Institutions need to spend money on the right technology and support mechanisms to make gamification possible. Also, gamification tactics need to be changed to meet the needs and resources of each subject. This will make sure that the activities are in line with the learning goals and get students involved in meaningful ways. If these problems are fixed, gamification can reach its full potential as a powerful tool for changing modern education.

6. CONCLUSIONS

Gamification signifies a transformative shift in contemporary education, providing students with immersive, significant, and collaborative learning experiences. This paper shows that gamification improves motivation, retention, and engagement by combining the results of Zirawaga et al. (2017) and Presadă (2015). It helps students learn how to use computers, work together, and think creatively. Gamification offers techniques that can be scaled up or down to fit diverse fields and tech settings. But to make it work, teachers need to plan ahead, get support from the university/institution, and train teachers to deal with problems and close the gap between what students expect and what they really learn. Gamification gives teachers the tools they need to rethink how they educate in ways that work for today's students and get them ready for the technology-driven, collaborative needs of the 21st century.

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Suprasegmental Challenges in TEFL: Word Stress Placement

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Abstract

Word stress is a key but often neglected aspect of English pronunciation, especially for Slovak learners whose L1 follows a fixed initial stress pattern. This study examines Slovak teacher trainees' accuracy in English word stress placement through recorded tasks of words in isolation and in sentences. Results show a strong tendency to shift stress to the first syllable and increased errors in longer, multisyllabic words, confirming the influence of Slovak-English interference. The findings highlight gaps in teacher trainees' readiness to model accurate pronunciation and call for greater emphasis on suprasegmental training in teacher education.

Keywords: English, pronunciation, word stress, placement, Slovak learners

1. INTRODUCTION

One of the factors that characterizes English is its complex pronunciation. Word stress is an integral and crucial part of English pronunciation, which often determines the effectiveness and clarity of communication. There are many challenges that teacher trainees of the English language will face during their practice, and teaching word stress is undoubtedly one of them. English language teachers serve as models of pronunciation for their students. Perception of word stress and learning of its correct placement is indispensable for all learners of English and therefore, the proficiency of future teachers of the English language should be considered pivotal.

Numerous differences can be found between the pronunciation of English and Slovak. However, word stress placement is at the forefront of the differences, and for Slovaks, this represents one of the most difficult aspects of English pronunciation. The main reason for that is the fact that the Slovak language is characterized by a fixed stress pattern, while the English stress pattern is unbound. Another reason may be the fact that the practice of English pronunciation and word stress placement is insufficient. The subsequent inability to place word stress correctly may then accompany the learners, even during their studies at a university.

As described by many authors, the issue of word stress is extremely complex and extensive, and there are countless opinions regarding the teaching and practice of word stress. The scope of this article does not allow for a focus on

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every such opinion in detail, but the authors rely mainly on the views of [1], [2], and [3]. From the panel of Slovak linguists, findings of [4], [5], and [6] are considered in particular.

2. COMPARISON OF ENGLISH AND SLOVAK WORD STRESS

There are numerous differences between English and Slovak word stress. [6] created a summary of the most significant categories and specified all the differences in them:

- PROMINENCE: English stress is more prominent in both primary and secondary stress placement. The choice of vowels in Slovak does not correlate with the amount of stress placed on the syllables.
- FUNCTION: In English, stress is the primary factor that can change one word class into another. In Slovak, the ability to determine meaning is precluded by the fact that Slovak stress is always bound to the first syllable.
- PLACEMENT: The English primary stress can be placed on any syllable, contrasting with the Slovak language, where it is normally placed on the first syllable of a word. In English, the secondary stress can either precede or follow the primary stress, while in Slovak, the secondary stress never comes before the main stress.

Across the globe, foreign language learners are influenced by their native language. Slovak speakers of the English language are no exception in this regard. If a speaker is influenced by their native language and transmits its features into the production of another language, this linguistic phenomenon – language interference is defined as "a negative transfer of a native language to the production in a foreign language" [4, p. 3].

3. METHODOLOGY

3.1. Objectives

The primary objective of the research was to find out the proficiency of Slovak TEFL undergraduate students in the issue of word stress placement. Initial data were obtained from a selected sample of respondents, and the subsequent perceptual evaluation of the data was aimed at the research objectives. Quantitative method was employed to obtain the data and subsequently state the occurrence of errors in the respondents' pronunciation. In this context, one research question and one research hypothesis were formulated:

- RQ_1: What are the most common errors in word stress placement in the speech of Slovak students?
- H_1: There is a relation between the number of syllables in a word and wrong stress placement.

3.2. Respondents

The research involved ten undergraduate TEFL students (4 male and 6 female) enrolled in an English teacher training program. All participants had completed coursework in phonetics and phonology and were at an upper-intermediate or advanced level of English proficiency [7]. While individual exposure to English varied (e.g., study abroad, teaching experience, or exclusive academic learning), the group represented a relatively homogenous cohort in terms of their training and study focus.

3.3. Material

The experimental material comprised twelve multisyllabic English words, evenly distributed according to stress placement on the 1st, 2nd, 3rd, and 4th syllables (Table1). These words were presented in two forms: (1) as isolated lexical items and (2) embedded within short sentences designed to reflect natural speech rhythm (Table 2). The material was created by the researchers to ensure balanced distribution of stress positions.

Table 1. Lexical items used in the research

Word	Part of speech	Number of syllables	Phonetic transcription	Stressed syllable
objective	noun	3	/əbˈdʒektɪv/	2nd
generalize	verb	4	/ˈdʒenrəlaɪz/	1st

necessity	noun	4	/nəˈsesəti/	2nd
activate	verb	3	/ˈæktɪveɪt/	1st
volunteer	noun	3	/ˌvɒlənˈtɪə(r)/	3rd
vision	noun	2	/ˈvɪʒn/	1st
deliberation	noun	5	/dɪˌlɪbəˈreɪʃn/	4th
ability	noun	4	/əˈbɪləti/	2nd
refugee	noun	3	/ˌrefjuˈdʒiː/	3rd
civilization	noun	5	/ˌsɪvəlaɪˈzeɪʃn/	4th
guarantee	verb	3	/ˌgærənˈtiː/	3rd
responsibility	noun	6	/rɪˌspɒnsəˈbɪləti/	4th

Table 2. Sentences used in the research

1) After hours of **deliberation** /dɪˌlɪbəˈreɪʃn/, the council came to a decision.	2) She is currently working as a **volunteer** /ˌvɒlənˈtɪə(r)/ for the Northeast **Refugee** /ˌrefjuˈdʒiː/ Service.
3) When it comes to culture and traditions, you cannot **generalize** /ˈdʒenrəlaɪz/.	4) Nowadays, telephones are a **necessity** /nəˈsesəti/, not a convenience.
5) I am going to take full **responsibility** /rɪˌspɒnsəˈbɪləti/ for my actions.	6) His **vision** /ˈvɪʒn/ blurred with tears.
7) The primary **objective** /əbˈdʒektɪv/ is to achieve the best results and **activate** /ˈæktɪveɪt/ prior knowledge.	8) Can you **guarantee** /ˌgærənˈtiː/ that this version is true?
9) She never mastered the **ability** /əˈbɪləti/ to interact with people.	10) **Civilization** /ˌsɪvəlaɪˈzeɪʃn/ does not remain static, it changes constantly.

3.4. Procedure

Data collection was conducted online via MS Teams, with each participant recorded individually in a quiet environment to ensure audio quality. Participants were asked to read first the isolated words and then the sentences, at a natural pace and volume. They were not provided with the material in advance, in order to reduce rehearsal effects and capture spontaneous performance.

Recordings were subsequently transcribed and analysed perceptually by the researchers. Each word was checked against its correct stress placement, and errors were logged according to syllable position. To ensure reliability, recordings were replayed multiple times, and ambiguous cases were carefully cross-checked. The data were processed quantitatively: error frequencies were calculated, compared across tasks, and examined in relation to word length and stress position. This procedure enabled the identification of systematic patterns, particularly the influence of Slovak fixed-stress transfer on English pronunciation.

4. RESULTS

In Task 1 (words read in isolation), respondents produced 43 incorrect stress placements out of 120 tokens. Errors concentrated on longer words with stress on later syllables, particularly *responsibility* (70% incorrect) and *civilization* (60% incorrect). By contrast, short words such as *vision* and *activate* were pronounced without error. Overall, 79% of the misplacements involved shifting stress to the first syllable.

In Task 2 (words read in sentences), the error rate increased to 51 out of 120 words. The same tendency toward initial-syllable stress was observed, with problematic items including *responsibility* (90% incorrect), *refugee* (70%), and *necessity* (70%). Again, shorter two- or three-syllable words (*vision*, *activate*) were least affected.
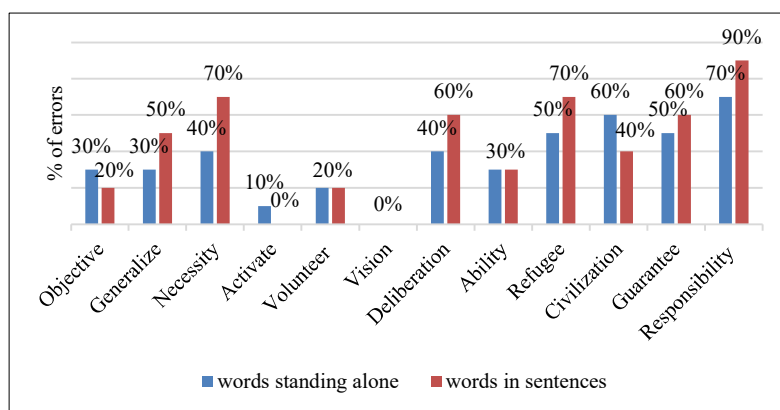
Fig. 1. Occurrence of errors (juxtaposition)

Figure 1 provides a clear comparison of the two tasks: stress misplacement occurred more frequently in connected speech than in isolated word reading, confirming that sentence-level processing exacerbates Slovak learners' reliance on their L1 fixed-stress system. The prevalence of stress shifts to the initial syllable across both tasks demonstrates the strong influence of Slovak prosodic patterns on English pronunciation.

5. DISCUSSION

The results highlight the persistent challenge of mastering English word stress for Slovak learners. The strong tendency to default to initial-syllable stress illustrates the impact of first-language transfer, which remains a dominant influence even at an advanced proficiency level. The greater error rates in longer words support the assumption that syllable count increases difficulty, while the drop in accuracy during sentence reading suggests that cognitive load further exacerbates stress errors.

From a pedagogical perspective, the findings signal an urgent need to strengthen suprasegmental training in teacher education. Since future teachers act as pronunciation models, insufficient mastery of word stress may affect their learners' intelligibility and reinforce incorrect patterns. Targeted practice with complex, multisyllabic words, combined with explicit awareness-raising of English stress regularities and strategies for overcoming L1 interference, could significantly improve teacher trainees' competence. Integrating such approaches into curricula would contribute to better preparation of English language educators and, by extension, their future students.

6. CONCLUSION

This study has demonstrated that Slovak teacher trainees of English frequently struggle with accurate word stress placement, largely due to interference from their native language [4]. The empirical findings confirmed two key points: first, that the likelihood of misplacing stress increases with word length, and second, that stress errors occur more often in connected speech than in isolated word reading. These results highlight a significant gap in pronunciation training, especially in the suprasegmental domain, which is often neglected in Slovak education.

By combining a theoretical comparison of English and Slovak stress systems with empirical analysis, the research underscores the need for greater pedagogical emphasis on word stress in teacher preparation. Equipping future teachers with deeper awareness and effective strategies for teaching stress can help mitigate recurring errors and improve learners' overall intelligibility.

Ultimately, this work reinforces the idea that pronunciation instruction must extend beyond segmental accuracy. Word stress is not only a technical feature of English but also a decisive factor in communicative clarity. Future research and teacher training should therefore continue to address this issue to ensure more effective English language education in Slovakia.

Acknowledgements

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Use of ChatGPT in English Literature Classes: Benefits 'and Challenges

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Abstract

The integration of Artificial Intelligence (AI) into education has accelerated in recent years, with the language and literature classroom among the fields most profoundly affected. This article presents a pedagogical experiment in the postgraduate course – Anglophone Literature 2, focusing on John Milton's Paradise Lost and the potential of generative artificial intelligence (AI) as a tool for literary interpretation. The study explores how ChatGPT, an AI language model, can serve as a dialogic companion in the analysis of Miltonic theology, rhetoric, and poetics. The activity's objectives were to enhance analytical engagement with the text, promote critical digital literacy, and foster reflexive thinking about interpretive authority. Drawing on classroom observation and students' written reflections, the results indicate that while ChatGPT offers stimulating entry points into complex themes – such as free will, divine justice, and Satan's heroism – it also reveals interpretive and ethical limitations. Students' commentaries highlight both the usefulness and insufficiency of AI-generated literary analysis, reinforcing the centrality of human critical judgment in literary scholarship.

Keywords: ChatGPT, English Literature, literary interpretation, education, AI in education

1. INTRODUCTION

The integration of artificial intelligence into educational contexts has reshaped the landscape of teaching across disciplines. Among the most transformative innovations is the emergence of conversational agents powered by large language models (LLMs), such as OpenAI's ChatGPT (Watts, 2023). Since its public release, ChatGPT has been widely adopted in classrooms, research environments, and informal learning settings, functioning as a writing aid, tutoring assistant, and research companion (Lee and Yoon, 2021; Luo et al., 2020). Its ability to generate coherent, context-sensitive text in response to natural language prompts has made it a powerful tool for both students and educators, supporting activities ranging from brainstorming and essay drafting to language learning and critical discussion (Krijgsman, 2018).

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In education practice, ChatGPT has been used to facilitate personalized learning experiences by providing immediate feedback, adapting explanations to learners' levels, and simulating dialogic exchange – features traditionally associated with one-on-one tutoring (Kohnke et al., 2023; Roy and Putatunda, 2023). Educators have also explored its role in promoting metacognitive awareness, encouraging students to question, evaluate, and refine AI-generated responses. At the same time, concerns about academic integrity, overreliance on algorithmic reasoning, and erosion of authentic critical thought continue to shape the debate around its pedagogical legitimacy (Zhang, 2022). Within the humanities, these tensions are particularly acute. Unlike fields with clear problem-solution structures, disciplines such as philosophy, history, and literature depend on interpretive subtlety, ambiguity, and subjective judgment – qualities that resist algorithmic codification. Yet precisely because of this resistance, ChatGPT offers a unique testing ground for the evolving relationship between human creativity and machine intelligence.

The rise of generative artificial intelligence has opened new dimensions in humanities education, particularly in the teaching of literature (Azizah et al., 2020). Large language models such as ChatGPT have emerged not only as writing assistants but also as potential interpretive partners – tools that can generate ideas, paraphrase complex passages, and mimic critical reasoning (Fitria, 2021; Elbechir, 2018). While many scholars have expressed concerns about AI's role in creative disciplines (Handayani et al., 2020; Aljohani, 2021; Lilianira et al., 2020), its introduction into the interpretive classroom can also be viewed as an opportunity to test the resilience of humanistic methods (Becerra-Fernandez, 2000).

For the study of John Milton's Paradise Lost, a text that dramatizes the tension between divine knowledge and human limitation, this experiment carried special symbolic weight. The poem's central conflicts – obedience and rebellion, faith and doubt, creation and interpretation – mirror the current academic tension between human and machine knowledge. As Milton's Satan seeks to rival the divine intellect, so too does humanity, through AI, aspire to transcend its own cognitive limits.

Milton's epic demands interpretive dexterity. Its intricate syntax, theological ambition, and shifting sympathies between characters require readers to sustain multiple perspectives simultaneously. For generations, Paradise Lost has been a proving ground for interpretive skill: from Stanley Fish's (1967) theory of readerly trial to feminist reinterpretations of Eve's agency (Lewalski, 2003). Introducing ChatGPT into such a classroom thus raised critical pedagogical questions:

Can AI meaningfully participate in the complex negotiation of meaning that literary study entails?

Or does its participation reduce interpretive labor to mechanical paraphrase?

This article reports on a classroom case study conducted in the Anglophone Literature 2 course at Constantine the Philosopher University in Nitra during the summer semester of the Academic Year 2024/2025. The lesson focused on using ChatGPT to engage Paradise Lost as both text and an interpretive problem. The results offer insight into how students perceive AI's role in scholarly discourse and how its inclusion can provoke deeper awareness of interpretive practice.

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students perceive AI's role in scholarly discourse and how its inclusion can provoke deeper awareness of interpretive practice.

2. PEDAGOGICAL GOALS

The activity was designed with three interconnected pedagogical goals:

1. **Enhancing textual analysis.** Students were encouraged to use ChatGPT to generate and challenge interpretive hypotheses about Paradise Lost. The aim was not to replace scholarly analysis but to use AI as a heuristic for exploring interpretive possibilities.
2. **Developing critical literacy.** By interrogating the outputs of a language model, students could practice assessing argument quality, identifying bias, and distinguishing between a coherent paraphrase and a genuine analysis.
3. **Promoting reflexive awareness of interpretation.** The exercise encouraged students to reflect on what constitutes a "reading" of a text – contrasting the algorithmic synthesis of AI with the historically grounded, ethical, and affective dimensions of human interpretation.

These objectives align with calls within digital humanities pedagogy for critical, not instrumental, uses of technology (Rockwell and Sinclair, 2016). Rather than treating ChatGPT as an analytical authority, students were invited to consider it a "mirror" reflecting dominant interpretive tendencies.

3. DESCRIPTIVE METHODOLOGY

3.1 Participants of the Activity

The study took place in a 90-minute seminar involving 14 first-year master's students enrolled in Anglophone Literature 2. The students had previously studied Milton's Paradise Lost and were informed of major critical responses like those of Fish (1967), and Lewalski (2003). All the students had experience using AI for academic purposes.

3.2 Lesson Structure

The seminar followed four structured phases:

a.   Introduction (15 minutes)

The instruction provided by a brief lecture on AI's role in textual interpretation, introducing ChatGPT as a language model trained to predict patterns of discourse rather than generate original insight. A live demonstration followed with the prompt:

"How does Paradise Lost reconcile divine justice with human freedom?"

ChatGPT's answer, while grammatically polished, emphasized theological harmony and neglected Milton's rhetorical ambivalence. The class dissected this response, identifying the absence of irony, tone, and historical nuance.

b.   Group Inquiry (30 minutes)

Students were divided into four thematic groups:

1. Characterization of Satan – exploring his rhetoric and heroism
2. Eve and Gendered Agency – examining Eve's reasoning and temptation
3. Theodicy and Free Will – analyzing God's and Adam's speeches
4. Narrative Voice and Epic Style – assessing Milton's self-positioning as poet-prophet

Each group used ChatGPT to generate interpretive responses to 2-3 prompts (e.g., "Does Milton sympathize with Satan?" or "Is Eve's reasoning flawed or heroic?"). Students recorded ChatGPT's answers, asked follow-up questions, and compared the AI's logic to scholarly interpretations.

c.   Class Discussion (30 minutes)

Groups presented their findings. Discussion revolved around interpretive accuracy, rhetorical style, and conceptual depth. The instructor guided meta-reflection on how ChatGPT's responses imitated academic discourse without necessarily demonstrating comprehension.

d.   Reflective Writing (10 minutes)

Students wrote brief reflections evaluating ChatGPT's usefulness and limitations in studying Paradise Lost. These were later collected as qualitative data.

4. RESULTS AND DISCUSSION

4.1. Student Engagement

Students responded with enthusiasm to the interactive format. The novelty of dialoguing with an AI about Milton transformed what might otherwise have been a dense seminar into a dynamic exercise in critique. As one student remarked:

"The activity was like arguing with a polite, well-informed person, who knows the material, but does not really think."

This engagement encouraged active participation rather than passive reception. Students experienced firsthand that interpretation requires not only knowledge but judgment.

4.2. ChatGPT as an Interpretive Catalyst

Students found ChatGPT helpful in outlining critical debates, especially the "Satan as hero" controversy. The AI's summary juxtaposed Romantic admiration (Blake, Shelley) with Milton's theological condemnation. This prompted students to revisit the ambiguity of lines such as Satan's defiant speech – "Better to reign in Hell than serve in Heaven" (Book 1, line 263) – and discuss the seductiveness of rhetorical rebellion.

However, the AI's tendency to neutralize contradictions was quickly noted. When asked whether Milton intended Satan's heroism, ChatGPT framed the issue as a "matter of scholarly interpretation," thereby reproducing safe academic language without commitment. Students recognized this as what one termed "the illusion of balance," a stylistic mimicry of objectivity masking interpretive shallowness.

4.3. Critical Literacy and Meta-Interpretation

Perhaps the most significant outcome was students' recognition of ChatGPT's discursive biases. Several observed that the AI consistently privileged moral coherence, portraying Milton's theology as internally consistent even when textual evidence suggested otherwise.

One of the students even commented:

"ChatGPT reads Milton as if contradictions are errors to be smoothed out, not deliberate provocations."

This realization allowed students to see Paradise Lost as a site of tension rather than consensus. They began questioning whether AI-generated readings – aggregated from mainstream critical discourse – might erase precisely the interpretive friction that drives literary study.

4.4. Ethical and Theological Resonance

Discussions often turned toward ethical parallels between Milton's narrative and the use of AI itself. Students likened human creation of ChatGPT to Milton's God creating Adam: a being capable of imitation but lacking independent will. Another student drew an analogy between Eve's curiosity and human technological innovation:

"Like Eve, we want to know more, even if the knowledge changes us."

This reflective turn revealed that the encounter with AI deepened rather than trivialized students' engagement with Milton's moral and theological themes.

4.5. Evaluating Usefulness

The students' written reflections converged on four recurring insights:

1. **Starting point, not Endpoint:** Students emphasized that ChatGPT was effective as a preliminary aid – to organize initial thoughts, identify key plot points, or summarize scholarly debates. Its ability to produce logically structured responses gave students a good starting point from which to begin deeper interpretive work. However, they consistently observed that the model's readings lacked subtlety, tension, and imaginative risk that characterize genuine literary interpretation. Rather than offering an "endpoint", it functioned as a scaffold: it clarified what could be said before true interpretation began.
2. **Efficiency in Mapping Knowledge:** It helped students quickly identify dominant critical positions, functioning as a "literary map," providing a panoramic view of critical discourse. This capacity allowed students to locate their own perspectives within broader intellectual terrains, even if the model's summaries often flattened nuance or ignored internal contradictions within each school of thought
3. **Prompt for Self-Critique:** A striking theme in the reflections was that ChatGPT's limitations themselves became productive pedagogical provocations. Students noted that its analytical voice was consistently confident but emotionally tone-deaf: irony, ambiguity, and the instability of meaning were often ignored. Confronting these omissions prompted students to articulate what genuine literary criticism demands – sensitivity and taking an interpretive risk. In this sense, ChatGPT operated less as an analytical partner and more as a mirror that reflected the boundaries of mechanized reasoning
4. **Awareness of Bias**: Several students commented on ChatGPT's claim to neutrality and objectivity, recognizing these qualities as forms of bias in themselves. The AI chatbot's polished academic tone and reliance on consensus views subtly reinforced existing hierarchies of authority in literary studies.   One student captured that this neutrality was itself ideological. As one student noted: *"It reproduces authority while pretending to erase it."* This insight indicates that engaging with AI prompted critical awareness not only of the tool's epistemological stance but also of the ideological assumptions embedded in academic discourse more broadly.

Overall, the students valued ChatGPT for its reflective potential. Is usefulness derived precisely from its deficiencies – its inability to "read" literature in a human sense made the process of interpretation newly visible. As a pedagogical mirror, ChatGPT illuminated what human reading entails, like empathy, doubt, and a willingness to inhabit uncertainty. In this way, its role was not to replace interpretation but to make the interpretive act itself an object of study.

4.6. Pedagogical Implications

From the instructor's perspective, this lesson demonstrated the potential of AI as a catalyst for deeper humanistic inquiry. ChatGPT externalized interpretive habits, allowing students to analyze interpretation itself as a process. The activity illustrated what Rockwell and Sinclair (2016) call the "hermeneutic loop," a recursive dialogue between computational pattern and human meaning.

At the same time, it reaffirmed Milton's warning against unreflective knowledge. Just as Satan's pursuit of godlike understanding leads to his fall, reliance on AI risks eroding the humility and patience essential to literary study. The lesson connected digital pedagogy to Milton's moral universe: intellect must be tempered by judgment.

5. CONCLUSION

Integrating ChatGPT into the postgraduate study of Paradise Lost revealed both opportunities and challenges for literary pedagogy. While AI can efficiently reproduce existing critical discourses, it lacks the interpretive depth that arises from close reading, historical awareness, and emotional engagement. Its limitations – the absence of irony and the inability to dwell in contradiction – became pedagogical strengths, inviting students to interrogate their own reading practices.

The activity underscored the enduring relevance of Milton's epic: both his narrative and our digital tools dramatize the tension between creation and control, freedom and obedience, knowledge and humility. In bringing ChatGPT into dialogue with Paradise Lost, students were not only interpreting Milton, but they were also reenacting his central theme: the moral complexity of knowledge.

One of the students commented:

"ChatGPT does not interpret Milton – it helps us interpret ourselves interpreting Milton."

Future iterations of this study will extend the approach to other canonical texts, assessing long-term effects on interpretive skill and digital literacy. Ultimately, the meeting of Milton and Machine suggests that the humanities' greatest strength lies not in resisting technology but in reading it critically.

Acknowledgements

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Teaching English for Specific Purposes in a Tourism Context Based on Learners´ Needs - The Most Relevant Methods, Approaches and Techniques

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Abstract

The study investigates the relevance of different teaching methods and approaches in English for Specific Purposes (ESP) within a tourism context. Focusing on learners' needs for language skill development, it discusses the pros and cons of selected methods and approaches, while exploring the suitability of various techniques for both general and specific English for Tourism Purposes courses. The study suggests that the future of ESP instruction lies in integrating multiple methodologies, incorporating communicative, task-based, computer-assisted, and content-based approaches as dictated by the context and learners' needs. However, traditional methods such as Grammar-Translation, Direct, and Audiolingual may still hold relevance and should be incorporated when appropriate to support a comprehensive and adaptable ESP curriculum.

Keywords: English for Specific Purposes, Tourism undergraduates, Teaching methods, approaches and techniques, Learners´ and market needs

1. INTRODUCTION

Throughout the history of language teaching, various methods and approaches, such as the Direct Method or Task-based Language Teaching, have emerged. Richards & Rodgers (2014) define an approach as a flexible framework of principles guiding teaching, while a method entails a structured system with explicit rules and procedures.

Hutchinson and Waters (1987) assert that no distinct methodology exists for teaching ESP, and the methodological differences between ESP and General English (GE) are minimal (Robinson 1991). In contrast, Dudley-Evans and St. John (1998) argue that ESP may require different methods, while Strevens (1988) states that ESP is not bound by a fixed methodology.

Drawing from practical teaching experience, we align with Dudley-Evans and St. John, proposing that certain methods and approaches are more suited to the specific needs of tourism undergraduates, which this study will investigate further

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2. IDENTIFYING ENGLISH FOR TOURISM PURPOSES LEARNERS' NEEDS

The discrepancy between university graduates' English language skills and the requirements of the tourism industry has been vocalized by several researchers throughout the world in the last two decades (Liao et al. 2017; Prachanant 2012; Sándorová 2019; Wu 2012 in Cloudia Ho 2020). In response to this phenomenon, a number of studies investigating tourism students' English language needs across the globe have been published.

Prachanant (ibid.) examined English language needs among 40 Thai tourism employees, finding all four skills essential, with speaking ranked highest, followed by listening, reading, and writing. Speaking was prioritized due to frequent oral interactions with tourists, while listening was crucial for understanding guests. Reading supported communication tasks, and writing was least required, mainly for emails and forms. Furthermore, employees faced challenges such as inappropriate word choice, difficulty with foreign accents, limited reading vocabulary, and insufficient grammar in writing (ibid., p. 123).

Other studies also identify speaking as the primary skill in tourism-related English training, followed by listening, reading, and writing (Reinsch and Shelby 1997; Waner 1995 in Prachanant ibid.; Weldy and Icenogle 1997; Wu 2012; Malini et al. 2022). However, according to other researchers (Al-Khatib 2005; Erazo et al. 2019), the relevance of specific skills varies by professional role; while speaking and listening are essential in hotel operations, reading and writing are more prominent in travel agencies.

Based on these findings, two main types of ETP courses emerge: "general" ETP courses, which prepare students for various tourism sectors, and specific ETP courses, tailored to fields like Hospitality or Tourism Management. The choice of methods and techniques should align with the learner's specialization, as outlined in their "graduate profile" (Kay 2017). The next chapter explores methods and approaches suited to different ETP learner needs.

3. METHODS, APPROACHES AND TECHNIQUES IN TEACHING ENGLISH FOR SPECIFIC PURPOSES IN A TOURISM CONTEXT

The chapter is divided into several subchapters. Each section briefly describes the given method and its fundamental principles and gives examples of situations or purposes when they might be beneficial for teaching ESP, particularly in ETP.

3.1. The Grammar-Translation Method in Teaching ETP

The grammar-translation method (GTM), originating from the 16th-century practice of teaching Ancient Greek and Latin, aimed to translate literary texts and develop intellectual skills. Although Latin later ceased to be used for communication, the translation-based approach persisted in foreign language teaching into the 19th century.

Despite its historical significance, GTM has been widely criticised (Zerzová 2016; Zhou 2015). Its deductive approach focuses on memorising vocabulary and grammar rules applied in translation exercises, often taught in isolation with minimal attention to context or communication. While it prioritises reading and writing, listening, speaking, and pronunciation are largely neglected, leaving learners weak in communicative competence (Kim 2008). Additionally, the native language plays a dominant role, as instruction frequently relies on it to explain new items and facilitate comparisons with the target language (Richards and Rodgers 2014, p. 7).

Nonetheless, the Grammar-Translation Method (GTM) offers benefits for ETP, particularly in developing accuracy, which tourism employers identify as a weakness (Zahedpisheh, Bakar and Saffari 2017). It is also useful in specific ETP courses, such as those for tour operators working with legal documents like contracts and tourism packages.

Techniques beneficial for ETP include translating literary passages, reading comprehension questions, and vocabulary exercises like antonyms and synonyms (Larsen-Freeman and Anderson 2011). In ESP, literary translation can focus on legal documents, such as travel insurance, a common task in travel agencies (Zahedpisheh, Bakar and Saffari 2017). Reading comprehension questions are essential for understanding tourism-related texts with specialized terminology.

Finding antonyms and synonyms supports vocabulary acquisition in ESP courses (Kováčiková 2020). The deductive application of grammar rules works well for adult learners who prefer structured learning (Pokrivčáková 2009; Kováčiková and Gajdáčová Veselá 2016). Techniques like filling in blanks and memorizing terms can be useful in ESP, especially for exams focused on vocabulary and grammar. Additionally, creating example sentences helps learners contextualize new vocabulary and grammar.

Composition tasks in ESP often involve writing formal letters, emails, complaints, or reports, usually based on provided examples

3.2. The Direct Method in Teaching ETP

The Direct Method (DM) arose as a response to the Grammar-Translation Method, advocating for teaching foreign languages similarly to how children acquire their first language. However, this assumption has been criticized for overlooking the realities of second or foreign language learning.

The DM rejects translation, conducting all instruction in the target language. Grammar is taught inductively, and learners acquire everyday vocabulary through realia, objects, and gestures. The method prioritizes speaking through teacher-student question-and-answer exchanges and emphasizes listening and pronunciation, while other skills receive less attention (Richards and Rodgers 2014; British Council 2022).

In ESP, particularly in ETP, the DM can be applied to B2-level students according to the CEFR (Council of Europe 2001) or selectively, focusing on specific topics or activities. For instance, a warming-up or follow-up activity could involve discussing the ecological impact of over-tourism, with students restricted from using their mother tongue. Furthermore, DM techniques in ETP include asking and answering questions in full sentences and engaging in conversation practice to reinforce new vocabulary and grammar. Role-switching allows students to experience various scenarios, such as phone calls or reservations, while gap-filling exercises are conducted inductively, based on prior examples and practice.

3.3. The Audio-Lingual Method in Teaching ETP

The Audio-Lingual Method (ALM) appeared in foreign language teaching in the USA toward the end of the 1950s based on structural linguistics and behaviourism theories. It primarily focuses on developing speaking skills through drills and repetition used for reinforcement and practice. Vocabulary is learnt in context and, similar to the DM, grammar or translation to the learners' mother tongue is kept to a minimum (Richards and Rodgers 2014). Language is modelled by the teacher or introduced by audio-lingual materials, such as music, videos and films, whereas the emphasis is put on correct pronunciation, rhythm, stress and intonation.

The Audio-lingual Method (ALM) can benefit ETP by practicing phone calls, customer inquiries at receptions, and sales dialogues. Techniques such as memorizing dialogues, completing dialogues, and transformation drills can increase students' confidence for real-world interactions. Memorizing dialogues can include acting out dialogues with body language. This helps reinforce vocabulary and grammar. In tourism, it can involve "at the restaurant" dialogues, check-in/out situations, or providing information at a tourist information centre.

Transformation drills can include turning affirmative sentences negative, changing direct questions to indirect ones for politeness, or converting active sentences to passive, useful for travel guides giving information about tourist attractions.

3.4. Communicative Language Teaching in Teaching ETP

Unlike the traditional GTM, the communicative language teaching (CLT) approach, developed in the 1970s, focuses on building communicative competence—the ability to use language effectively in real-life situations (Ahmed and Pawar 2018; Larsen-Freeman and Anderson 2011). CLT emphasizes "function" over "form" and "fluency" over "accuracy," promoting communicative skills through activities such as role-plays, brainstorming, group discussions, problem-solving, and games (Larsen-Freeman and Anderson 2011; Richards 2006). Authentic materials and contexts are integral to the method, fostering both productive and receptive skills (Richards and Rodgers 2014; Brown 2014). However, it may not suit learners, particularly older ones, who prefer structured grammar and vocabulary instruction (Zhou and Niu 2015).

CLT is widely recommended for ETP courses, as based on empirical findings it improves learners' English proficiency, confidence, and communication skills (Cloudia Ho 2020; Hsu 2018; Shih 2012). Effective activities in ETP include role-plays, group discussions, problem-solving tasks, and games. Ho (ibid. p. 4) adds that communicative activities must integrate interaction, functions, meanings, tasks, and authenticity to maximize their impact.

Role-plays, a key CLT technique due to the high level of interaction between service providers and customers (Erazo et al. 2019), can be structured (with detailed instructions) or less structured (more authentic, with student-generated dialogue). Feedback is essential, and alternatives like mock job interviews can also be used.

Group discussions, where students debate or solve problems, are useful in ETP to explore topics like tourism trends or issues (Green 2021). Brainstorming facilitates collaborative problem-solving, such as generating ideas for tourism packages or new products (Northern Illinois University Center for Innovative Teaching and Learning 2012). Problem-solving tasks help revise grammar and vocabulary while simulating real-life situations, often within case studies (Tennant 2020; Dubicka and O'Keeffe 2016; Strutt 2013).

Information gap activities, where students must communicate to exchange missing information, are valuable in ETP for tasks like describing hotel facilities or itineraries (British Council 2022). Games make communication enjoyable and can be used for vocabulary or grammar practice, as seen in course-books like English for International Tourism (Dubicka and O'Keeffe 2016). Group competitions boost motivation and communication, often integrated with problem-solving or discussion tasks in tourism contexts, for example, in tourism product or itinerary development activities.

Finally, activities like unscrambling sentences develop learners' pragmatic competence and understanding of text cohesion, such as with formal letters or tourism dialogues (Larsen-Freeman and Anderson 2011).

3.5. Task-based Language Teaching in Teaching ETP

Task-based Language Teaching (TBLT), an extension of CLT, involves pair or group task-solving activities followed by classroom discussions and comparisons (Larsen-Freeman and Anderson 2011; Kováčiková 2020). It emphasizes meaningful, purposeful interaction through tasks, defined as activities where learners use the target language to achieve a communicative outcome (Bygate et al. 2001 p. 11). According to Ellis (2003), tasks can simulate real-life activities, such as attending interviews or responding to complaints, and incorporate any combination of the four language skills. Typical tasks include collecting, classifying, and evaluating information to meet communicative goals (Kováčiková 2020), which can vary in duration, from brief tasks to projects lasting several lessons or even a semester (Kawasaki 2022).

A variety of tasks can be used in ETP courses, such as creating projects on sustainable hospitality practices, making promotional videos, or writing content for websites, based on learners' proficiency level, age, and real-life needs (Cameron 2001). Activities should reflect the specific needs of different areas, such as English for Food and Beverage Services (e.g., creating a menu or gastronomic tour itinerary), English for Air Flight Services (e.g., calming nervous passengers), English for Hotel Services (e.g., check-in/check-out procedures), and English for Tour Managers and Guides (e.g., explaining tourist attractions).

Erazo et al. (2019) emphasize the benefits of technology-mediated collaborative tasks for improving linguistic skills in future tourism professionals. Rojas, Villafuerte and Soto (2017) found that such collaboration and technology enhanced writing skills, particularly in vocabulary acquisition, writing style, and text coherence. Similarly, González‑Lloret and Ortega (2014) argue that these activities also improve oral production, language learning, and motivation.

3.6. Content and Language Integrated Learning in Teaching ETP

Content and Language Integrated Learning (CLIL) was first introduced in 1994 by UNICOM at the University of Jyväskylä and the European Platform for Dutch Education (Veselá 2012). Rooted in ESP, CLIL aims to simultaneously teach language and content (Kováčiková 2020; Veselá 2012). Kenny (2016 p. 260) highlights that while ESP focuses on integrating content and language, CLIL uses an additional language to teach non-language content (Marsh 2003; Veselá 2012). The primary distinction lies in focus: CLIL emphasises content and is often taught by content teachers, whereas ESP centres on language and is taught by language teachers (Kováčiková 2020).

Both approaches share common characteristics: they are input-based, learner-centred, task-based, content-oriented, and meaning-focused, fostering collaboration and learner autonomy (Veselá 2012). Research by Kováčiková (2020) demonstrated that integrating CLIL techniques, such as project work, in ESP classes enhanced communicative competence and vocabulary acquisition. Other CLIL techniques include case studies, reports, and presentations (Chalikandy 2013). In ETP, CLIL can utilise real-life online sources, such as newspaper articles or video interviews with tourism experts, to explore trends not covered in traditional tourism courses.

3.7. Computer-Assisted Language Learning in Teaching ETP

Computer Assisted Language Learning (CALL) refers to "the use of technologies in teaching/learning foreign languages" (Veselá 2012, p.34). A specific type of CALL is blended CALL which refers to a combination of face-

to-face delivery and e-learning. However, according to Khan (2005), it can include other dimensions, such as structured and unstructured learning or collaborative and self-paced learning.

Undoubtedly, the ubiquitous presence of computer technology has also affected language teaching, including ESP (Gruba 2004; Wheeler 2015). In particular, in ETP, CALL can be implemented almost in every lesson or topic, due to the constant emergence of new sources and software, gradually but only partially replacing traditional materials and aids, such as the course-book or the blackboard. For example, instead of the texts on the latest trends in tourism in the book, online articles or websites can be used, or listening comprehension exercises on gastronomy issues can be replaced by youtube videos that make the lesson and its content more memorable and fascinating. Also, reported speech rules often used in writing meeting minutes can be explained through interactive exercises. At the same time, new vocabulary on air travel and the pronunciation of the terms can be practised using an online glossary creator. Furthermore, Erazo et al. (2019) recommended self-video recording, (for example, describing a tourist attraction), as it improves tourism students' linguistic skills. It can help to detect grammatical, lexical and phonological errors leading to self-correction and self-regulation.

3.8. Computer-Assisted Language Learning in Teaching ETP

CA-CLIL methodology, i.e., the combination of CALL and CLIL in ESP, was proposed by Veselá (2012), arguing that it meets the needs of teaching ESP in the third millennium for several reasons. First, blending CALL and CLIL can be supported by their common objectives and principles. One of them is their primary objective, i.e., teaching language effectively (backed by the theory of constructivism and connectivism). In addition, they are both learner-centred and task-based, emphasising the learner's autonomy and interactivity, facilitating cooperation and collaborative learning, as well as highlighting agency and co-efficiency (Veselá 2012).

Furthermore, motivation is a vital issue in both the CALL and CLIL methodologies. Regarding the former, according to Lee (2000), motivation is enhanced because using technology is trendy and evokes the feeling of being independent and having fun. In terms of the latter, increased motivation is reached through content-based and meaning-focused learning. Hence, the presumption is that CA-CLIL synergises learners' motivation (Veselá 2012).

The above-suggested possibilities of using CALL and CLIL in teaching ETP already include the elements of the CA-CLIL methodology. On the one hand, the mentioned CALL tasks use technology to develop language skills while focusing on tourism-specific content. On the other hand, in the given CLIL activities, the tourism-oriented content is mediated through language and technology.

4. CONCLUSION

In conclusion, the methods, approaches, and techniques discussed in this paper highlight the diverse strategies applicable to English for Tourism Purposes (ETP) instruction. As Prabhu (1990) asserts, no single method is inherently superior, and the choice of method should primarily be determined by a thorough analysis of learners' specific needs (Kenny 2016; Barnard and Zemoch 2003). Dudley-Evans and St John (1998) advocate for an integrated skills approach, which aligns with the more recent emphasis on blending various pedagogical principles and techniques. For instance, González‐Lloret (2020 p. 260) suggests that collaborative, technology-mediated tasks can foster both productive language output (speaking and writing) and interactive learning, thereby motivating students to continue developing their language skills. This view is also supported by Erazo et al. (2019), who identify student collaboration through technological tools as crucial for enhancing ETP at the university level.

Furthermore, Cloudia Ho (2020) contends that Communicative Language Teaching (CLT) is well-suited to meet the communication needs of Tourism English, while Kováčiková (2020) emphasizes the efficacy of combining CLT with task-based and content-based approaches in ESP courses. Similarly, Chalikandy (2013) identifies Computer-Assisted Language Learning (CALL), Task-Based Language Teaching (TBLT), and Content and Language Integrated Learning (CLIL) as particularly beneficial for ESP learners. Therefore, it is apparent that the future of ESP instruction lies in the integration of multiple methodologies, drawing on communicative, task-based, computer-assisted, and content-based approaches as the context and learner needs dictate. However, traditional methods, such as the Grammar-Translation, Direct, and Audiolingual Method, may still be relevant and should be incorporated when appropriate to support a comprehensive and adaptable ESP curriculum.

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Strategic Management of Human Resource Development in Educational Institutions

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Abstract

Strategic human resources planning in educational institutions refers to a management approach designed to increase student achievement, maximize teacher and staff productivity, and achieve the institution's mission and vision. This approach requires educational institutions to consciously manage their human resources and take strategic steps to meet their needs. This process includes developing the talents of teachers, administrators, and support staff, placing them in the right positions, and increasing their motivation. Strategic human resources planning plays a crucial role in helping educational institutions achieve their long-term goals while also improving student success. Educational institutions worldwide utilize human resources as a fundamental element in every aspect of their operations. The impact of human resources on organizations is evolving over time and with the advancement of technology. This study aims to examine the importance of Strategic Management of Human Resource Development in Educational Institutions under the light of literature. It has been concluded that human resources management should identify the necessary actions for critical human resources issues, taking into account the organization's vision, mission, strategic objectives, corporate culture, belief and value system, and projected future strategic position, and should assume responsibility for planning and implementing these actions.

Keywords: Educational Planning, Educational Management, Strategic Management, Educational Policies

1. INTRODUCTION

The most important factor that ensures the efficient and effective operation of organizations is their human resources. The human resources management approach has demonstrated that organizational success depends on the development of human resources rather than the development of technological resources. This concept is considered an investment that increases organizational productivity (Celik, 1991). However, today, there is confusion in defining the concept of Human Resources Management (HRM).

The first studies on HRM began under the name "Personnel Management." This concept has been widely used for 50-60 years to describe various activities and competencies related to the training, management, and supervision of personnel. The personnel management process is based on the organization's technical activities. This has led to the perception of people working within the organization as capital that needs to be controlled and managed. Furthermore, the increase in their functions has led to a tendency among all managers to minimize their responsibility for managing personnel. The concept of human resources emerged in the 1980s with the understanding that the negative effects of developing and utilizing the unlimited talents of human resources could be eliminated. Thus, in contrast to the

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traditional personnel management approach, management is centered on people within the human resources management approach.

HRM does not invalidate the principles and practices of personnel resources; on the contrary, it places them within a different conceptual framework. Personnel become an asset to be invested in and developed to help the organization achieve its goals and objectives. The direction of HRM is to empower employees within the organization while providing them with resources, goals, and opportunities to contribute to the organization's growth.

HRM principles, processes, and capabilities are the most neglected and misunderstood aspect of educational management. However, educational management is the process of using the organization's material and human resources in the most efficient way. The most important human resources in a school are administrators, teachers, students, and non-teaching personnel.

Effective personnel management in education is quite problematic due to fragmentation and frequently changing control centers. In educational institutions, administrative personnel are often politically motivated, and therefore, administrators do not always reflect effective management principles.

The practical consequences of these factors are described in Torrington and Weightman's research (Torrington & Weightman, 1989).). Accordingly, it was determined that schools often lack effective personnel management policies, and that teaching and non-teaching staff are a seriously underutilized resource, particularly for female teachers and non-teaching staff. Senior and middle-level administrators in schools often lack a clear management role. This is due to a lack of clarity in role definition, inadequate training, and inappropriate placement of non-teaching staff. The conclusion of this research is that for a school to function effectively, its existing human resources must work effectively in line with organizational objectives.

Human resources management in education is a set of managerial activities that involve the planning, organization, development, direction, and evaluation of an educational organization's human resources to achieve educational objectives. The human resources of educational organizations consist of teachers, education and school administrators, education specialists, inspectors, civil servants, and support staff.

Human Resources Management is a strategic management process developed to ensure that an organization utilizes its human resources most effectively. This process encompasses a wide range of activities, starting with employee recruitment and continuing through training, development, performance evaluation, motivation, compensation, career planning, and employee relations management. HRM aims not only to engage employees in business processes but also to achieve the organization's overall goals by supporting their individual and professional development. Human resources management aims to increase the organization's efficiency and success by enhancing employee competencies, skills, and motivation. In this context, HRM plays both an operational and strategic role in modern organizations and provides a systematic approach to maximize employee potential. Human resource management in school administration not only involves managing employee administrative processes but also is a strategic element that directly impacts the school's overall success and student outcomes. Maximizing the potential of teachers and other staff enables the school to achieve its educational goals and supports sustainable educational success. Human resource management strengthens the school's functioning as both an academic and social institution and has emerged as an essential requirement in contemporary educational environments. Effective implementation of HRM principles by school administrators enhances the quality of educational processes and contributes to the school's long-term success.

2. HUMAN RESOURCE MANAGEMENT IN EDUCATIONAL INSTITUTIONS

Human Resource Management (HRM) in schools has many definitions put forward by experts and educational specialists.

Byars and Rue, in their book "Human Resource Management," state that HRM in schools involves planning, organizing, directing, and supervising human resources to effectively achieve educational goals (Byars and Rue, 2004).

Dale H. Schunk argues that HRM in schools can be defined as a systematic approach to managing human resources in educational institutions (Schunk, 1991). This includes planning, developing, managing, and maintaining human resources so that they can make maximum contributions to educational goals.

Wayne Cascio defines HRM in schools as the process of planning and managing human resources to achieve educational goals effectively and efficiently (Cascio, 2000). This involves determining personnel needs, recruitment, skills development, and performance evaluation.

According to Leon C. Megginson, HRM in schools is a series of activities involving planning, organizing, directing, and supervising human resources to achieve educational goals efficiently and effectively (Megginson, 2013).

Gary Dessler and Biju Varkkey, in their book Human Resource Management, HRM in education is defined as the effort to manage people within educational institutions so that they can achieve educational goals effectively and efficiently (Dessler & Varkkey, 2005).

Gary Dessler states that HRM in educational institutions is an effort to manage, direct, and develop human potential so that they can make optimal contributions to achieving the goals of the educational organization (Dessler et al., 2001).

Griffin argues that HRM in the educational context involves human resource management policies and practices, including recruitment, training, performance appraisal, and career development, with the goal of improving the quality of education (Griffin, Phillips & Gully, 2020).

Human Resource Management in Education is a systematic approach designed to manage all aspects related to people within the context of educational institutions. Its primary focus involves the planning, development, management, and maintenance of human resources to maximize their contribution to achieving educational goals. In this context, human resource entities include teachers, support staff, and all members of the educational community. First and foremost, human resource planning in education is highly relevant. This process involves identifying human resource needs, determining the number and type of personnel required, and developing strategies for recruiting, developing, and retaining qualified personnel. This planning serves as a crucial foundation for ensuring that educational institutions have competent teams aligned with their vision and mission..

The following discussion relates to human resource development in the educational context. This development encompasses a series of activities such as training, skills development, and professional development of educational staff members. It is imperative that teachers and educational staff continuously improve their knowledge and skills to provide quality education. Effective human resource development programs within educational institutions will positively impact the quality of teaching and learning.

The next relevant definition is educational human resource management. This management involves the process of organizing, supervising, and directing personnel to achieve the educational institution's goals. This includes determining responsibilities, assigning tasks, and evaluating staff performance. Educational human resource managers need to be equipped with effective leadership skills to effectively manage teams.

The next discussion concerns human resource maintenance. This maintenance encompasses efforts to create a work environment that supports, motivates, and retains staff. Several crucial factors in this maintenance include fairness, work-life balance, and recognition for individual contributions. All of these factors play a vital role in maintaining morale and staff well-being.

A thorough analysis of educational human resource management shows that its effectiveness depends heavily on the proper integration of human resource planning, development, management, and maintenance. The synergy between these four aspects creates a dynamic work environment oriented toward achieving educational goals. Human resource planning helps educational institutions anticipate future personnel needs. Meanwhile, human resource development ensures that personnel have the necessary skills and knowledge to carry out their duties efficiently. Human resource management focuses on the organization and supervision of personnel, while human resource maintenance emphasizes creating a positive work environment.

Examples of the application of these concepts can be found in successful educational institutions. They likely have meticulous planning policies to ensure personnel needs are optimally met. Human resource development programs can include various activities, such as ongoing training, workshops, and mentoring, aimed at improving teacher skills and knowledge. Human resource management involves clearly assigning responsibilities and providing necessary support to staff. Human resource maintenance, on the other hand, can involve implementing incentives, recognizing achievements, and a balanced work-life balance policy.

Overall, educational human resource management involves continuous efforts to improve individual performance and contribution to achieving educational goals. A strong integration of human resource planning, development, management, and maintenance will form a strong foundation for creating a dynamic and successful educational institution.

2.1. Functions of Human Resource Management in Educational Institutions

Human Resource Management (HRM) plays a vital role in educational institutions. HRM functions form the foundation for operational success and the achievement of educational goals. In this context, Human Resources Management (HRM) is not only limited to administrative aspects but also plays a strategic role in managing human potential to maximize contribution. The outlines of HRM functions in educational institutions include Human

Resource Planning, Recruitment and Selection, Employee Development, Performance Evaluation, Performance Management and Well-Being, Conflict Management and Resolution, Leadership Management and Organizational Development, Compensation and Benefits Management

• *Human Resource Planning:* The primary function of HRM in educational institutions is human resource planning. This includes identifying workforce needs, determining the number and type of personnel required, and developing recruitment strategies. Through this planning, educational institutions can ensure they have the number and type of staff that aligns with the institution's goals and vision and mission. In the planning phase, HRM must also consider the diversity, skills, and expertise required to support holistic educational development. Furthermore, career planning for educational staff is integral to ensuring sustainable development.

• *Recruitment and Selection:* HRM is responsible for implementing the recruitment and selection process. This involves attracting individuals with qualifications and potential that align with the institution's needs. This process includes assessing the candidate's technical skills, personality, and fit with the organizational culture. In the educational context, HRM also needs to ensure that teachers and support staff are committed to educational values and professional ethics. Involving the educational community in the selection process can help ensure that selected individuals have a positive impact on the educational environment.

• *Employee Development:* Another HRM function is employee development. This encompasses various activities such as training, coaching, and skills development. In educational institutions, this development is not limited to improving academic skills but also involves developing social, leadership, and innovation skills. Teachers and support staff must stay updated with the latest developments in education, technology, and teaching methodologies. It is argued that professional development programs can improve teaching quality, motivate staff, and help educational institutions adapt to the dynamic educational environment.

• *Performance Evaluation:* It is a crucial aspect of HRM in educational institutions. This process includes assessing individual goal achievement and contributions to organizational goals. Performance evaluation helps identify employee strengths and weaknesses, provide constructive feedback, and formulate further development plans. In the educational context, teacher performance evaluations can provide insight into the effectiveness of teaching, interactions with students, and contributions to student development. This process also allows educational institutions to identify areas where further support and development are needed.

• *Performance Management and Well-Being:* HRM is responsible for ensuring the well-being of employees in educational institutions. This involves effective performance management, fairness in the allocation of responsibilities and tasks, and fair compensation. Well-being management also includes policies and practices that support work-life balance, health and safety, and recognition of individual contributions. Employee well-being has a direct impact on motivation and productivity. In educational institutions, teachers who feel valued and supported are more likely to provide quality instruction and contribute to a positive school atmosphere.

• *Conflict Management and Resolution:* Conflict can arise within educational institutions, both among staff and between staff and students or parents. The HRM function also includes conflict management and resolution. This involves identifying sources of conflict, developing strategies to address conflict, and implementing equitable and sustainable solutions. Effective conflict management can create a harmonious environment in schools, support collaboration among staff, and improve relationships between schools, students, and parents.

• *Leadership Management and Organizational Development:* Human Resources Management in educational institutions should also focus on developing leadership and an organizational culture that supports educational goals. This includes identifying and developing potential leaders, establishing an effective leadership structure, and promoting values and norms that strengthen the institution's identity. Leadership development and a positive organizational culture can create an atmosphere where innovation is encouraged, collaboration is emphasized, and each member feels responsible for achieving shared goals.

• *Compensation and Benefits Management:* The HR function in compensation and benefits management addresses aspects such as payroll systems, benefits, and reward policies. This includes developing fair and transparent

compensation policies and offering benefits that meet employee needs. Adequate compensation and benefits not only increase employee motivation and satisfaction but can also be a determining factor in retaining and attracting talented individuals to educational institutions. To achieve success in achieving educational goals, the HR function in educational institutions is crucial. With sound human resource planning, careful recruitment, continuous employee development, objective performance evaluation, effective performance and welfare management, prudent conflict management, leadership development and a positive organizational culture, and appropriate compensation and benefits management, HR can be a key pillar in building a superior and sustainable educational institution.

2.2. Principles of HR in Educational Institutions

Human Resource Management (HRM) in educational institutions is an organized system for managing human resources to achieve established educational goals. Several HRM principles form the primary foundation for the operational success and achievements of educational institutions. HRM principles include the Principle of Integration with the Educational Mission and Vision, The Principle of Employee Participation and Involvement, The Principle of Diversity and Inclusivity, Principle of Career Development and Educational Opportunities, Principle of Work-Life Balance, Principle of Fair and Continuous Performance Evaluation, Principles of Effective Conflict Management, The Principle of the Importance of Supportive and Inspirational Leadership, The Principle of Fair Compensation and Rewards, The Principle of Technology Use and Innovation.

- *The principle of integration with the educational mission and vision* emphasizes that every HRM policy and practice must align with the goals and values espoused by the institution. This demonstrates that HRM is not merely administrative but also strategic in supporting the achievement of the educational vision and mission.

- *The principle of employee participation and involvement* is key to building a productive work environment. It is argued that providing employees with opportunities to participate in decision-making not only increases motivation but also creates a sense of ownership over the outcomes. This helps foster strong collaboration among staff, creating a positive work climate.

- *The principle of diversity and inclusivity* is highly relevant. Educational institutions are diverse places, both in terms of students and staff. It is crucial to recognize, value, and leverage this diversity to enhance the sustainability of educational institutions. Human Resources (HRM) policies must ensure fairness and equality for all individuals, regardless of background or personal characteristics.

- *Principle of Career Development and Educational Opportunities*: Investing in employee development is a long-term measure that can improve staff skills and knowledge. In educational institutions, teachers and support staff must continuously improve their qualifications to cope with changes in the educational landscape.

- *Principle of Work-Life Balance* is an HRM principle that emphasizes the importance of providing staff with time for rest and personal activities. This not only ensures employee well-being but can also increase productivity and job satisfaction. HRM that addresses this aspect can create a healthy and sustainable work environment.

- *Principle of Fair and Continuous Performance Evaluation* is an HRM principle that provides a foundation for motivating and guiding staff towards achieving goals. Regular performance evaluations provide an opportunity to provide constructive feedback and formulate development plans. They can also serve as a basis for providing recognition and rewards, creating a positive atmosphere in educational institutions.

- *Principles of effective conflict management* is an HR principle that can help educational institutions wisely address internal challenges. In an educational environment, where interactions between teachers, staff, students, and parents are intense, the ability to handle conflict effectively is crucial. This principle encourages an open, transparent approach and the search for solutions that strengthen relationships among staff members.

- *The principle of the importance of supportive and inspirational leadership* is an HRM principle that emphasizes the role of leaders in guiding, supporting, and motivating staff. In educational institutions, leadership must reflect

educational values and foster a positive work culture. Leaders who provide support and inspiration can create an atmosphere where innovation is encouraged and collaboration is emphasized.

- *The principle of fair compensation and rewards* emphasizes the importance of a transparent compensation system that reflects employee contributions and achievements. Appropriate rewards are also important factors in increasing employee motivation and satisfaction. HRM that addresses this aspect can help educational institutions attract and retain valuable talent.

- *The principle of technology use and innovation* is an HRM principle related to educational institutions' adaptation to technological developments. This principle emphasizes the importance of adopting technology to improve the efficiency of HRM processes and support innovation in education. More than just an administrative tool, technology can be a catalyst for positive change in educational institutions.

By understanding and implementing these HRM principles, educational institutions can create a positive work culture, support staff, and ultimately, improve the quality of education they provide. These principles form a comprehensive framework for effective human resource management in educational institutions, bridging the gap between educational goals and employee well-being.

3. PLANNING HUMAN RESOURCES IN EDUCATIONAL INSTITUTIONS

Planning human resource (HR) needs in schools is a critical step in ensuring that educational institutions have an adequate and qualified workforce to achieve established educational goals. This planning process involves identifying human resource needs, determining the number and type of personnel required, and developing strategies to recruit, develop, and retain personnel aligned with the school's needs and vision and mission (Belizón & Kieran, 2022).

Identifying human resource needs begins with analyzing the long-term and short-term educational goals the school wishes to achieve. This step includes understanding the school's vision and mission, the direction of curriculum development, extracurricular programs, and specific policies that may impact human resource needs. Next, schools need to evaluate the current staff composition. This includes assessing the skills, knowledge, and expertise of teaching and non-teaching staff. This analysis can provide an overview of the areas of expertise already covered and areas that may require improvement. In identifying human resource needs, schools must also consider developments and changes in the world of education. Technological developments, curriculum changes, and educational trends can impact the types of skills and expertise required by staff. Therefore, schools need to ensure that staff have the necessary skills to integrate innovation and meet future educational needs.

After identifying needs, the next step is determining the number and type of personnel needed. This involves calculating the number of teachers, support staff, and administrative staff needed to support daily educational activities and projecting needs for a specific period. Understanding the student-teacher ratio, class size, and non-teaching job specifications are also important factors in determining human resource needs. The next step is developing a strategy to recruit, develop, and retain personnel aligned with the school's needs. Recruiting individuals who align with the school's vision and mission is a crucial initial step. This can involve a rigorous selection process, effective utilization of recruitment resources, and developing networks within the educational community to attract potential talent.

Developing staff is the next stage in the human resource planning strategy. This includes providing ongoing training and development to enhance staff skills and knowledge. This development program must be designed according to the school's needs and priorities, so that each staff member can optimally contribute to achieving educational goals. Furthermore, schools should consider mentoring and coaching programs to support employee development. Mentorship can be an effective means of transferring knowledge and experience from experienced staff to new or less experienced ones.

Retaining quality human resources is also a crucial aspect of strategic planning. Employee welfare policies, incentives, and recognition for individual contributions can help maintain staff morale and motivation. Creating a supportive, inclusive, and motivating work environment can help increase the retention of qualified staff. Furthermore, in human resource planning strategies, schools should also consider diversity. Creating inclusive and diverse teams can provide broader perspectives and reflect the diversity of students. Training programs on equity and fairness and supporting diversity in the workplace can foster a positive school culture.

It is important to remember that human resource planning in schools is not a one-time process. Changes in educational needs, technological developments, and dynamics in student composition may require schools to

continuously evaluate and update their human resource planning strategies. Overall, planning human resource needs in schools requires a systematic and integrated approach. This process involves not only managing staff numbers but also skills development, recruiting talent, and creating a supportive work environment. With a sound human resource planning strategy, schools can ensure they have a competent and committed team to achieve their educational goals (Veronika et al., 2023).

4. HUMAN RESOURCE DEVELOPMENT IN EDUCATIONAL INSTITUTONS

Human resource development in educational institutions refers to a series of systematic activities designed to enhance the knowledge, skills, and abilities of educational staff. It encompasses a variety of approaches and strategies to support professional growth, performance improvement, and individual empowerment so they can make maximum contributions to the school's educational goals. It involves enhancing individual knowledge and skills. This can include training and courses to broaden understanding of the latest teaching methods, educational technology, and changes in the curriculum. Teachers and educational staff need to continually update their knowledge to remain relevant and effective in supporting the learning process (Swanson, 2022).

Furthermore, human resource development in schools also includes developing leadership skills. Leadership is not solely the domain of the principal; it is also relevant for teachers and other staff who have leadership roles within specific teams or projects. Leadership development programs can include training, mentoring, and collaborative projects to hone their leadership skills.

It is important to note that human resource development in schools is not only related to academic aspects, but also to the development of interpersonal and soft skills. Teachers and educational staff need to have the ability to communicate effectively, work collaboratively in teams, and adapt to changing educational environments. Therefore, development programs can also include training in interpersonal skills, time management, and conflict resolution. Furthermore, human resource development in schools involves empowering individuals to innovate and create positive change. Teachers and staff need to be encouraged to create innovative learning environments, use technology effectively, and identify opportunities to enhance students' learning experiences. This individual empowerment can include developing research projects or new learning initiatives.

5. CONCLUSION

Within the context of HRM, the importance of human resource development in educational institutions cannot be overstated, as it is key to achieving educational goals and creating an optimal learning environment. HR development in schools encompasses a variety of activities designed to enhance the knowledge, skills, and abilities of educational staff. HR development in schools has a direct impact on improving the quality of teaching and learning. Teachers involved in development programs have the opportunity to update their knowledge of the latest teaching methods, effective learning strategies, and educational technology. This helps create more relevant and engaging learning experiences and motivates students to achieve higher levels of achievement.

HR development creates an environment where innovation and creativity are empowered. Teachers and educational staff who have the opportunity to develop leadership, interpersonal, and innovative skills tend to be more open to creating new learning methods, creatively integrating technology, and presenting innovative ideas in the educational process. In the ever-changing world of education, it is crucial for educational staff to be able to adapt to changing environments. Human resource development programs provide a means to increase staff adaptability to curriculum changes, new technologies, or emerging educational trends. This helps schools remain relevant and responsive to student needs and evolving educational demands.

Human resource development also plays a role in increasing staff engagement and satisfaction. Development programs that address individual needs and aspirations help create a climate where staff feel valued, supported, and have opportunities for growth. High staff engagement and satisfaction can lead to better productivity, more effective collaboration, and a positive work climate.

The primary goal of every school is to achieve high levels of education and provide meaningful learning experiences for students. Human resource development directly contributes to the achievement of these school goals. Skilled and continuously developing staff have a greater potential to positively impact student outcomes and help achieve educational excellence.

Through human resource development, the overall performance of teachers and staff can be improved. Training and development programs provide opportunities for staff to enhance their skills, identify areas for development, and

work towards achieving higher performance standards. With improved performance, schools can provide a better educational experience for their students.

Human resource development supports the creation of a culture of continuous learning in schools. This culture emphasizes the importance of lifelong learning, where staff are recognized as lifelong learners who continually strive to improve themselves. A culture of continuous learning creates a positive cycle where personal and professional development becomes the norm.

Educational challenges can vary from one learning environment to another. Human resource development provides a means to address these challenges by empowering staff to develop creative and effective solutions. With enhanced skills and a better understanding of changes in the educational landscape, staff can face challenges with confidence and courage.

Human resource development programs provide opportunities for staff to enhance their career opportunities and professional development. By engaging in training and development programs, staff have the opportunity to build a portfolio of skills and achievements that can support their career growth. This creates a clear path to career advancement and recognition within the educational community.

Human resource development also involves collaboration and community engagement. Development programs can foster strong relationships between schools, families, and the surrounding community. Community involvement can increase resources, support, and understanding of the unique needs of students and the educational environment. The importance of human resource development in schools extends beyond improving individual skills, but also involves creating a culture of continuous learning, improving school performance, and achieving educational goals. Through these efforts, schools can better address educational challenges, provide a better educational experience for students, and contribute to the development of future-ready individuals. In line with the rapid development of education, investment in human resource development is increasingly crucial for creating a dynamic and successful educational environment.

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Didactics of Art Education in Alternative Preschool Pedagogy

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Abstract

This article deals with the didactics of art education in the context of alternative preschool education. The aim of the research was to analyze the conditions and approaches to art education in alternative kindergartens especially forest kindergartens and to identify how school leadership, particularly the role of the principal and strategic school management, can influence the quality of aesthetic education and the development of creativity in preschool children. The theoretical part defines key concepts such as aesthetic education, children's artistic expression, creativity, and its development in the preschool period. The importance of art in a child's life and the role of the environment and the teacher in developing individuality, self-confidence, and intrinsic motivation through artistic activities are emphasized. Furthermore, alternative pedagogical approaches (forest kindergartens and others) and their specifics in art education are analyzed, including aspects of school management (vision, mission, school climate) that shape the educational environment. The empirical part uses a questionnaire survey among teachers and kindergarten operators to verify hypotheses concerning the importance of a prepared environment, quality of management, artistic stimuli, and support for creativity in the educational process. Data analysis confirmed that a stimulating art environment and pedagogical support significantly influence the development of children's creativity and that strong, value-based school leadership is an important factor in improving the quality of preschool education. The results show that alternative preschools, especially forest preschools, provide more space for spontaneous creative activities than regular schools, both in terms of time and organization. At the same time, it has been shown that the presence of a specialized space for artistic activities in preschools positively correlates with children spending more time on artistic activities. The role of qualified and motivated teachers and supportive school management in creating an environment that stimulates creativity in preschool-age children is also discussed.

Keywords: pres-school, ethics, art education, alternative preschool pedagogy

1. INTRODUCTION

Institutional preschool education significantly complements family upbringing and plays a key role in shaping a child's personality, influencing their further educational path and future social integration. A high-quality preschool program should provide children with a stimulating environment for individual development, including the development of creativity and aesthetic sensibility. According to the Convention on the Rights of the Child, every

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child has the right to an education that develops their abilities and respects their personality; in this process, teachers play a fundamental role as guides and guarantors of these rights. Early childhood is a period when the foundations of physical, cognitive, and social development are formed, which is why sound pedagogical guidance in preschool institutions is indispensable.

In the Czech Republic, the content framework for preschool education is defined by the Framework Educational Program for Preschool Education (*Rámcový vzdělávací program pro předškolní vzdělávání*, 2021). In addition to traditional kindergartens, there is also a growing segment of alternative kindergartens that emphasize respect for the individuality of the child, support for creativity, learning through play, close cooperation with the family, and other innovative approaches. These principles are in line with the child-centered tradition dating back to Comenius' ideals of holistic education. Alternative schools—such as Montessori, Waldorf, forest kindergartens, etc. operate within the framework of the state curriculum but implement original pedagogical concepts. Forest kindergartens are a specific type of alternative kindergarten where teaching takes place mainly outdoors in nature. These kindergartens provide children with direct contact with the natural environment and are often associated with the philosophy of environmental education. Preliminary studies suggest that forest kindergartens can have a positive impact on children's social, emotional, and creative development (Sella et al., 2023).

To a certain extent, every kindergarten or children's group is a unique organization with its own program and character. It is headed by a director, who currently plays not only the role of administrator, but increasingly also the role of manager and educational leader. With the decentralization and growing autonomy of schools, high demands are placed on principals, including not only knowledge of legislation, but also broad managerial skills and strategic thinking. In cooperation with the founder, the principal formulates the vision and strategy for the development of the school, shapes the overall climate of the school, and supports the teaching staff. High-quality school management can thus significantly influence the extent to which innovation and creativity are supported in schools. This also applies to preschool education: well-established kindergarten management that supports creative activities and aesthetic education can create conditions for effective teaching and the development of children's potential.

This article focuses on the intersection of the aforementioned areas – art education, children's creativity, and school management – in the context of preschool education. The aim is to explore the didactics of art education in alternative preschool facilities and any differences compared to traditional kindergartens. Specifically, we focus on what conditions (material, organizational, personnel) support the development of children's creativity and what role school management plays in shaping these conditions. It also includes findings on whether and how alternative concepts especially forest kindergartens - influence approaches to aesthetic education and children's creativity. The research section of the article presents the results of a questionnaire survey that tested several hypotheses related to the above- mentioned aspects (prepared environment, management support, etc.).

The structure of the article corresponds to that of a standard scientific text. The introduction outlines the context and formulates the objective. This is followed by a literature review summarizing the theoretical background and current knowledge about art education, creativity, and alternative approaches in preschool education. The Data and Methods section describes the design and course of the empirical study. The chapter Results presents the findings of the research, and the chapter Discussion interprets these findings in the light of theory and practice. The conclusion summarizes the most important findings and indicates their significance for pedagogical theory and practice.

2. LITERARY RESEARCH

Art (aesthetic) education is an important means of developing creativity, aesthetic perception, and self-expression in preschool education. Preschool age is often referred to as the "age of play" – play is a natural activity through which children learn about the world and realize their ideas. Free creative play and art are closely related: when drawing, painting, or creating, children work in a similar way to when they play – they experiment, explore, and express their experiences and imagination. The goal is not to create an aesthetically perfect product, but rather to enjoy the activity itself and satisfy the basic needs of self-realization and learning (Slavík & Wawrosz, 2011). Slavík (2011) emphasizes that if we want to develop creativity and imagination in children, they should go through an authentic creative process – experience an artistic experience in which they enter various stages of creation through their own activity. It is the experience of the creative process, not just the resulting creation, that is the main benefit of art education and an important educational goal (Slavík & Wawrosz, 2011).

From a psycho-didactic point of view, artistic and creative activities contribute to the development of the whole personality of the child. Children develop fine motor skills and sensorimotor coordination and learn concentration and patience. At the same time, we stimulate cognitive processes—children learn to perceive relationships between shapes and colors, plan their work, solve problems, and seek original approaches, which supports the development

of thinking. Artistic expression is also linked to emotional and social development: through drawing or modeling, children express their feelings and experiences, gain self-confidence from their own creations, and can share the joy of their creations with others (Fichnová et al., 2012). Creativity as such is defined in many ways. For example, Opravilová (2016) understands creativity as the ability to combine thinking, feeling, and perception - the joy of discovering and combining knowledge into new contexts. In preschool children, creativity manifests itself spontaneously and without inhibitions; children are not bound by conventions and adult evaluation criteria, which allows them to approach artistic activities with immediacy and an open mind (Opravilová & Uhlířová, 2013). Young children usually draw and create for the joy of the activity itself, not for the result—the creative process is a game and a discovery for them, in which they make full use of their imagination and ever-expanding experience (Opravilová & Uhlířová, 2013).

The preschool period also sees the characteristic development of children's artistic expression. From early scribbles and first random shapes, the child gradually moves on to more intentional depictions – around the age of 4, they begin to draw so-called cephalopods (figures with distinctive heads and limbs), and around the age of 5–6, they already capture real objects with basic features and details. These changes reflect the development of children's thinking, perception, and symbolic expression of the world. Drawing is therefore not just entertainment, but contributes significantly to the development of cognitive abilities and creative thinking – when drawing, children plan, compare, make decisions, and solve problems, thereby learning higher thought functions (Fichnová et al., 2012; Lowenfeld, 1957). It is important for teachers to support this process sensitively, without imposing templates and evaluations that could inhibit the child's spontaneity.

The personality of the teacher and the quality of the educational environment play a fundamental role in the entire educational process. The kindergarten teacher should act as a qualified "guide" for the child through the world of knowledge and creativity. Preschool teachers are subject to relatively high demands – they should be empathetic, supportive, perceptive, and creative in order to create an environment of trust and inspiration. A good teacher can awaken curiosity in children, provide them with stimuli for creativity, and at the same time respect their individual pace and ideas. A classroom atmosphere based on trust, respect, and openness to new things is key to the development of creativity (Opravilová, 2016). If a child feels accepted and safe, they will more easily express their imagination and courage to try new things.

Equally important are the material and organizational aspects – that is, the environment and conditions in which teaching takes place. According to pedagogical concepts (e.g., Montessori, Reggio Emilia), the environment is considered the "third teacher" – if it is to serve the child, it must be thoughtfully prepared and stimulating (Montessori, 2018). A "prepared environment" in kindergarten means that the classroom or playroom is arranged so that children have free access to art supplies and materials that are appropriate for their age. An art corner or studio encourages children to engage in creative activities by offering a variety of materials (paper, paints, brushes, natural materials, scissors, glue, etc.) and sufficient space to work. Maria Montessori pointed out that the task of education is to prepare appropriate stimuli and resources for a given stage of a child's development and then let the child create freely (Montessori, 2018). The environment should therefore be aesthetically pleasing, organized, safe, but at the same time sufficiently variable and stimulating to encourage children's independent activity.

Empirical experience confirms that if a kindergarten has a specially equipped art studio or workshop, children spend more time there doing creative activities than in a kindergarten that does not have a dedicated art space (see the results of the research in this study). Opravilová (2016) emphasizes that both the physical environment and its equipment, as well as the overall creative atmosphere in the classroom, are pedagogically important for the development of creative activities. She lists the following as basic conditions for supporting creativity in kindergarten: sufficient suitable aids and materials, free access to them for children, an aesthetically stimulating environment, time for longer creative games, and, last but not least, a welcoming attitude of teachers towards children's ideas (Opravilová, 2016; Opravilová & Uhlířová, 2013). A teacher who perceives art activities not only as a "mandatory activity" but as a path to self-discovery and child development can create a culture that supports creativity in the classroom. Such a teacher is more likely to offer children inspiring ideas and materials than to draw a template for them; they are able to appreciate the child's original expression and lead children to share the joy of creation with each other instead of competing for the best picture.

Reform pedagogy during the 20th century brought a number of alternative approaches that also influenced the field of preschool education. Among the best known are Montessori pedagogy, Waldorf pedagogy, Reggio Emilia, and forest kindergartens. The common denominator of these approaches is an emphasis on the child as an active creator of their own knowledge, respect for individual needs and pace of development, and an increased role for the environment and direct experience. In the context of art education, alternative kindergartens often offer innovative approaches: for example, Montessori schools prefer open-ended art materials and emphasize sensory learning and the

child's internal motivation (Montessori, 2018, 2019). Waldorf kindergartens, on the other hand, include artistic activities (watercolor painting, modeling with beeswax, etc.) as a means of harmonious development, often in tune with the seasons and natural cycles. The Reggio Emilia approach stands out for its original concept of art education the studio and atelierista (art specialist) are an integral part of the kindergarten, and children have a great deal of freedom in what and how they create; the key is documenting the creative process and reflecting on it together, making art a language of learning. These approaches agree that artistic activities are not marginal entertainment, but the core of educational activities for children.

Forest kindergartens are a specific type of alternative preschool facility that has become widespread in recent years in the Czech Republic. Forest kindergartens provide children with education and care mainly outdoors, in direct contact with nature, with minimal facilities (often a yurt, trailer, or shelter). Despite this – or perhaps because of it they offer rich stimuli for the development of creativity. Spending time outdoors every day allows children to continuously observe the changes in nature and discover natural materials and laws, which stimulates their curiosity and imagination. Art and craft activities in forest kindergartens are organically linked to the surrounding environment: children create from natural materials (leaves, pine cones, twigs, clay...), are inspired by natural formations and phenomena, and use found materials for creations or play. Teachers in forest kindergartens choose themes and techniques that can be implemented outdoors – they often use land art (creating patterns from natural materials), environmental art, or simple art experiments in the field. If the weather does not allow outdoor activities, the children have access to heated facilities (yurts, etc.) where they can create at a table or on the floor. Even there, it is usually possible to set up a small "art corner" with available materials, similar to a regular classroom (Čížová, 2014).

Research focused on forest kindergartens suggests a number of benefits of this environment. In her study of the social and emotional development of children in forest kindergartens, Čížová (2014) states that children from forest kindergartens show a comparable (if not better) level of social skills and adaptability as children from regular kindergartens, despite the different conditions. In terms of creativity, it can be assumed that direct contact with nature promotes creativity thanks to rich sensory experiences and endless opportunities for play. Sella et al. (2023) conclude in their systematic review that forest kindergartens can have a positive impact on children's mental well-being, strengthening their self-confidence, independence, and creative thinking through free movement and spontaneous play in nature. Children in forest kindergartens learn to appreciate natural materials and often combine them with recycled or found objects in their creations, thereby developing environmental awareness and sustainable habits. This creates a remarkable connection between aesthetic education and environmental education—children learn that nature has always been an inspiration for human art and that it is possible to create sensitively in harmony with the environment (using, for example, traditional folk techniques such as felting sheep's wool, making natural dyes, weaving wreaths, etc., while also learning about the cultural aspects of working with natural materials).

The role of the teacher in a forest kindergarten is somewhat different from that of a teacher in a regular classroom – they often act more as a facilitator and guide than a directive instructor. Their task is to ensure the children's safety and provide them with basic tools (knives, string, paper, natural dyes, etc.), then leave the creative work to them. The teacher in the forest only helps with technical difficulties (e.g., holding materials, advising on tools), but leaves creative ideas to the children and the stimuli provided by the environment. The evaluation of children's creations in forest kindergartens is usually non-violent and informal – rather, the joy of successful creations is shared, children show them to each other or incorporate them into their games (for example, they organize a small "exhibition" of their forest sculptures for imaginary elves). Such a respectful and free approach supports children's self-confidence and inner motivation to try again. Forest kindergartens thus represent an inspiring model that shows that quality art education does not depend on luxurious equipment or studios – it consists mainly of the school's philosophy, an atmosphere of trust and openness to creativity, and the personal enthusiasm of the teacher (Jančaříková & Kapuciánová, 2013; Opravilová, 2016). These conclusions can also enrich the broader discussion on the form and meaning of aesthetic education in preschool age.

The issue of school management in kindergartens often remains in the background compared to didactic issues, but it is essential for the overall functioning of kindergartens and the quality of education. The kindergarten director is responsible for the organizational, personnel, and conceptual management of the institution. They must not only ensure the administrative running of the school, but also set the vision and values of the school, motivate the teaching staff, and communicate with parents and the founder (Častorál, 2009). In terms of supporting creativity in school, the priorities set by the management are crucial – if the director emphasizes the importance of aesthetic education and creative activities, this will be reflected in the school curriculum, classroom equipment, further education of teachers, and even in the projects implemented by the school. Strategic school management should include care for material conditions (e.g., setting up an art studio or a well-equipped art corner), staff development (supporting teachers

in innovative methods, enabling them to participate in art therapy seminars, etc.) and organizational climate (creating an open environment where teachers share ideas and children are encouraged to be creative) – see Eger (2002).

Modern trends in school management emphasize leadership – that is, leadership based on a clear pedagogical vision and the ability to inspire others to work toward common goals (Háša, 2016). A leader-principal supports innovation in teaching, sets an example in creative approaches, and is able to create an organizational culture that values teachers' ideas and initiative (Armstrong et al., 2015). In kindergartens, this may mean, for example, that the management supports unconventional projects (e.g., art workshops with artists, outdoor environmental creative projects), that it is open to alternative methods (project-based teaching, linking art education with other areas), and that it provides teachers with trust and space for self-realization. It is also true that value-based management— management with a clear philosophy and priorities—creates a climate in which creative activities can flourish. For example, a school whose mission statement includes "supporting children's natural curiosity and creativity" is likely to organize itself and its staff to achieve this goal (purchasing art supplies, including more art activities in the curriculum, involving parents in creative events, etc.).

The literature also points out that managerial support is particularly important in alternative schools, which sometimes face specific challenges (e.g., legislative requirements, financial security of operations). The management of alternative preschools (typically established by a parents' association or privately) often has to defend its concept externally, seek sources of funding, and build public trust. A strong and capable director or coordinator of such a kindergarten is key to maintaining quality—this also applies to forest kindergartens, where management must ensure the safety of children in non-traditional conditions, communicate with parents about the specifics of the outdoor program, and support teachers in their field work. Research on school management suggests that where leadership focuses on innovation and creativity, schools achieve better results in developing so-called soft skills in children (Havránková, 2023). In other words, if creativity is explicitly promoted by management as a value, this is reflected in the daily practice of teachers and the learning activities of children.

Theoretical principles therefore suggest that the development of children's creativity in kindergarten is a multifactorial process. It is influenced by the personality of the teacher and the quality of interactions, the material and psychosocial environment of the classroom, the philosophy and program of the school, but also by systemic leadership and support from the school management. Our research therefore focused on some of these factors (especially the environment, management support, alternative vs. traditional program) and examined their relationship to the intensity of art activities carried out with children. The following section describes the data and methods of the selected survey.

3. DATA AND METHODS

To achieve the research objectives, a quantitative research strategy was chosen, specifically a questionnaire survey among kindergarten teachers. The questionnaire was created by the author of the study and contained a combination of closed and semi-open questions focused on the conditions of art education in kindergarten and teachers' attitudes towards creative activities. The target group of respondents were teachers and principals of kindergartens in the Czech Republic, both from classical (traditional) and alternative facilities (forest kindergartens, Montessori, Waldorf, etc.). The questionnaire was distributed electronically – the link was shared via professional networks and groups for kindergartens (e.g., the Association of Forest Kindergartens, online forums for preschool teachers, etc.). In this way, a robust sample of responses was obtained. A total of $N \approx 1140$ respondents participated in the survey, which ensures sufficient statistical power for analysis (the actual number of responses to individual questions varies slightly depending on the completion rate).

The questionnaire surveyed the basic characteristics of each kindergarten (type of school – traditional vs. alternative; size; whether the kindergarten has a specialized classroom/art studio for creative activities; teacher qualifications; etc.) and also focused on the frequency and scope of art activities. The key variable was the estimated time children spend on art activities each week under the guidance of a given teacher (respondent). This time was categorized, for example, as: less than 1 hour per week, 1–2 hours per week, 3–4 hours per week, more than 4 hours per week. Questions were also asked about the teacher's personal relationship to art education (e.g., the popularity of art education compared to other educational areas), the teacher's level of formal education, and whether the school principal actively supports art education in the given kindergarten (subjective perception of support from management).

Based on theoretical assumptions, several research hypotheses were formulated:

H1: If a kindergarten has a special space (classroom or studio) for art activities, children in this school spend more time on art activities than children in schools where such a space is lacking. (Hypothesis focused on the influence of the prepared environment.)

H2: Alternative preschool facilities (i.e., schools with alternative programs, especially forest kindergartens, etc.) devote more time to creative activities than traditional kindergartens. (Hypothesis comparing alternative and traditional approaches.)

H3: The higher the formal education of a kindergarten teacher, the more time per week their pupils spend on creative activities. (Hypothesis assuming a positive influence of teacher qualifications on the scope of creative activities.)

H4: If the kindergarten director actively supports art education (e.g., emphasizes it in the school program, provides supplies, motivates teachers), the pupils of that school spend more time on creative activities. (Hypothesis targeting the influence of school management.)

H5: If a kindergarten teacher personally likes art and art education (i.e., lists it as their favorite educational area), their pupils spend more time on creative activities than pupils of a teacher who prefers another area (e.g., music or physical education). (Hypothesis testing the influence of the teacher's personal attitude.)

Statistical methods appropriate to the type of items were used to evaluate the data. First, a descriptive analysis was performed – frequency distribution of responses, average values, etc. Subsequently, the hypotheses were tested using appropriate statistical significance tests. Given the predominantly categorical data (e.g., time category vs. presence/absence of a studio, type of school, etc.), Pearson's chi-square test of independence was used to determine the association between pairs of nominal/ordinal variables. For some hypotheses (H1, H2, H5), contingency tables were analyzed and the dependence between the relevant categories was tested. For hypothesis H3 (teacher education as an ordinal scale vs. time spent on art activities), the chi-square test was also used after categorizing education into levels (secondary, higher vocational, higher education). The significance level was set at $\alpha = 0.05$ as standard, but for some tests with a large N, lower p-values ($p < 0.01$ or $p < 0.001$) were also interpreted as highly significant.

The data also took into account the division of the sample into traditional vs. alternative preschools – for comparison, the sample was divided according to the type of school indicated by the respondent. This made it possible to compare responses and values between these groups (e.g., average time spent on art activities per week in alternative vs. traditional preschools). Overall, the research design tracks correlations between factors and does not allow for causal conclusions; however, the data obtained may point to significant connections in the real practice of preschools.

4. RESULTS

The results of the questionnaire survey provided a number of interesting insights into the relationships studied. Below is a summary of the findings according to the tested hypotheses:

H1 (art studio vs. activity time): This hypothesis was confirmed. The analysis showed a statistically significant relationship between whether a kindergarten has a dedicated space for art activities and the amount of time children spend on art activities per week (χ^2 test, $p < 0.01$). Kindergartens with a dedicated art studio or workshop did indeed report more time allocated to art activities. Specifically, in kindergartens equipped with a studio, a significantly higher proportion of respondents reported spending 3–4 hours per week or more on art activities with children, while in kindergartens without a studio, the category 1–2 hours per week predominated. This result supports the importance of a prepared environment—when children have a well-equipped art space at their disposal, educators clearly use it for more frequent activities, and children thus have more opportunities to create.

H2 (alternative vs. traditional preschools and time spent on creative activities): The second hypothesis was also basically confirmed, although the differences were not extreme. Overall, alternative preschools reported slightly higher participation of children in art and creative activities than traditional preschools. For example, the proportion of respondents who indicated that children spend 3 or more hours per week on art activities was higher in alternative preschools than in traditional preschools. In specific numbers, approximately 42% of teachers from alternative preschools reported 3-4 hours per week of art activities, compared to ~31% of teachers from traditional preschools; 15% vs. 8% reported more than 4 hours per week (illustrative data). However, the statistical test was borderline significant (χ^2, $p \approx 0.07$), so strictly speaking, it cannot be said that the difference is significant at the 5% level. Nevertheless, the trend suggests that alternative kindergartens devote somewhat more space to creative activities. This finding corresponds with their pedagogical focus – many alternative concepts (including forest kindergartens) place great emphasis on spontaneous artistic and craft activities. At the same time, creativity also receives attention in

traditional kindergartens (thanks to the RVP PV, which includes art activities as part of the educational areas), which explains why the difference is not significant.

H3 (teacher education vs. scope of art education): This hypothesis was not confirmed. The expectation that teachers with a higher level of education would devote more time to children in art activities was not confirmed by the data in fact, an interesting opposite trend emerged. On average, the children of teachers who have attained higher vocational education (typically graduates of higher vocational schools of education) spend the most time on art activities. On the contrary, teachers with university education (Bachelor's/Master's degree) did not spend a higher proportion of time on art education; they often fell into similar categories as teachers with a high school diploma. Approximately, it can be said that the group of teachers with higher vocational education had the highest representation of answers 3–4 hours per week and >4 hours per week, while university-educated teachers slightly more often answered 1–2 hours. The chi-square test did not confirm a statistically significant correlation between the level of education and the time devoted to art activities (p > 0.1). This finding suggests that the formal qualification of a teacher does not in itself guarantee greater involvement of children in creative activities. It is possible that a more practically oriented education (higher vocational school) better prepared teachers to carry out art activities, while a university education (more theoretically oriented) does not always mean a higher frequency of creative activities in practice. In any case, the data show that the factor of teacher education does not play as significant a role as was assumed.

H4 (principal's support vs. time for creativity): This hypothesis could not be verified, as it turned out that 100% of respondents stated that their kindergarten principal actively supports art education. In other words, there was not a single respondent in the entire sample who felt that their school's management did not support creative activities. On the one hand, this result is very encouraging – it shows that kindergarten principals generally consider aesthetic and art education to be an important part of preschool education and declare their support for it. On the other hand, there was a lack of variability in the responses (everyone answered "yes") for statistical testing of hypothesis H4, so it was not possible to compare differences in the amount of time allocated to creative activities between the groups with and without support. It can be said that management support is universal—at least on a declarative level—and therefore other factors (such as the environment, teacher personality, etc.) will ultimately determine the level of creative activities. From a methodological point of view, this finding points to a possible socially desirable effect: respondents (teachers) may have tended to express loyalty to their principals by stating that management supports creativity, which is consistent with the generally positive image of how a school should function.

H5 (teacher's personal relationship to art education vs. time spent on creative activities): This hypothesis proved to be partially confirmed. A statistically significant correlation was found between the teacher's personal liking of art education and the time they spend with children on creative activities (χ^2 test, p < 0.001). However, a more detailed look revealed a certain paradox: teachers who identified art education as their favorite subject/area tended to implement art activities 3-4 hours per week more often (and also fell less often into the lowest category of <1- 2 hours). This suggests that a teacher's positive attitude towards art does indeed lead to the regular and frequent inclusion of creative activities in the curriculum – such teachers seem to have an intrinsic motivation to develop art projects with children. However, the category more than 4 hours per week (the highest time allocation) was relatively most common among those respondents who did not list art education as their favorite, i.e., they preferred another area (e.g., music, physical education). In other words, the absolute highest amount of time spent on creative activities was also recorded among a number of teachers who do not consider themselves "art enthusiasts." Hypothesis H5 therefore holds true in the sense that teachers with a positive attitude towards art education are significantly less likely to devote only a minimum amount of time to creative activities and more often achieve medium to higher time allocations (which is a positive effect). On the other hand, the mere fact that a teacher does not prefer art education does not mean that they are depriving children of creative activities – many "non-artistically" oriented teachers also carry out a relatively large number of art activities, probably due to other circumstances (school philosophy, program requirements, children's interests, etc.). These findings show that the personal preferences of the teacher have an influence, but are not the only determining factor in the extent of art education in kindergartens.

Overall, it can be said that the research questions were answered as follows: The most significant relationships were found in material conditions (presence of a studio) and, to some extent, in the type of school (alternative vs. regular). The personality or qualification characteristics of the teacher did not manifest themselves as strongly as expected, with the exception of their personal relationship to creativity, which has a certain but not entirely clear influence. Support from school management proved to be ubiquitous (at least according to teachers' statements) and therefore could not be quantitatively evaluated – however, the fact that a greater extent of creativity was recorded where there is better equipment and probably a more progressive program indirectly confirms the role of management (the directors of these preschools have apparently created the conditions for the establishment of studios and support

an alternative approach). The following section of the discussion is devoted to the interpretation of these results and their placement in the broader context of previous studies.

5. DISCUSSION

The results obtained provide valuable information about the factors that support (or, conversely, limit) the development of creativity in children in preschool education. Overall, they confirm the importance of the environment and pedagogical guidance for children's creative activities, which is consistent with the professional literature (Montessori, 2018; Opravilová, 2016; Opravilová & Uhlířová, 2013). In the discussion, we will focus on the individual relationships identified and attempt to interpret them in the context of theoretical principles.

First, one of the clearest findings was that a prepared art environment—specifically, the existence of a dedicated studio or corner—is significantly related to the amount of children's creative activities. This corresponds with pedagogical concepts that emphasize the environment as a key element of the educational process (Maria Montessori refers to the environment as the "third teacher," Reggio Emilia emphasizes the aesthetic quality of space, etc.). Our data specifically showed that where school management invested in setting up a specialized art classroom, teachers felt motivated and able to devote more time to art education. This makes intuitive sense: in a well-equipped studio, more demanding and longer projects can take place, children have a place to store their work in progress, they can work in groups at large tables, there is less mess in the regular classroom, etc. Conversely, if art activities take place only "provisionally" on a bench in the corner of the classroom, teachers may be limited by space and time (the need for quick cleanup, etc.). This finding supports a recommendation for practice: it is desirable for preschools, if space allows, to set aside space for art activities. This does not always have to be a separate room; in many kindergartens, corners or activity centers directly in the classroom, where the art corner is one of them, function successfully (children can independently take materials and create there). It is important that the environment "encourages" creative play (Opravilová, 2016) – i.e., colorful aids within reach, the possibility of displaying creations, inspirational decorations, etc.

Furthermore, it has been shown that the type of educational program plays a role: alternative preschools tended to spend more time creating than traditional preschools. This difference was not very significant, which can be interpreted to mean that even in many regular preschools, children are encouraged to engage in rich artistic activities (especially where teachers are enthusiastic and the management is inclined towards creativity, a traditional preschool can offer comparable space for artistic activities as an alternative preschool). However, the slight lead of the alternatives suggests that their child-centered and creativity-oriented philosophy is having an effect. Forest kindergartens in particular, as evidenced in the literature, integrate creativity into everyday outdoor activities—e.g., spontaneous drawing with sticks in the dirt, building forest houses, creating things from natural materials—which teachers may not formally perceive as "art education," but which nevertheless develops creativity. In contrast, in traditional kindergartens, art activities may be more structured (e.g., an "art club" once or twice a week or an art activity led by a teacher). Alternative schools more often give children the freedom to create continuously, integrating art into other activities (e.g., children draw something while telling a story, model numbers out of plasticine while learning arithmetic, etc.). From a practical point of view, it would be good for regular preschools to take inspiration from alternatives: to allow children to engage in art and creative activities not only within predefined lessons, but on an ongoing basis, according to the children's interests. This does not mean giving up on guidance, but rather creating a flexible program—when I see that children are interested in playing with colors, I let them paint for a longer time and postpone another activity, instead of ending the task after 15 minutes because of the schedule. At the same time, the fact that alternative preschools spend a little more time on creative activities can also be interpreted as meaning that traditional preschools still have some catching up to do in terms of supporting spontaneous creativity (even though they formally comply with the RVP PV). Greater administrative or personnel constraints in regular preschools (higher numbers of children per teacher, a fixed schedule set by school rules, etc.) may also play a role here, while alternative preschools often operate with smaller groups of children and greater freedom in their schedule.

The failure to confirm hypothesis H3 (the influence of teacher education) is interesting and thought-provoking. We could have assumed that teachers with a university education would have a better understanding of the importance of creativity and would therefore consciously include more art activities. The data does not support this. A possible explanation is that the level of formal qualification does not reflect actual pedagogical inventiveness or a relationship to creativity. Many teachers with "only" secondary or higher vocational education may be extremely creative and practical, while some university-educated teachers may prefer other areas (e.g., cognitive preparation for school) at the expense of creative activities. In addition, as mentioned above, there used to be specialized secondary pedagogical schools and higher vocational schools in the Czech Republic that placed considerable emphasis on art

and music activities in the training of kindergarten teachers. Graduates of these schools may therefore be very well equipped in terms of methodology for art education. In contrast, today's university studies in preschool education (Bachelor's/Master's) have a broader theoretical scope and perhaps less time for practical art training. This interpretation is supported by the fact that teachers with VOŠ (higher vocational) qualifications in our sample showed the highest level of involvement of children in art activities – VOŠ places emphasis on the practical methodology of art, music, and physical education. For school policy, this implies that the role of practical education and continuous methodological training of teachers in creative activities should not be underestimated. Obtaining a degree alone does not guarantee that a teacher will develop children's creativity in practice – they need to be guided and motivated by the content of their education and, later, by the school management.

The result that all teachers declared their support for leadership in the field of art education is methodologically inconclusive for testing H4, but it is noteworthy in terms of the general trend. It shows that aesthetic education is currently perceived as an important part of the curriculum, with which managers also identify. This is a shift from the past, when art education could be seen as just a "supplementary" activity to keep children occupied. Today, there is clearly a consensus that the development of creativity is as important as, for example, the development of pre-reading skills. However, it would be interesting for further research to examine this issue in greater depth, for example, to determine qualitatively how specifically principals support creativity (only verbally, or do they actually allocate resources and time?) and whether teachers feel they receive real support or only formal support. Our findings may also be influenced by the fact that teachers do not want to criticize their management. In any case, indirect evidence in the data shows that where excellent conditions were created (studio, alternative program, etc.), more creativity was generated – and these conditions are usually supported by enlightened school management. We can therefore agree with the statements in the literature that well-designed strategic school management directly influences the level of the creative environment (Eger, 2002; Háša, 2016). Conversely, even the best teacher would have less chance of implementing creative innovations if working in an environment with restrictive or apathetic management.

Hypothesis H5 revealed an interesting insight into how a teacher's personality is related to their teaching practice. It was confirmed that teachers who themselves love art activities often project this passion into their work with children – none of them completely neglected art education, and most of them devoted themselves to it above average. This is in line with intuition and literature, which emphasizes that the teacher's personal interest and creativity is transferred to children. At the same time, however, it turned out that teachers who prefer music or sports, for example, sometimes also devoted an extremely high amount of time (more than 4 hours per week) to art education – how is this possible? It may be because these teachers work in an environment (UnicornSchool) where art education is strongly embedded in its program or tradition, so even teachers with other personal preferences adapt and lead children to create because the school requires or allows it. For example, in a Waldorf kindergarten, where art activities take place daily (drawing, wet watercolor painting, etc.), even a teacher who prefers singing will keep up with the rhythm and paint with the children regularly. Another reason may be that some teachers simply integrate artistic elements into other activities: a teacher who loves music may often ask children to draw something to accompany a song, while a teacher focused on sports may make sports equipment (flags, medals) with the children, etc. So the unpopularity of art does not mean it is omitted if the teacher understands its importance or is motivated by the management. In practice, this means that the ideal situation is, of course, to have an enthusiastic "artist" in the kindergarten who will inspire the children. If this is not the case, it is important to have a school program and culture in place where even less artistically inclined teachers include creative activities because they know that it is valuable for children. This can be facilitated by joint planning among the teaching staff, sharing ideas, or involving external art lecturers who inspire teachers.

The research also revealed one surprising finding that is worth considering more broadly: namely, that a teacher's positive attitude toward art education alone does not guarantee the highest possible level of creative activities in practice—organizational and time constraints also play a role. Some teachers with a passion for art may not have enough time to devote more than two hours a week to it with their students (perhaps due to other responsibilities or a rigid schedule). On the other hand, some teachers who prefer other areas may be able to do creative activities with children very often in certain types of schools (such as forest schools) because it arises naturally from the situation. This again confirms that the systemic setup of the school and classroom is key. In a broader context, our results support the hypothesis that high-quality pedagogical leadership in schools (well-established school management with an emphasis on creativity) has a direct impact on creating an environment that supports artistic activities and the overall harmonious development of children (Langmeier & Krejčířová, 2006; Matějček & Langmeier, 2011).

It is also worth mentioning certain limitations of the research. First, the data are based on subjective statements by teachers, which carries the risk of bias (social desirability, inaccurate time estimates, etc.). For example, the 100% support for leadership may be the result of a certain loyalty or unwillingness to criticize employers. In the future, it would be useful to supplement the questionnaire survey with qualitative interviews or observations directly in

classrooms to find out how art activities actually take place and how support for creativity manifests itself "in action." Secondly, the categories of time spent on creative activities are rough and indicative—teachers do not always keep accurate records of how many hours children spend on creative activities, and creative activities may overlap with other activities (e.g., children paint during free play). The interpretation of "more hours = more creativity" is also not absolute; the quality and meaning of the activities are also important. Our research focused more quantitatively on time as an indicator, but did not evaluate how creative or beneficial the activities were. It may be that someone "creates" with children for four hours a week, but perhaps according to a template, without invention, while another teacher does an amazing creative project with children in one hour. These nuances are not captured by quantitative research. Therefore, the results must be interpreted cautiously and in context.

However, despite the limitations mentioned above, the study provided important empirical evidence for what theory and experienced educators have long claimed: art education in preschool age is an irreplaceable tool for the development of creativity and the whole personality of the child (Opravilová, 2016). The finding that the environment and management support play a major role could motivate education policymakers and school principals themselves to take action—e.g., investing in kindergarten equipment, providing teachers with methodological support in aesthetic education, incorporating elements of alternative pedagogy into regular kindergartens, etc. The data discussed also showed that all stakeholders (principals, teachers) are aware of the importance of creativity, which is a starting point for further improvement. It will be important to translate this declared support into concrete steps: allowing children to create, discover, and experiment as freely as possible.

6. CONCLUSION

The aim of this article was to examine the importance of art education and creativity in various stages of the educational process of preschool children, with particular emphasis on alternative kindergartens and the role of school management. Based on theoretical analysis and our own research, we can formulate several concluding statements:

First, art (creative) activities prove to be very important for preschool children. The preschool period – the "age of play" – is a period of intense development when children acquire basic skills and attitudes. Play and creative play are natural ways for them to learn about themselves and the world around them. Artistic play allows children to satisfy their natural curiosity, express themselves without words, process experiences, and develop their imagination. If a child has space for spontaneous artistic expression, not only does their aesthetic sensibility develop, but also their intellect, creative thinking, emotional intelligence, and social skills. In our research, this is also supported by teachers—all participants agree that their kindergarten management supports art education, which indicates a general awareness of its importance. Theory and practice thus confirm that aesthetic education in kindergarten is not an extra luxury, but a fundamental pillar of educational work aimed at developing the child's full personality (Fichnová et al., 2012; Opravilová, 2016).

Secondly, alternative pedagogical approaches – especially forest kindergartens – bring inspirational enrichment to the educational process with elements that promote creativity and a relationship with art. Forest kindergartens bring a new dimension to art education: nature becomes both a studio and a teaching aid. Children in the forest create from natural materials, learn through direct experience with nature, and develop environmental sensitivity. Our research has shown that alternative kindergartens generally spend slightly more time on creative activities than traditional kindergartens, and a literature review has documented the qualities of forest kindergartens in this area (Čížová, 2014; Sella et al., 2023). Alternative preschools—especially forest preschools—thus provide more space for spontaneous creative activities than traditional preschools, not only in terms of time but also in terms of organization. This is thanks to an emphasis on a prepared and stimulating environment, openness to creative processes, and respect for the individual pace of each child, principles from which mainstream education can also draw inspiration. It can be concluded that alternative approaches offer functional models for integrating art and creativity into everyday kindergarten life, thereby contributing to the cultivation of aesthetic perception and creativity in young children.

Thirdly, the results of the questionnaire survey emphasized that material and organizational conditions significantly influence the implementation of creative activities. In particular, the existence of a specialized art corner or studio proved to be a factor associated with more frequent and longer implementation of art activities. In other words, children create more and more often where they have the necessary facilities (tools, space, tools at hand) and where art education is systematically supported. This finding should be taken into account when equipping kindergartens, even relatively small investments in art supplies or space modifications can lead to a significant improvement in the conditions for children's creative activities.

Fourthly, the fundamental role of a qualified and motivated teacher has been confirmed. Although formal education did not prove to be a decisive factor, it is clear that a teacher who is empathetic, creative, and able to guide children appropriately shapes the quality of interactions and the atmosphere in the classroom. Such a teacher, regardless of their title, can either develop or suppress children's natural creativity through their approach. The results suggest that it is not so much the level of education achieved, but rather the practical skills and personal attitude of the teacher that matters. There is room here for further training of teachers in creative methods, art therapy, innovative forms of teaching, etc. It is also important to ensure sufficient staff capacity – a teacher who is overworked or burned out will find it difficult to create an inspiring creative environment for children. Therefore, school management should pay attention to supporting teachers, their motivation, and the conditions for their creative work.

Fifthly, it was somewhat surprising to find that a teacher's personal relationship to art education does not necessarily correlate closely with the volume of art activities – organizational conditions and managerial support proved to be more crucial. Even a teacher who does not consider themselves to be "artistically inclined" can lead children to create very intensively if they work in an environment that enables and supports this (and vice versa). This leads to an emphasis on the systemic framework: it is necessary to set curricular requirements, school programs, and leadership that ensure that creativity is cultivated in kindergarten as a natural part of the day – not just according to the preferences of individual teachers. Of course, it is best when both are present (an enthusiastic teacher in an inspiring school), but the system must ensure that, on average, every child has the opportunity to develop their creativity. This includes the education and selection of future teachers: when hiring teachers for preschools, one of the criteria should be creativity and a willingness to create, in addition to expertise.

Sixth, on a broader scale, it has been confirmed that well-designed school and strategic management, one that supports a clear mission and vision for the school focused on the harmonious development of the child—has a direct positive impact on creating an environment conducive to creativity. Schools whose management has made the development of creativity a priority have usually taken concrete steps to achieve this (equipping studios, project days with artists, cooperation with galleries, natural gardens for outdoor creativity, etc.). There, creativity really comes to life. Conversely, if the management did not support creativity (which we did not have in our sample, but hypothetically), it is likely that this would be noticeable – there would be a lack of resources, teachers would feel unmotivated, and art education could fall into a rut. School managers should therefore be trained in how to cultivate creativity in their organization—it is part of the modern concept of quality in education. After all, creativity is now considered a key competence for the 21st century, and its seeds are sown as early as preschool age.

In conclusion, art education and creativity in preschool education are not isolated components, but permeate the entire educational process. The development of children's creativity depends on a complex interplay of factors - thoughtful pedagogy that builds on children's curiosity and spontaneity, a stimulating environment full of stimuli, inspiring teachers, and supportive school leadership. When these conditions are met, kindergarten becomes a place where children can freely create, discover their abilities, and grow in all aspects. Such children take with them into their future lives not only a suitcase full of pictures, but above all developed creativity, self-confidence in self-expression, and an open mind – values that are immeasurable but essential for their future in school and society.

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Contemplation as a Complementary Force
in the Teaching-Learning Process

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Abstract

The author explores certain overlooked issues in the teaching-learning process. It is widely recognised that a learner-centred approach means a pro-learner, supportive way of dealing. Additionally, there are crucial features that can enhance the teacher's effectiveness. He highlights contemplation as an example of such a force. Teaching practices are highly individualised. To succeed, all teachers – prospective, novice, experienced – must incorporate their own personality into their practice. Again, he underlines that communication is a rudiment of professional success and goal fulfilment. Contemplative activities remind us that teaching practices are not only about teaching.

Keywords: contemplation, contemplative activities, teaching practices, the teaching-learning process

1. INTRODUCTION

Teachers can engage with their learners in various ways. Except for curricula, standards, internal school regulations, and other existing methodological guidance, teachers are the primary practitioners of educational interaction with learners in the class. On the other hand, it does not limit them from leaving sufficient space for their learners to perform and show their own individuality and uniqueness. We mean not only knowledge, skills, and experiences, but also nature, personality, and emotional aspects. To do so, teachers must be prepared, motivated, and willing to get "closer" to their learners, and vice versa. Clear, bias-free, and respectful communication is the only way to professional success and goal fulfilment. All that creates a bias- and anxiety-free atmosphere of mutual trust and positive creativity, enabling the complex cognitive and emotional development of learners.

The essence of *contemplation* and *contemplative activities*, overall, lies in making teaching practices both complex and effective. To do so, there must be activities, reflective and introspective, supporting learners' self-awareness, emotional intelligence, empathy, and deeper engagement and involvement. It is not only cognitive development, but also emotional development. It emphasises the affective part of the teaching-learning process. TEFL is not an exception. This article is focused on the synergy between the need to have contemplative features in the teaching-

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learning process and the essential interest in learners' needs and demands, generally identified as *a learner-centred approach*.

As seen in humanistic psychology, we should perceive education as the process of becoming rather than mere acquisition (Rogers, 1983, p.20). Learners get information actively while building on their own inner cognitive, personal, and emotional potential. Also, their motivation and the level of engagement must be considered. As for a teacher, his/her role is not just simply to deliver information. A teacher should be the mediator and facilitator of suitable conditions under which learning occurs; Rogers, in his own words (ibid., p.105): *"I see the facilitation of learning as the aim of education, the way in which we develop the learning man, the way in which we can learn to live as individuals in the process. I see the facilitation of learning as the function which may hold constructive, tentative, changing, process answers to some of the deepest perplexities which beset man today."* Discussing this framework, the contemplation functions as a supplementary force that deepens learners' self-awareness, enhances their capacity for reflection, and strengthens empathy. Therefore, these are the rudiments of successful language learning and intercultural communication.

In modern approaches to TEFL, the importance of the affective domain has been increasingly recognised, see Arnold and Brown (1999, pp.1-24). Emotions, attitudes, and self-concept strongly influence linguistic performance. However, while reflective teaching has become a widely accepted professional standard (Wallace, 1991, p. 53), the contemplative dimension-dealing with stillness, mindfulness, and ethical awareness has only recently gained attention (Barbezat and Bush, 2013, p. 8); they note: *"In fact, contemplative modes of instruction provide the opportunity for students to develop insight and creativity, hone their concentration skills, and deeply inquire about what means the most to them. These practices naturally deepen understanding while increasing connection and community within higher education."* Integrating contemplation into learner-centred education thus extends the focus from mere learner autonomy towards holistic self-realisation and social empathy.

2. DEFINING CONTEMPLATION AND CONTEMPLATIVE EDUCATION

In terms of origin, the word *contemplation* comes from Latin, and throughout the ages, it has had several distinct meanings. The primary context is religious. As defined by Merton (1972, pp.1-2), in his book named 'New Seeds of Contemplation': *"Contemplation is the highest expression of man's intellectual and spiritual life. It is that life itself, fully awake, fully active, fully aware that is alive. ... contemplation reaches out to the knowledge and even to the experience of the transcendent and inexpressible God."*

In education, according to Zajonc (2013, pp.83-94), contemplation refers to a focused form of attention that connects thinking, feeling, and ethical awareness. Reflection looks back at past experiences. On the other hand, contemplation is about being present at the moment and being aware of thoughts and emotions as they happen, and allowing understanding and compassion. As he states, contemplative pedagogy serves several educational goals. Research shows that contemplative practice, even if performed for short periods, improves attention, cognition, and cognitive flexibility. The practices are: Mindfulness, Concentration, Open Awareness, and Sustaining Contradictions.

Compared to a few dictionary sources, we bring definitions, or better said, explanations of the term *contemplation*:

- The Cambridge Dictionary (s. a.) → serious and quiet thought for a period of time;
- The Britannica Dictionary (s. a.) → the act of thinking deeply about something;
- Longman Dictionary of Contemporary English (s. a.) → quiet serious thinking about something → meditation.

Historically, the idea of contemplative thinking in education appeared in Aristotle's concept of theoria, which referred to a reflective existence dedicated to truth and understanding. Aristotle (ca.4th century BCE/2011, pp.223-224), in his 'Nicomachean Ethics, Book 10', stated: *"If happiness is an activity in accord with virtue, it is reasonable that it would accord with the most excellent virtue, and this would be the virtue belonging to what is best. So, whether this is the intellect or something else that seems naturally to rule, to command, and to possess intelligence concerning what is noble and divine, whether it itself is in fact divine or the most divine of the things in us - the activity of this, in accord with the virtue proper to it, would be complete happiness. And that this activity is contemplative has been said."* There (ibid., p.307) also appeared the definition of contemplation as *"the act of looking upon something so as to understand it, an understanding that is sought as an end in itself and hence without regard to any subsequent doing or making."*

St. Thomas Aquinas, in his 'Summa Theologica II-II' (s.a., Q. 180, Art. 3), directly regarded contemplation as the supreme human endeavour, connecting intellect and spirituality. In the centre of his interests were contemplation, meditation, and cogitation. He (ibid.) stated: *"Hence, cogitation may comprise not only the perceptions of the senses in taking cognisance of certain effects, but also the imaginations. And again the reason's discussion of the various*

signs or of anything that conduces to the truth in view. ... Cogitation may signify any actual operation of the intellect. ... Meditation would seem to be the process of reason from certain principles that lead to the contemplation of some truth... Contemplation regards the simple act of gazing on the truth."

In modern philosophy, Dewey (1933, p. 6) described reflective thinking as *"active, persistent, and careful consideration"* of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends, constitutes reflective thought. He emphasised intellectual responsibility. However, his pragmatic view lacked the inner calm found in meditative practices. In the 20th century, humanistic psychology revived reflection in education, especially through Maslow's concept of peak experience (1968, pp. 71-114) and Rogers's client-centred approach.

In the last decade of the 20th century and the first two decades of the 21st, contemplative pedagogy gradually gained recognition as a legitimate and respected part of education. Drawing on insights from psychology and neuroscience, it views contemplative activities as ways to develop metacognition – the ability to reflect on and regulate one's own thinking (Metakognícia: vzdelávacie štandardy, s.a.) – as well as emotional balance and empathy. Over these decades, researchers have progressively defined contemplation, contemplative pedagogy, and contemplative practices as methods that unite intellectual, emotional, and reflective dimensions of learning.

Miller (1994, pp. 53-69) described contemplative practice as *"a deliberate slowing down of cognitive activity to allow for inner awareness and reflective insight."* His perception of contemplative education was characterised by its understanding as *"stillness, attention, and inwardness"*. It was the means of deepening both intellectual understanding and personal growth.

Within the field of language education, contemplation thus extends beyond silence or meditation. It represents a reflective and ethical approach to teaching and learning. As Palmer (1998, p. 11) observed: *"Good teachers join self and subject and students in the fabric of life."* He continued (ibid., p. 13): *"Good teaching comes from the identity and integrity of the teacher ... good teaching comes from good people."* Together, identity and integrity form an ongoing process of self-discovery and growth toward wholeness and vitality rather than fragmentation and alienation. Contemplative awareness enables both teachers and learners to connect more genuinely with themselves, with one another, and with the subject they study. When applied to TEFL, contemplative activities help cultivate a classroom atmosphere where language use becomes mindful, empathetic, and ethically aware.

Stock (2006, pp. 1760-1764) did not give a simple, formal definition of contemplative education, but rather explained it through historical and philosophical examples. He presented it as an approach to teaching and learning that weaves together reflective or meditative practice with intellectual inquiry, aiming to nurture both the mind and moral self. From his discussion, contemplative education emerges as a holistic educational model focused on "the whole person", uniting self-knowledge, ethical and spiritual awareness.

In her article, Morgan (2015, pp. 197-218) described contemplative education as an educational approach grounded in contemplative states of consciousness – states that connect the intellectual, emotional, and spiritual dimensions of learning. She argued that it represents the re-emergence of an ancient mode of learning found across Buddhist, Hindu, Christian, Sufi, Jewish, and Indigenous traditions. It seeks to restore wholeness and meaning to education by linking mind, body, and spirit through practices such as reflection, meditation, dialogue, and mindful awareness. Contemplation is *"an essential part of who we are and how we learn"* (ibid., p. 198).

In the case study of Wang and Liu (2016, pp. 141-155), mindful or contemplative learning means learning with awareness → not just attending to content, but attending to one's own mental processes: noticing thinking, emotions, difficulties, and making those part of the learning process. The attributes are:

- awareness-oriented learning → students are encouraged to attend their own internal processes (thoughts, feelings, assumptions) while doing tasks;
- inquiry and reflection → part of learning is stepping back, noticing, questioning the approach, and adjusting;
- collaboration in the construction of a mindful surroundings → teachers and students collaboratively maintain a classroom climate that allows slowing down, introspection, safe vulnerability;
- outcomes beyond linguistic gains → creative thinking, deeper comprehension, learner ownership, more engagement and satisfaction.

According to Scida and Jones (2017, pp. 573-599), contemplative practices are reflective and awareness-based activities, e.g. meditation, mindful breathing, or journaling. They help learners quiet the mind, cultivate attention and compassion, and develop self-awareness. Moreover, they serve both affective (emotional regulation, anxiety reduction) and cognitive (focus, engagement, deeper learning) purposes. As the authors note (ibid., pp. 577-578): *"Contemplative practices quiet the mind, develop insight and self-awareness, and promote an attitude of kindness*

and compassion toward ourselves and others. Examples include a wide variety of practices such as yoga, sitting and moving meditations, writing, contemplative arts, and deep listening, among others."

For Giveh (2018, p. 61): *"Contemplative education integrates introspection and experiential learning into academic study to support academic and social engagement, develop self-understanding, as well as analytical and critical capacities, and cultivate skills for engaging constructively with others."*

In Gönen (2022, pp. 78-96), the term contemplative education is not used explicitly, but her framework mirrors its foundations, i.e., slowing down the learning process, deep listening and non-judgmental awareness, inner inquiry and emotional insight, and transformative outcomes-greater empathy, focus, and self-understanding. She (ibid., p. 79) noted: *"The implementation of mindfulness practices may have a transformational effect on the conscious choice of reactions given to mental and physical actions and situations in learning and teaching environments that would have a direct impact on learning. Thus, it may be possible to make learning-teaching environments more effective through the integration of mindfulness practices. Mindfulness-based practices (MBPs) provide various benefits for both teachers and students."*

3. PERCEIVING CONTEMPLATIVE ACTIVITIES

From the practical point of view, there can be various ways to judge contemplative activities.

Columbia Center for Teaching and Learning (2017) describes contemplative pedagogy as *"an approach to teaching and learning with the goal of encouraging deep learning through focused attention, reflection, and heightened awareness. Learners are encouraged to engage deeply with course material through contemplation and introspection (examining their thoughts and feelings as related to the classroom content and their learning experiences)."*

According to the Center for Contemplative Mind in Society (2021), there is the Tree of Contemplative Practices (see Figure 1). Their explanation is:

"On the Tree of Contemplative Practices, the roots symbolise the two intentions that are the foundation of all contemplative practices: cultivating awareness and developing a stronger connection to God, the Divine, or inner wisdom. The roots of the tree encompass and transcend differences in the religious traditions from which many of the practices originated, and allow room for the inclusion of new practices that are being created in secular contexts. The branches represent the different groupings of practices. For example, Stillness Practices focus on quieting the mind and body in order to develop calmness and focus. Generative Practices come in many different forms (i.e. prayers, visualisations, chanting) but share the common intent of generating thoughts and feelings of devotion and compassion, rather than calming and quieting the mind. Please note that these classifications are not definitive. For example, mantra repetition could be considered a Stillness Practice rather than a Generative one."
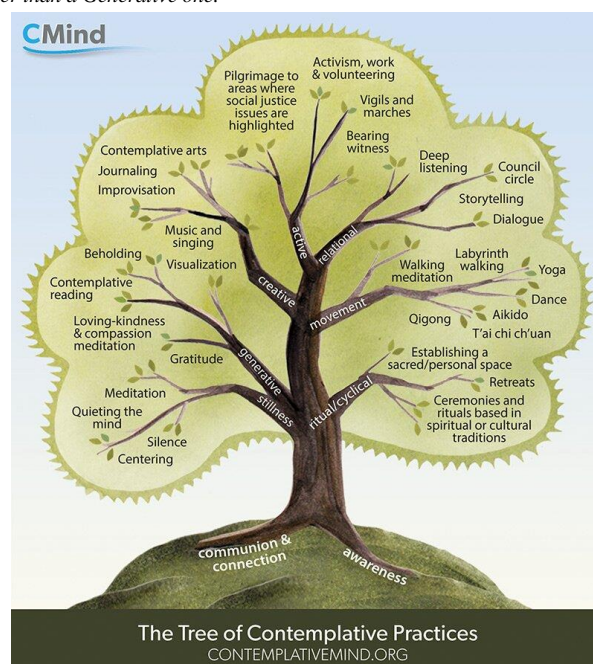

Figure 1   The Tree of Contemplative Activities
(https://contemplativemind.org/practices/tree)

Contemplative activities in the teaching-learning process indicate moving towards a more holistic, human-centred, and ethically aware pedagogy. It allows learners to engage more consciously with themselves, other learners, and the instructions when given in classes. Everyone in the teaching-learning process should understand language as an expression of awareness, empathy, and relationship. The impact of contemplative activities can be seen in several dimensions:

- cognitive and metacognitive dimensions → contemplative activities support the learners' attentional control and metacognitive awareness by helping them notice and regulate their thoughts, emotions, and focus. As Kabat-Zinn (2013, p. 25) explained that mindfulness is *"the awareness that arises by paying attention on purpose, in the present moment, and non-judgmentally"*. Mindfulness-based exercises increase learners' concentration, and they also encourage self-efficacy and autonomy – see Benson (2011, 296p.).
- emotional and affective dimensions → contemplative activities help lower down affection by cultivating calmness, self-acceptance, and openness; help reduce anxiety, help keep self-regulation under control;
- intercultural and ethical dimensions → contemplative activities foster curiosity, openness, and non-judgmental awareness; learners can explore cultural differences; learners learn to understand the human side of other learners without biases and prejudices;
- teacher awareness and professional growth → teaching practices require patience and self-awareness, as well as emotional literacy.

As Kraľová et al. (2025, p.89) claim: *"Choosing appropriate activities to stimulate learners' positive emotions can thus greatly enhance learning."*

4. CONCLUSION

Bringing contemplation into the teaching-learning process helps education not focus only on results but also on the factor of well-being. We overcome performance with a deeper focus on awareness, presence, and genuine human connection. With our learners, not only is the factor of independence and active engagement /participation important. Having a contemplative element means that something special as a superstructure was added, and it brings a special essentiality to the teaching-learning process. It connects thinking, feeling, and values, plus in addition, it involves the strong ethical aspects of human existence. This makes the teaching-learning process more balanced and meaningful. It is beneficial to learners that contemplative practices support basic qualities, such as empathy and openness. It helps them grow as reflective and responsible people. As for teachers, it supports authenticity, calmness, and compassion. Therefore, they have their complete teacher integrity. Contemplation enriches education by grounding it in awareness and empathy. It helps recreate classrooms into places to be, that are not only places for gaining knowledge but also communities of respect, understanding, and shared humanity.

Acknowledgements

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Native-like Pronunciation vs. Intelligibility

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Abstract

This paper explores the paradigm shift in English pronunciation teaching and learning from the pursuit of native-like norms towards the prioritisation of intelligibility. Historically, Received Pronunciation (RP) functioned as the standard model in English teaching instruction. However, as English has evolved into a global means of communication used predominantly by non-native speakers, the relevance of native-speaker models has been increasingly challenged. Drawing on Jenkins' concept of Lingua Franca Core (LFC) and subsequent development, the paper contrasts the traditional nativeness perspective with the intelligibility perspective. While native-like pronunciation continues to carry value for some learners, intelligibility might provide a more inclusive, realistic, and functionally grounded goal. The discussion concludes that the tension between native-like pronunciation and intelligibility is likely to remain a central issue in pronunciation pedagogy.

Keywords: English pronunciation, native-like pronunciation, intelligibility, Global English, pronunciation priorities

1. INTRODUCTION

Pronunciation has long been recognised as a fundamental component of communicative competence in English language learning and teaching. It not only influences the degree to which learners can be understood but also shapes their linguistic identity and confidence as speakers (Kholid and Hidayat, 2025).

Historically, pronunciation instruction has been closely associated with native-speaker norms, particularly Received Pronunciation (RP), which for decades served as the primary model of correctness and prestige in the contexts where British English was taught (Roach, 2009). However, as English has developed into a global language used by speakers from diverse linguistic and cultural backgrounds (El Garras, 2025; McCrum et al., 1987; Melitz, 2016), the traditional emphasis on native-like pronunciation has been increasingly questioned (Jenkins, 2000; McCrum, 1987; Walker et al., 2021).

This shift has led to the reconceptualisation of what constitutes successful pronunciation learning. Rather than striving for native accent imitation, modern approaches prioritise intelligibility, which ensures that communication remains clear and effective across international contexts (Hinkel, 2006). Consequently, current pedagogical perspectives increasingly favour communicative functionality over conformity to native standards (Yazan, 2015).

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This paper, therefore, explores the evolution of pronunciation teaching from the traditional native-like norms to the contemporary emphasis on intelligibility.

2. FROM NATIVENESS TO INTELLIGIBILITY

Pronunciation is one of the central aspects of language learning and teaching as it influences comprehension and communicative effectiveness. Given its role, this chapter examines pronunciation norms, contrasting the traditional native-speaker model of Received Pronunciation (RP) with a modern approach that emphasises intelligibility.

2.1. The traditional view of pronunciation – Received Pronunciation

It can be inferred that each individual's pronunciation differs to some extent from that of others (Jones, 1966). One reason is that there are many accents in all languages, and the English language is no exception. There are many varieties of English spoken around the world, either standard or non-standard.

Given this variety, it is important to note that for the purpose of considering whether learners still aspire to achieve native-like pronunciation, the accent used as the target norm of native-like pronunciation is "the one that is most often recommended for foreign learners studying British English" (Roach, 2009, p. 3) – Received Pronunciation (RP). Terms such as BBC pronunciation, Standard Southern British English (SSBE), or Southern British Standard (SBS) are often used interchangeably with RP. This is largely because the label has come to be perceived as somewhat outdated. In response to both phonetic shifts and evolving attitudes towards its social significance, many linguists now favour the SSBE label (Hughes et al., 2013). Still, in this paper, the term used is RP, as it is the most commonly used one. RP represents a variety of pronunciation, which is regionally and geographically based, and appears to be highly intelligible (Jones, 1977). This pronunciation model has traditionally been based on the phonological pattern of an idealised native speaker, with accented speech interpreted as a sign of inadequate phonological mastery. It was traditionally defined by strict adherence to specific segmental and suprasegmental features (see Table 1.).

Although RP has undergone significant changes since it was first established (Hinton, 2015), it might be argued that the emphasis on acquiring native-like pronunciation has hindered the progress of pronunciation teaching and learning (Council of Europe, 2020). Even with that, native-like pronunciation can be a goal for certain learners; therefore, it should not be completely dismissed. Smit and Dalton-Puffer's findings (2000) indicate that students studying English demonstrate a strong motivation to enhance their pronunciation, with many aspiring to attain near-native pronunciation. Brabcová and Skarnitzl (2018) aimed to investigate whether learners preferred native or non-native models. They discovered that over 70% of respondents aspired to acquire a native-like accent, most often General British, even though they mostly communicated with other non-native speakers.

In conclusion, native-like pronunciation can still be considered relevant in the context of global communication. Moreover, despite the growing acceptance of diverse English accents and the increasing emphasis on intelligibility, the pursuit of native-like pronunciation continues to be relevant for many learners.

2.2. A new approach to the sound norm of English – Intelligibility

As mentioned above, the native-like accent can sometimes still be seen as less relevant, as it does not reflect global linguistic diversity or align with varied learner goals (Atar, 2018). Therefore, in today's context, in general, achieving native-like pronunciation might not be the main goal. When combined with the ongoing significant development of the perspectives, methodologies, and objectives of pronunciation teaching, it can be deduced that currently, the emphasis has shifted towards prioritising intelligibility over attaining a pronunciation that closely resembles that of a native speaker, which was previously deemed more significant. "The rapid pace of internationalisation of English has led to the changing perspectives on the teaching of pronunciation" (Hinkel, 2006, p. 115).

In the context of teaching and learning pronunciation, we can divide the traditional approach and the new approach according to the concept of success in acquiring pronunciation. Generally, a distinction can be made between the Intelligibility perspective and the Nativeness perspective. The first supports the development of communicative competence, while the latter develops native-like pronunciation (Henderson, 2021).

Contemporary approaches to pronunciation increasingly emphasise intelligibility, commonly defined as the extent to which an interlocutor is able to comprehend a speaker's message (Hinkel, 2006). This concept holds relevance for English language education, as it supports the goal of enabling learners to communicate effectively across diverse English-speaking contexts (Yazan, 2015). Closely related to English as a lingua franca (ELF), "the paramount

importance of ensuring intelligibility (as opposed to approximation to native-speaker models) has been strongly argued for in relation to pronunciation teaching in ELT" (Yazan, 2015, p. 203).

Supporting this, Kholid and Hidayat (2025) found out, among other things, that many students associate native-like pronunciation with higher social prestige, academic competence, and professional advancement. However, while some learners admire native-like fluency, others resist adopting a completely foreign accent. For these students, preserving their own speech identity is more important than perfecting a native-like accent. Furthermore, intelligibility is often viewed as a more practical and achievable objective, as effective communication depends on mutual understanding rather than accent perfection.

In summary, while native-like pronunciation continues to hold value for some learners, the contemporary focus in pronunciation pedagogy has shifted towards fostering intelligibility as the primary goal – reflecting a more inclusive, realistic, and communicatively effective approach to global English use.

3. ENGLISH IN THE GLOBAL CONTEXT

Building on the discussion of intelligibility as the main aim of contemporary approaches to pronunciation, this chapter examines English in its global context. As the English language has developed into a global means of communication spoken by over a billion native and non-native speakers worldwide, the chapter also explores the spread and status of English in the world and examines how its global role has influenced pronunciation priorities, particularly compared to the traditional view of pronunciation.

3.1. Global English

It is undoubtedly obvious that the English language is becoming progressively more widespread in the world, not only as a native language but mainly as a second or foreign language. Hence, English has been referred to as global. What does it mean for a language to hold such a status? A language attains true global status when it assumes a distinct function acknowledged across all nations (Crystal, 2003). To be declared as such, the language must be adopted by nations across the world, which consciously choose to assign it a special role within their societies, even if there are few or no native speakers (Crystal, 2003). To date, around 1.5 billion people around the world are competent in English. Hence, it is now more geographically distributed and more extensively used, both in speech and writing, than any other language in history, having evolved into a truly global means of communication (El Garras, 2025; McCrum et al., 1987; Melitz, 2016).

When considering English as a global language, it is important to note that most of its speakers are non-native (Sa'd, 2018). Thus, another useful title ascribed to this language is English as lingua franca (ELF), which is used when English is the means of communication between two or more speakers with different native languages (Seidlhofer, 2005).

As English is now widely regarded as an international language, the focus of pronunciation teaching has shifted accordingly. Walker et al. (2021) propose a hierarchy of pronunciation features based on Jenkins' Lingua Franca Core (LFC) that should be prioritised in English language instruction. These authors also use the term English as an international language (EIL) to highlight the role of English as a global means of communication. In the next chapter, these priorities will be explained and compared to those of a native speaker.

3.2. The sound of Global English

The goal of the above-mentioned English, whether any of the mentioned terms are used to name it, is a primary focus on achieving proficient communication rather than attaining native-like pronunciation. The established priorities concerning English pronunciation in this sense are as follows, most consonant sounds, aspiration of /p/, /t/, and /k/ at the beginning of a word, consonant clusters at the beginning or in the middle of a word, vowel length, nuclear (sentence) stress, and word stress (McCrum et al., 1987). These priorities were further developed and are compared to the native-speaker accent in the table below.

Table 1. EIL and Native-speaker Pronunciation Priorities from Walker et al. (2021, p. 15)

Aspect of pronunciation	EIL priorities (based on the LGC)	Native-speaker accent priorities
Consonant sounds	Most sounds are important except for LFC-acceptable variants	All sounds
Consonant clusters	Important at the beginning or in the middle of words	Important in all positions
Vowel length	Long/short contrasts and shortening of vowels before voiceless consonants are important	Long/short contrasts are important
Nuclear (sentence stress)	Important	Important
Word stress	Important	Important
Vowel quality	L1-influenced vowel qualities are acceptable as long as they are consistent	Important. Vowel qualities should be as close as possible to the target native-speaker accent, with minimal influence from L1.
Vowel reduction, use of schwa (/ə/), and weak forms	Unhelpful to intelligibility; only taught for receptive purposes	Important
Assimilation, elision, coalescence	Can be unhelpful to intelligibility; only taught for receptive purposes	Important
Stress-timed rhythm	Not important	Important
Pitch movement (fall, rise, fall-rise, etc.)	Not important	Important

In the second column, the EIL priorities are listed. As mentioned above, these priorities are based on the Lingua Franca Core (LFC) created by Jennifer Jenkins. LFC refers to a set of phonological features in English pronunciation that are necessary to ensure intelligible communication among non-native speakers (Jenkins, 2000). In contrast to the native-like pronunciation approach, the LFC prioritises segmental features (consonants and vowels) while assigning a less central role to suprasegmental features (rhythm, stress, and intonation) (Dauer, 2005; Jenkins, 2000). Jenkins introduced the Lingua Franca Core (LFC), outlining the key phonological features necessary for intelligibility in English as a Lingua Franca. Dauer (2005) provides a concise summary of these features. In the descriptions below, American English (AmE) and British English (BrE) are used to indicate the pronunciation norms typical of each variety.

For the consonants mentioned in the first two rows of the table, the core items are:

- All consonants (except /θ, ð/ (*thin*, *then*), which can be replaced by /f, v/).

- Final /r/ as in AmE (do not drop /r/ in *he<u>r</u>e*, *hai<u>r</u>*, etc., as in BrE).

- Medial /t/ as in BrE (do not voice /t/ in *ma<u>tt</u>er* nor delete it in *win<u>t</u>er* as in AmE).

- Approximations of core sounds are acceptable as long as they will not be heard as another sound (e.g., phonemic distinctions must be maintained).

- Aspiration of word initial voiceless stops /p, t, k/ (*pin* /pʰɪn/, *tin* /tʰɪn/, *kin* /kʰɪn/).

- No omission of consonants in word initial clusters (*<u>pr</u>omise*, *<u>str</u>ing*).

- Omission in medial and final clusters only according to inner circle English rules (*facts = fax*, *bands = bans*).

- Addition (vowel epenthesis) is preferable to omission (*product* as [pər'adʌkʊtə], not ['pɑdʌk]). (Dauer, 2005, pp. 544-545)

For vowels found in the third, sixth, and seventh rows of the table, the core items are:
- Contrast between so-called long and short vowels (*seat*, *sit* /iː-ɪ/ or /i-ɪ/; *cooed*, *could* /uː-ʊ/ or /u-ʊ/; *cart*/*class*, *cot*, *caught* /ɑː-ɒ-ɔː/ BrE or /ɑr-æ-ɑ- ɔ/ AmE).

- No substitutions for the vowel in *bird*, /ɜː/, (AmE /ɚ/; e.g., *heard* distinct from *hard*) but other nonnative regional qualities are acceptable as long as they are consistent (e.g., it is not necessary to diphthongize /eɪ/, ʊə/ in *say*, *so*).

- Vowels shortened before voiceless consonants and lengthened before voiced consonants (*sat*, *sad* /sæt-s æːd/, *pick*, *pig* /pɪk-pɪːg/). (Dauer, 2005, p. 545)

And lastly, the suprasegmental core items are:
- Correct placement and production (lengthening) of nuclear stress and contrastive stress (*You deserve to be SACKED* vs. *You deSERVE to be sacked*).

- Division of the speech stream into word groups. (Dauer, 2005, p. 545)

Thus, this table unmistakably demonstrates that EIL pronunciation priorities have evolved, no longer adhering to the stringent emphasis on native-like pronunciation that was previously required.

4. CONCLUSION

To summarise, the teaching and learning of English pronunciation has undergone a significant shift from prioritising native-like norms to emphasising intelligibility. While Received Pronunciation (RP) and other native-speaker models remain relevant for some learners, contemporary approaches recognise the practical and communicative needs of English as. global language. The Lingua Franca Core (LFC) illustrates how pronunciation priorities now focus on features essential for mutual understanding among speakers of diverse linguistic backgrounds, rather than exact replication of native norms. This evolution reflects a more inclusive, realistic, and functionally oriented approach, ensuring that learners can communicate effectively across international contexts while maintaining their own linguistic identity. Nevertheless, the longstanding debate over whether pronunciation instruction should aim for native-like accuracy or intelligible communication is likely to persist for many years to come, reflecting the dynamic and evolving nature of English in the global context.

Acknowledgements

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From Stage to Classroom: A Review of Key Drama Techniques in ELT

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Abstract

Recent developments in communicative language teaching have prompted growing interest in drama as a means of enriching English language instruction. Although individual techniques, such as role-play, improvisation, tableaux, pantomime, and scripted performance have long been used in educational and theatrical traditions, their systematic integration into English language teaching (ELT) remains neither consistently defined nor widely implemented. This review addresses these gaps by examining the historical development, pedagogical applications, and learner-centred outcomes of five key drama techniques within EFL contexts. Evidence suggests that drama provides embodied, experiential learning that supports authentic communication, reduces anxiety, and fosters motivation, empathy, and collaboration. While challenges remain, such as limited resources, classroom management, time constraints, and insufficient teacher training, the research suggests that, when applied thoughtfully, drama can effectively integrate linguistic, cognitive, and affective learning. Overall, it emerges as a viable pedagogical approach that enhances language development and personal growth; however, further rigorous empirical work is still needed to strengthen its place in the general teaching approach of ELT.

Keywords: Drama techniques, English language teaching, experiential learning, communicative language teaching

1. INTRODUCTION

Despite advances in communicative language teaching, many classrooms still struggle to engage learners effectively or to connect language learning with real-life experiences. Researchers argue that drama-based pedagogy addresses these limitations by integrating cognitive, emotional, and social dimensions of learning (Stinson & Winston, 2011; Even, 2008). Through embodied participation and authentic contexts, drama enables learners to experience language as a meaningful activity rather than just abstract knowledge (Galante, 2018; Via, 1987). As a pedagogical tool, drama is a broad concept encompassing a variety of techniques and activities. These methods have gradually gained popularity in English language teaching (ELT), each rooted in historical traditions; nonetheless, there is still no universally accepted categorisation of them. For example, Gaudart (1990) distinguished between the

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four language skills they influence, differentiating among language games, mimes, role-plays, and simulations. Helderbrand (2003) emphasises non-verbal activities for young learners: body talk, silent trips, story-miming, and meaningful sequences. Basaran (2024) identifies five categories: warm-ups, awareness-raising, confidence-building, and techniques for speaking, listening, reading, and writing. Puskás (2018) lists ten standard techniques: improvisation, teacher-in-role, sculpting, still image, thought bubbles, teacher narrative, hot-seating, mirroring, mingling, and miming. According to Celik (2019), the most frequently used drama-based techniques are improvisation, role-play, and pantomime. However, as several authors note, most research focuses on drama as a general pedagogical approach rather than examining specific techniques and their distinct contributions (Luo et al., 2024; Mardiningrum, 2016).

This literature review addresses this research gap by focusing on five key drama techniques (pantomime, tableaux, role-play, improvisation, and scripted plays) within the context of English language teaching (ELT), examining their historical development, pedagogical use, and learner-centred outcomes. The review aims to show how these techniques, rooted in theatrical, psychological, and educational traditions, have developed into practical tools for communicative and experiential language learning.

From this main goal, three secondary objectives arise:

1. To trace the historical and conceptual origins of the chosen drama techniques by exploring their beginnings, key theorists, and adaptation within ELT settings.

2. To analyse the pedagogical application of drama techniques, focusing on the strategies, benefits, and challenges involved.

3. To examine the emotional and cognitive effects of these techniques, especially regarding learners' motivation, anxiety, empathy, communication, and collaboration.

Relevant literature was identified through searches of Scopus, Web of Science, ERIC, and Google Scholar using combinations of keywords such as drama, process drama, improvisation, role-play, tableaux, and ELT. Peer-reviewed articles and book chapters published in English were considered. Studies focusing on non-ELT contexts or theatre education unrelated to language development were excluded. Although not exhaustive, this search strategy aimed to provide a representative overview of how drama techniques are discussed within ELT research.

2. HISTORICAL FOUNDATIONS OF DRAMA TECHNIQUES

The primary purpose of this chapter is to outline the historical evolution of the selected drama techniques and to clarify their core definitions within educational and linguistic contexts. The historical evolution of the selected techniques and their definitions. By tracing their development from theatrical and psychological roots to modern language pedagogy, the chapter aims to show how these techniques have influenced communicative and experiential learning.

It is said that role-playing as an instructional method was used as early as ancient Greek times (Corsini et al., 1961). Later, Moreno revolutionised role-playing by adapting it for psychiatric purposes, introducing psychodrama as a means of exploring truth through dramatic methods (Rojas & Villafuerte, 2018). In the field of language teaching, Paulston et al. (1975) emphasised the growing popularity of role-playing games during the rise of the communicative approach, as educators sought to replace scripted dialogues with more spontaneous and student-initiated interaction.

The concept of improvisation also has deep historical roots. Montuori (2003) explains that the term "improvisation" originates from the Latin word "improvises," which means unexpected or, more precisely, an unexpected event. Von Walter et al. (1998, as cited in Holdhus et al., 2016) highlight that, since ancient Greece, improvisation has been recognised as a sophisticated rhetorical skill requiring extensive training. According to Holdhus et al. (2016), improvisation later evolved into an educational practice within drama-based learning, enabling students to create and act out scenarios for learning purposes rather than for performance.

Pantomime, another key technique, can be traced back to prehistoric times as a means of expressing curiosity through the imitation of natural phenomena and animals. As Zywiczynski (2016: 1) notes, the word itself translates as an "imitator of all/everything". Although their exact origin in education is unclear, Gardenfors and Hogberg (2017) argue that pantomime and demonstration have long been intertwined as intentional teaching forms. Hughes (2013) further notes that pantomime was already used as a form of teaching and entertainment in ancient Greece and Rome before gaining popularity in France and Italy.

The origins of tableaux as a dramatic method lie in nineteenth-century theatre and visual art, where static poses were used to represent moral and narrative scenes without the need for dialogue. As Foutch (2017) explains, tableaux originally served as a form of "living picture" in cultural and artistic contexts before educators began adopting the technique to teach observation, empathy, and interpretation. According to Carless (2009), tableaux can be described as a "picture-freeze that depicts a real-life/abstract situation of impending or resulting action" (p. 27). Over the twentieth century, particularly under the influence of the drama-in-education movement, tableaux transformed into a classroom method emphasising reflection and embodied understanding (Branscombe & Schneider, 2013).

The use of scripted plays in education has a similarly layered history. According to Flynn (2022), the integration of scripts into classrooms began in the late nineteenth and early twentieth centuries, when dramatisation was introduced to reinforce moral lessons and reading fluency. In the mid-twentieth century, this performative use of texts evolved as educators recognised drama's potential to foster creativity, collaboration, and language development. During the communicative revolution in language teaching in the 1970s, scripted performance gained new importance as a tool for integrating pronunciation, vocabulary, and pragmatic competence in a realistic setting (Maley & Duff, 1978).

These techniques have progressed from their origin and have come a long way, from their theatrical and artistic beginnings to now becoming a practical pedagogical tool. What once served to entertain or express ideas on stage is now used to help students communicate, imagine, and experience language in new ways. Each technique carries traces of its past, but together they show how drama has steadily found its place in education, not as performance, but as a way of learning through doing.

3. PEDAGOGICAL PRINCIPLES OF DRAMA TECHNIQUES

In this chapter, the focus shifts to the pedagogical application of drama techniques in language teaching. More specifically, it will explore the pedagogical goals these techniques serve, practical strategies for incorporating them into lessons, and the common barriers teachers encounter in practice.

Over the past two decades, numerous studies have examined the pedagogical goals of drama techniques. Although individual findings vary in emphasis, they consistently describe drama as a means of fostering a communicative, experiential, and emotionally engaging learning environment. The research generally agrees that such techniques help students use language in meaningful situations rather than rely on mechanical practice. For example, while Ustuk (2022) highlights how role-play can prompt learners to address real-world issues, other works (Gill, 2008; Kuzembayeva et al., 2023; Saglamel & Kayaoglu, 2013) associate drama more directly with communicative gains and reduced speaking anxiety. Together, these studies suggest that role-based activities can shift learners' attention from accuracy toward purposeful interaction. This aligns with earlier perspectives from Heathcote and Herbert (1985), who emphasise the role of character-taking in encouraging emotional and cognitive engagement, and Gervais (2006), who associates these activities with problem-solving. Kerekes and King (2010) similarly connect interactive dramatisation with collaborative learning. While each contribution highlights a different benefit, collectively they illustrate how drama can support personal, social, and linguistic development within ELT settings.

Additional techniques reveal similar pedagogical tendencies. Zondag (2021) argues that the spontaneous nature of improvisation can help learners respond more naturally in conversation and develop confidence. Meanwhile, Gardenfors and Hogberg (2017) describe pantomime as a method linking physical movement with cognitive processing, a perspective complemented by Korkut and Celik's (2021) observation that pantomime can support vocabulary learning. Tableaux, advocated by Branscombe & Schneider (2013), emphasise visualisation and collaboration. Viewed together, these studies show that although each technique foregrounds slightly different skills, they all encourage embodied, participatory learning.

Research into effective implementation consistently highlights several overlapping priorities: preparation, repetition, amusement, unpredictability, variety, flexibility, willingness and feedback. Although these principles are addressed separately, many function interdependently. For instance, preparation and structure help ensure purposeful practice, as teachers must plan objectives, structure, and materials that match learners' proficiency, comfort, and goals to ensure that drama activities are purposeful and well-managed (Belliveau & Kim, 2013; Peppler et al., 2023). Another important aspect is repetition, as it reinforces fluency and accuracy by allowing learners to internalise language patterns through frequent practice, which strengthens confidence and memory (Winston & Tandy, 1998; Mercer & Littleton, 2007). Incorporating amusement into lessons plays a crucial role, as it enhances motivation and engagement. Enjoyable activities sustain attention and foster a positive atmosphere (Bailin,

2011). Introducing unpredictability through improvisation and spontaneous interaction encourages creativity and critical thinking, keeping students actively involved (Stern, 1980; Hulse & Owens, 2017). The need for variety and flexibility, frequently highlighted across studies (Bellievau & Kim, 2013; Piazzoli, 2012), reflects the reality that drama must adapt to learner needs, interests, and classroom conditions. Respecting students' willingness to participate is equally crucial, as voluntary engagement fosters confidence, cooperation, and emotional safety (Heyward, 2010). Finally, feedback strengthens learning outcomes by helping both teacher and students reflect, refine, and build communicative competence over time (Peppler et al., 2023). Altogether, these interconnected principles demonstrate that the successful implementation of drama techniques relies not only on a single strategy but also on a teacher's ability to create an adaptable, inclusive, and engaging learning environment that nurtures both linguistic and personal growth.

When it comes to specific techniques and their successful implementation, we have found the following steps to be effective. According to Bessadet (2022), scripted plays should be implemented through three stages: text analysis, rehearsal and performance. Firstly, students should read and analyse the text with the teacher's guidance to clarify its meaning and language. Then, the teacher should supervise rehearsals, focusing on pronunciation, intonation, and body language. Finally, the teacher should lead reflective discussions after the performance to consolidate learning.

Improvisation, on the other hand, functions best when learners are given an open scenario rather than a fixed script. Breaute (2023) recommends presenting a situation or conflict and allowing students to build the dialogue spontaneously, encouraging authentic speech production and cooperative creativity. Both of these approaches focus on communication among learners, while improvisation emphasises fluency, and scripted plays emphasise accuracy.

Role-playing can be introduced in more guided ways by providing specific roles and communicative goals. As Ly (2024) suggests, teachers should pre-teach essential vocabulary, set the social context (e.g. a job interview or travel situation), and then allow students to interact freely within those parameters before concluding with peer or teacher feedback.

Tableaux, according to Carless (2009), are most effective as pre- and post-reading tasks, in which groups of students create frozen images representing a moment, idea, or emotion from a text. Following this, one extension technique involves the teacher or classmates "tapping in" individual students to animate their image by voicing thoughts or lines, thus moving it from stillness to interaction (Cremin & Roger, 2013). +

Finally, pantomime is particularly suitable for lower proficiency learners, where teachers should model gestures or actions to communicate meaning without speech, and have students replicate or interpret them, which is very helpful when introducing new vocabulary (Alipour & Molana, 2020).

Across the literature, recurring challenges relate primarily to resources, time, space, preparation, and classroom management. Royka (2002) stated that teachers often struggle with the materials needed for these activities and that teachers must understand the technique and its variations to use them effectively. This is also noted by Isyar and Akay (2007), who found that teachers without prior drama education struggled with these techniques and used them less frequently because they did not fully understand them. Another challenge that frequently occurs is classroom management (Angelianawati, 2019). Due to the constant movement and interaction these activities entail, learners tend to diminish classroom discipline, which means teachers must not only facilitate the lesson but also maintain order and discipline. Furthermore, it had been proven that teachers struggled to fit everything into the 45-minute window during a complete, structured lesson. Another barrier that arose was student anxiety about participating in these activities (Atas, 2015). However, later on, although students initially felt uncomfortable, they realised its value and started to enjoy them (Brash & Warnecke, 2009). This was also noted by McDonnell and O'Boyle (2021), who found that although participation from their learners began quite hesitantly, it gradually increased across a nine-lesson drama sequence.

To conclude, the effective use of drama in language teaching depends on more than simply applying techniques – it requires understanding their purpose, careful planning, and adaptation to classroom realities. When implemented thoughtfully, these methods create space for authentic communication, confidence building, and creativity. Despite the practical challenges teachers may face, the evidence shows that drama remains one of the most efficient ways to connect language with real human experience.

4. AFFECTIVE AND COGNITIVE OUTCOMES

In this chapter, we present empirical evidence demonstrating how drama techniques influence learners' affective domains, particularly their motivation, empathy, and anxiety reduction. Furthermore, the chapter will examine the

broader social and personal dimensions of drama-based learning, including its impact on collaboration, communication and individual growth.

The affective domain has long been recognised as central to successful language learning. According to Krashen's (1982) Affective Filter Hypothesis, learners acquire language more effectively when anxiety is low and motivation is high, as emotional barriers can impede the reception of meaningful input. Within this framework, drama-based techniques such as role-play and improvisation serve as anxiety-reducing strategies, easing learners' fear of public speaking (Aykac, 2011, in Sahin & Sen, 2023; Erbay & Sunay, 2010). Similarly, Kwiencien-Niedziela, Polok, and Mala (2020) found that regular engagement in drama-based activities correlates with lower levels of language anxiety and greater fluency, indicating that drama provides a psychologically safe context for experimenting with language. Although these studies examine different contexts, they converge on the notion that safety and confidence emerge as foundational to subsequent growth in communication.

Several studies have linked these affective gains to practices that address learners' physiological readiness. As part of preparing for drama-based lessons, students can engage in breathing or mindfulness activities. Gluck (2020) emphasises that drama can be effectively integrated with meditation and mindfulness exercises to amplify its stress-relieving effects. This was also demonstrated by Balban et al. (2023), who found that structured breathwork yields greater improvements in mood and a reduction in negative emotions, including state anxiety. Several studies highlight that movement, play, creativity, and mind-body connection support social-emotional development, help learners manage stress, enhance focus, and build resilience (Heath, Smith, and Young, 2017; Anari, Dadsetan, and Sedhpour, 2009). Gallwey (1976, as cited in Via, 1987) introduces the concept of "relaxed concentration" as a state that helps learners overcome anxieties associated with stage fright and classroom mistakes. Azrin & Nunn (1974) note that slow, deep breathing neutralises spastic breathing in anxiety and speech disfluency, fostering a natural flow. Together, these studies suggest that emotional and physiological regulation may reinforce one another; however, most research treats them individually, leaving the interaction between these strategies and broader language development insufficiently explored.

Beyond anxiety reduction, research also shows that drama stimulates intrinsic motivation and fosters emotional engagement. Luo et al. (2024) found that drama encourages students to take an active role in meaning-making, thereby increasing both enjoyment and sustained participation. Bessadet (2022) reported comparable findings, noting that the combination of verbal and non-verbal expression through performance led to heightened learner involvement and enthusiasm for learning English. When considered alongside the anxiety-focused studies above, these findings suggest a reciprocal relationship: students who feel psychologically secure are more willing to engage, and active engagement in turn further strengthens their confidence. However, as noted by Luo et al. (2024), few studies examine these emotional domains together, meaning the causal direction remains unclear.

Drama techniques also support the development of empathy and social awareness. According to Celume, Besancon and Zenasni (2020), sustained participation in drama-based activities enhances learners' socio-emotional competencies such as perspective-taking, emotional regulation, and cooperation. Likewise, Wirag (2024) observed that EFL students who engaged in process drama and improvisation activities exhibited increased empathy, openness, and self-confidence, all of which contributed to personal and interpersonal growth. These findings align with earlier work, which notes that embodied role-taking enables learners to explore alternative viewpoints, potentially deepening both emotional understanding and communicative expression. Vygotsky's (1978) Sociocultural Theory emphasises that effective learning occurs through social interaction, which is inherently embedded in drama. Hu and Shu (2025) describe drama education as a "collective creative process" in which students collaborate, co-create, and coordinate shared tasks. Through this group work, learners develop teamwork skills and strengthen their social understanding and emotional growth, which also supports the development of interpersonal communication. In addition, Gascon (2019) noted that drama techniques help create a "community practice" in which students develop mutual trust and interdependence through shared creative experiences. Similarly, Hu and Shu (2025) observed that collaborative dramatic tasks not only improve communicative competence but also cultivate group empathy and collective problem-solving, demonstrating that drama enhances linguistic performance and fosters social cohesion and emotional resilience within the classroom community. However, although these studies highlight advancements in empathy, they mainly depend on self-reports rather than actual behavioural or long–term data. This limitation has been frequently noted in reviews of drama in ELT, which advocate for systematic, long-term, and comparative empirical research, preferably using mixed methods (Belliveau & Kim, 2013; Luo et al., 2024).

The evidence clearly demonstrates that drama techniques go well beyond language development. They address emotional and social elements of learning by reducing fear, fostering empathy, and strengthening classroom relationships. These outcomes support each other: emotional safety promotes participation, and active involvement

further boosts confidence. However, most research examines these effects separately and relies on short-term self-report data, which restricts conclusions about their long-term influence. When used thoughtfully, drama encourages communication that is both personal and meaningful; nevertheless, future research should adopt more systematic and mixed-method approaches to better track how emotional and social gains evolve. Drama is proven to be more than a teaching method; it acts as a bridge between emotional understanding and linguistic growth, illustrating that language learning also involves learning to connect with others.

5. CONCLUSION

This review has examined how drama has developed from its theatrical roots into a powerful educational tool within language teaching. By analysing the historical origins, pedagogical uses, and emotional impacts of key techniques—pantomime, tableaux, role-play, improvisation, and scripted plays—it becomes evident that drama acts as a bridge between language practice and emotional understanding. These methods motivate learners to use language creatively and meaningfully, fostering confidence, empathy, and collaboration, while reducing anxiety and boosting motivation.

However, drama really works in the classroom when it is carefully planned, combined with flexibility and the teachers' sensitivity to the needs and feelings of the students. Applied thoughtfully, drama turns language learning into a vivid process in which communication, imagination, and reflection all interlink. It enables learners not only to speak another language but also to understand different perspectives, express themselves authentically, and connect with others on a deeper level. Ultimately, drama in ELT serves as a poignant reminder that learning a language is as much about forming genuine connections as it is about mastering words and grammar.

Taken together, these findings demonstrate that drama techniques have deep historical roots, adaptable pedagogical applications, and meaningful affective benefits in supporting communicative development. Most research, however, does not explore these dimensions in combination, leaving open questions about how emotional, cognitive, and linguistic gains might interact during the learning process. Longitudinal and mixed-method designs could help address these gaps and establish drama as a more established part of mainstream ELT.

Acknowledgements

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Learning from Glitr: A Case Study on Designing Educational Application for Early Childhood Education

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Abstract

This study examines the online platform Glitr, a Czech-developed tool that allows teachers to design educational applications. We aim to examine whether it is suitable for use in preschool education. In the era of mobile technologies and many educational applications, there is a growing need for suitable content creation tools that would help teachers create digital content suitable for a specific group of children. Using a qualitative case study, this research evaluated teachers' experiences with Glitr, as well as preschool children's engagement in the resulting activities. Five kindergarten teachers created digital educational tasks using Glitr, which were then tested by 25 preschool children aged 4–6. Mixed method was used to collect data, using assessment tool derived from different frameworks for evaluation of educational applications with written reflections, and observations. Data was then analyzed thematically and using descriptive statistics and Pearson correlation analysis. The results show that Glitr offers good usability and supports intuitive navigation and task creation. However, limitations were also identified in the area of interactivity and adaptive feedback for children. Correlation analysis showed that overall satisfaction was strongly correlated with the interaction process (r = 0.89), which highlights the importance of interface simplicity for teacher engagement. Observations of children demonstrated high initial motivation, especially for activities involving active exploration and movement, although some tasks were too repetitive for children. The research suggests areas for improving Glitter as a tool to make it more effective in pedagogical terms. In particular, by expanding feedback options, richer interactivity, and adaptive design elements. Future research should verify these findings with larger and more diverse samples. However, the research primarily points to the possibilities of using Glitter as a pedagogical diagnostic tool thanks to the possibility of statistically using the children's results that the game collects.

Keywords: education, application, digital, preschool, case study

1. INTRODUCTION

In recent years, the use of mobile technologies has increased significantly especially among young children. Tablets and smartphones have become a common part of households and are increasingly being used in educational institutions (Cordes, Egert & Hartig, 2023). There are currently tens of thousands of educational applications designed

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for preschool and early school-age children, promising to develop skills ranging from letter recognition to mathematical skills with the help of interactive and engaging digital experiences (Booton, Hodgkiss & Murphy, 2021). This creates an urgent need to provide parents and educators with reliable information about their effectiveness, appropriate use, and optimal design principles (Cordes, Egert & Hartig, 2023; Hirsh-Pasek et al., 2015). Users face difficult task of choosing from a plethora of applications that vary significantly in their educational quality. Many of these, while labeled *educational*, often lack scientifically based design principles or content appropriate to the developmental level of children (Papadakis et al., 2021; Taylor, Kolak, Norgate et al., 2022).

In addition to the wide range of ready-made educational applications, a new and promising trend has recently emerged – online platforms that allow teachers to create their own educational apps (Voštinár, 2018; Penz & Mäkiö, 2019). These tools give educators the opportunity to design interactive learning experiences tailored to the needs, age, and learning goals of their students, without the need for advanced programming skills (Sofi-Karim, Bali & Rached, 2023). Through this process, teachers ware able to experience a sense of empowerment, as they gain better control over the content, pacing, and pedagogical design of their lessons. Creating their own applications enhances their digital literacy but also strengthens their professional identity and confidence in integrating technology into teaching practice (Hsu & Ching, 2013).

1.1. Creating an Application

Among the available options are several platforms that allow users to create their own mobile applications, such as App Inventor (Hsu & Ching, 2013), Thunkable, AppsGeyser, AppyBuilder, or Infinity Monkeys (Voštinár, 2018). However, our study opted for the Czech-developed platform Glitr[1], as it is already fully functional and requires only the insertion of educational content rather than any programming. Glitr is an educational mobile application that provides users with access to pre-created content, didactic exercises, QR code-based escape games and outdoor escape games. The license includes access to an administration interface that allows users to create customized content – exercises, outdoor escape games and project days – without the need for programming skills.

This makes its interface intuitive and the overall use easier and more accessible, even for teachers with limited technical experience. Glitr offers a simple and user-friendly design that allows teachers to create interactive activities effectively and independently. By using Glitr, we try to find a balance between relying on already existing commercial applications and developing customized educational content that reflects pedagogical goals. This approach allows teachers to actively participate in the creation of digital content (Kara, Cömert & Samur, 2025).

1.2. Glitr Design Features

Glitr consists of two main parts – a game application and a management interface. The game itself is designed for tablets, mobile phones or other touch devices and is available through an application that users can download from the App Store[2]. On the other hand, the Manager interface is accessible only through a web browser and is used by creators to design games and enter educational content. It is in this interface that teachers and authors can create interactive activities, add multimedia materials and edit instructions or feedback for individual tasks without the need for programming experience.

In the Manager interface, creators are able to:
- Customize instructions and feedback for each task
- Add multimedia content, including images, videos, audio, or text
- Create sliding puzzles from images
- Add pop-ups
- Show players progress
- Invite players to take a photo
- Invite players to scan an in-game QR code
- Design matching tasks using drag-and-drop
- Create crossword activities

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[1] https://www.glitr.cz/
[2] https://play.google.com/store/apps/details?id=com.friendlystudio.glitr

- Develop custom sorting games
- Share activities online or integrate them into digital lessons

Glitr provides educators with the ability to choose the mechanisms for how tasks and games are scored, allowing for flexible adaptation to different pedagogical goals. Teachers can choose from two distinct scoring styles:

Time-Based Scoring: In this mode, a player is given a time penalty for each incorrect answer. This approach introduces a performance-based challenge that encourages accuracy within time limit. Point Scoring: Educators can also choose a traditional point system, where correct or incorrect answers either increase or decrease the player's score, depending on the settings. This system allows for adjustable reward or penalty and supports feedback strategies that can reinforce learning outcomes or promote adaptive challenge. These options illustrate Glitr's flexibility in task design, allowing teachers to tailor feedback and assessment to educational goals, student age, or desired motivation.

Glitr offers the ability to track and analyze player performance. When setting up games or tasks, each participant can be identified by either a unique name or a code that they enter at the beginning of each game. This allows for tracking their progress and results. In the platform's management interface, educators have access to detailed metrics, including:

- Each player's total score, which reflects the points or penalties accumulated during the course of a single game.
- Total game duration, which indicates how long it took a player to complete a single game.
- Task response times (from task entry to first response click), which allows for detailed analysis of how quickly participants respond to individual questions.

These features facilitate the systematic collection of data on player performance and offer insight into task interaction.
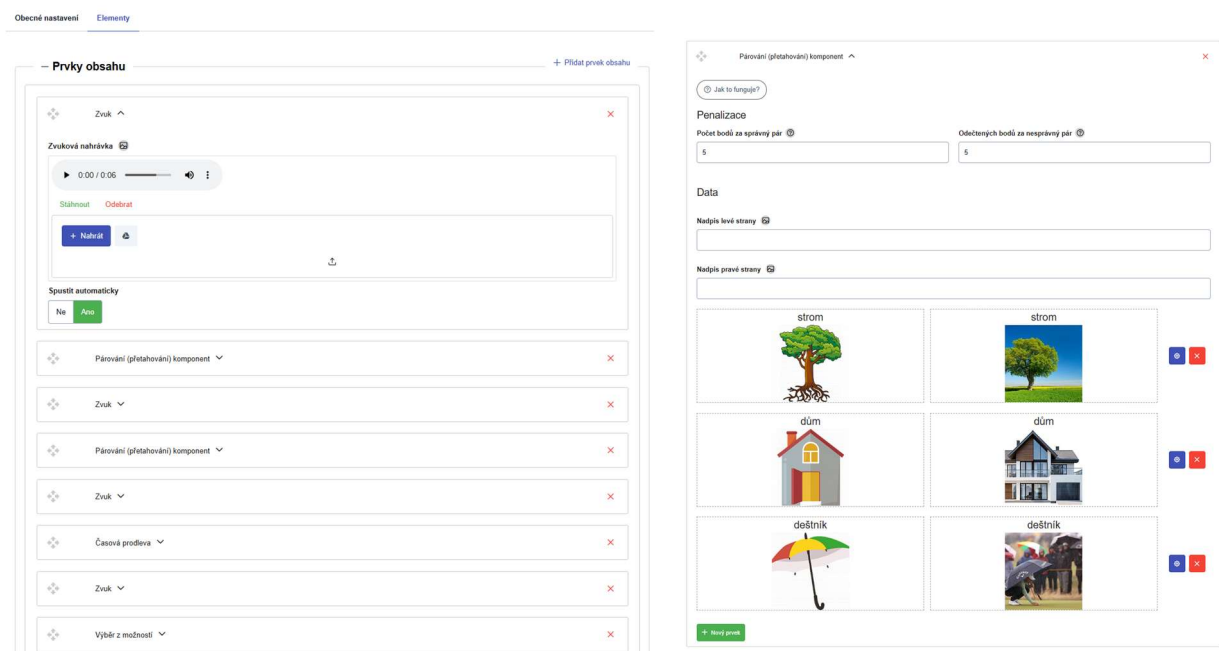

Fig. 1 Manager Interface (a) task line-up; (b) task designer

1.3. The Challenge of Application Assessment

Evaluating educational applications for preschool children presents specific challenges. The target population (children aged 3–6) represents a critical developmental period characterized by rapid cognitive, language, and socioemotional growth (Vasquez, 2019). Applications must be evaluated not only for content accuracy but also for their developmental appropriateness (Taylor, Kolak, Norgate et al., 2022). Testing should also include consideration of whether the content is appropriate and whether it supports appropriate behavior (Voloshyna et al., 2024). In research, we can find different types of evaluation frameworks focused on existing educational apps. Evaluation

methods focus on various aspects - the presence of learning objectives (Neumann et al., 2019; Taylor and Kolak et al., 2022), the quality of feedback (Vasquez, 2019), adjustable contact and levels (Taylor and Kolak et al., 2022), interactivity and social affordance (Ralph et al., 2020), design and functionality, in-app performance metrics (Tengku, Noor, Sahari et al., 2023), or psychometric properties of the assessment (Avralev, Efimova, and Makoveychuk, 2017; Milovanova et al., 2017). Below are summarized various frameworks for application assessment.

Table 1. Overview of applications evaluation tools

Assessment Framework	Coverage and Focus	Indicators
Neumann et al. (2019)	Combines educational features with psycholinguistic analysis	Interactivity, usability, cultural awareness, collaboration (parent, teachers, players), language content, learning outcomes (feedback, tests, meassurable outcomes)
Kolak et al. (2022)	Developmentally grounded tools for practitioners and researchers	Learning goal, feedback, adjustable content, social interaction, design features; screen elements, visual background, other interactions, feedback delivery, feedback content
REVEAC rubric (Papadakis et. al., 2021)	Focuses on educational design for preschool apps	Educational content, design, functionality, technical characteristics
Hirsh-Pasek (2015) four-pillar model	Developmental and play-based principles for app design	Active learning, engaged learning, meaningful content, social interactions
REAL Rubric for the Evaluation of Apps for Learning (Weber at al., 2024)	Practitioner-focused, validated rubric for instructional quality	Instructional design, evidence base, engagement, accessibility; psychometric validation reported
Rosell-Aguilar (2016)	Taxonomy and Framework for Evaluating	Language learning, pedagogy, user experience, technology

In this study, we focus on evaluating Glitr as a tool for creating educational applications for children, rather than the applications themselves. To achieve this goal, a synthesis and evaluation of criteria was conducted, drawing on a number of established evaluation frameworks and creating an assessment tool applicable to Glitr. These frameworks included contributions from Taylor et al., Kolak et al., REVEAC, Hirsh-Paseka, REAL, and Rosell-Aguilar. Although each of these frameworks offers relevant areas of evaluation, such as pedagogical effectiveness, interactive capabilities, feedback mechanisms, multimodal content integration, and overall usability, it is essential to note that their original conceptualization focused on evaluating completed software applications. The proposed framework keeps the important dimensions of educational design, user interaction, content flexibility, multimedia quality, feedback mechanisms, and technological aspects, but recasts them to assess the capabilities and potential of the tool itself, rather than the resulting application. Each criterion is rated on a three-point scale (2 = excellent, 1 = satisfactory, 0 = poor), allowing for a systematic, comparative assessment of different application tools while reflecting their pedagogical and technical capabilities. This approach ensures that the assessment is practical, comprehensive, and directly applicable to the improvement of the application. Final Assessment framework is presented in Appendix A.
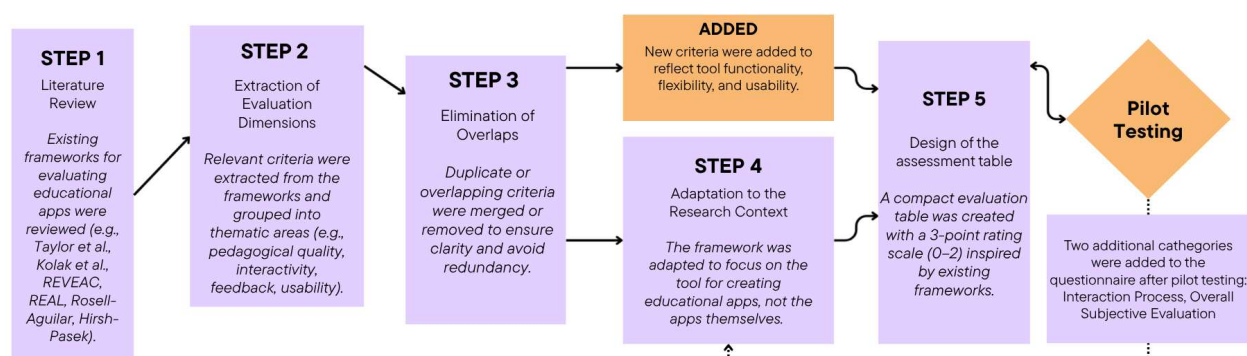

Fig. 2 Process of Developing the Assessment Framework

2. METHODOLOGY

The primary objective of this study was to assess whether the Glitr platform is a suitable tool for creating educational applications for preschool children. Specifically, the study seeks to determine whether it provides educators with an intuitive, meaningful, and technically sound environment for developing interactive educational activities. By examining teachers' experiences with designing tasks and engaging children in the resulting activities, the research aims to assess the usability and educational potential in the context of preschool education. A qualitative case study approach was used, focusing on usability testing and observation. The study examined both educators' experiences with using Glitr to create activities and children's interaction with the resulting tasks allowing formative evaluation for the educational design (Nieveen, 2013).

RQ1: How do teachers perceive the usability of the Glitr when designing activities for preschool children?

RQ2: What are the strengths and limitations of Glitr in terms of pedagogical aspects within early childhood education contexts?

RQ3: How do preschool children engage with activities created using Glitr in terms of motivation, task completion, and interaction?

RQ4: How are usability and interactivity related to educators' overall satisfaction and the perceived educational effectivity of Glitr?

The study involved two groups of participants: educators and preschool children (age 4 - 6 years old). Five kindergarten teachers participated in the study to test the Glitr application. They were responsible for creating educational activities using the Glitr application to examine their experiences with the tool. Additionally, 25 preschool children took part in testing, during which they engaged with the activities developed by the teachers to test them. The children's interactions provided insight into the usability and of the application from the learner's perspective.

2.1. Data Collection

An assessment framework was used to systematically collect feedback from teachers. Teachers were given a structured questionnaire including evaluation criteria (see Appendix A). In addition to selecting pre-defined response options, teachers were encouraged to write notes with their own reflections, examples and suggestions for improvement for each category. These written responses provided contextual insight into the perceived effectiveness and usability of Glitr.

To supplement the feedback from teachers, the researcher conducted observations of children interacting with activities created in Glitr. The observations focused on engagement with tasks, success in completing them and signs of difficulty or frustration, which provided a perspective on how children perceived the activities in the application environment. Field notes were taken to capture both quantitative indicators and qualitative observations (verbal or non-verbal expressions).

2.2. Data Analysis

Data were collected from teacher questionnaires and notes. The aim was to identify patterns, notes and recurring themes regarding usability, pedagogical potential and interactivity within the app. Observation data were used to triangulate findings, ensuring that insights into children's engagement and task completion complemented teachers' perspectives. This mixed approach allowed us to understand the strengths and weaknesses of the application, pointing out areas for future potential improvement. Qualitative data were analyzed thematically to identify patterns related to usability, engagement, and pedagogical potential. Quantitative questionnaire data were summarised using descriptive statistics to support the qualitative findings. We used Pearson's correlation coefficient (r) to explore potential relationships between categories. This method measures the strength and direction of linear associations between two variables. Correlation values were interpreted: 0.1–0.3 - weak correlation; 0.3–0.5 - moderate correlation; 0.5–1.0 - strong correlation.

3. RESULTS

3.1. Teacher Assessment

Category	Mean Score	SD
Pedagogical Flexibility	1.36	0.33

Interactivity & Social Aspects	0.30	0.14
Multimodal & Visual Quality	0.87	0.12
Usability & Interface	1.75	0.10
Feedback & Evaluation	1.00	0.53
Technological & Commercial Aspects	1.07	0.83
Interaction Process	1.75	0.10
Overall Subjective Evaluation	1.60	0.00

Table 2. Overview of Applications Evaluation Tools

Usability & Interface (1.75) and *Interaction Process* (1.75) received the highest scores, indicating that the application is intuitive, easy to navigate, and generally straightforward to use. Teachers confirmed in their comments, that Glitr is easy to learn and well-supported by instructional manuals and developer assistance. *Overall Subjective Evaluation* (1.60) shows high teacher satisfaction, reflecting the practical usability of the tool. Customization options allow teachers to design games with different themes and adapt content for their classrooms, while mobile features such as QR codes and tablet interaction enhance engagement.

Interactivity & Social Aspects (0.30) and *Multimodal & Visual Quality* (0.87) were rated lowest, highlighting limited interaction types and constrained multimedia support. Teachers noted that preschool children can only tap, cannot swipe, record their voice, or fully interact with videos. *Feedback & Evaluation* (1.00) is restricted; although teachers can track progress, the application does not automatically respond to incorrect answers or adapt feedback dynamically. *Pedagogical Flexibility* (1.36) depends heavily on teacher expertise, and certain functions, such as language learning activities or differentiated difficulty, are limited. *Technological & Commercial Aspects* (1.07) are generally satisfactory, but restrictions on export, multiplayer use, and occasional technical issues reduce overall effectiveness.

The Pearson correlation analysis reveals several meaningful relationships between the evaluation categories, offering insights into the usability and pedagogical potential of Glitr for preschool education.

Variable 1	Variable 2	Pearson r	Strength / Interpretation
Interaction Process	Overall Subjective Evaluation	0.89	Strong positive
Interactivity & Social Aspects	Technological & Commercial Aspects	0.76	Strong positive
Pedagogical Flexibility	Interactivity & Social Aspects	0.67	Moderate positive
Multimodal & Visual Quality	Feedback & Evaluation	0.56	Moderate positive
Pedagogical Flexibility	Usability & Interface	-0.65	Strong negative
Pedagogical Flexibility	Feedback & Evaluation	-0.68	Strong negative
Interactivity & Social Aspects	Overall Subjective Evaluation	0.56	Moderate positive
Interactivity & Social Aspects	Interaction Process	0.53	Moderate positive
Technological & Commercial Aspects	Overall Subjective Evaluation	0.50	Moderate positive
Technological & Commercial Aspects	Interaction Process	0.69	Strong positive

Table 3. Pearson Correlation Analysis

Interaction Process strongly predicts overall satisfaction. The correlation between *Interaction Process and Overall Subjective Evaluation* is **r = 0.89**, indicating that teachers who experienced intuitive, smooth navigation and task creation rated the application more positively overall. This highlights the critical importance of an easy-to-use interface in educational tools in preschool contexts.

Interactivity and technical aspects are positively linked. *Interactivity & Social Aspects* correlates strongly with *Technological & Commercial Aspects* (**r = 0.76**). Teachers who valued interactive features also appreciated the platform's technical support and licensing model, suggesting that perceived technical reliability enhances the educational value of interactive functions.

Pedagogical flexibility shows moderate positive associations with interactivity. *Pedagogical Flexibility and Interactivity & Social Aspects correlate moderately* (**r = 0.67**), implying that teachers who can create richer, more flexible learning content also tend to engage more with interactive features. This suggests a connection between content design and user engagement.

Multimodal quality supports feedback. A moderate positive correlation exists between *Multimodal & Visual Quality and Feedback & Evaluation* (**r = 0.56**), indicating that richer multimedia options are associated with better possibilities for monitoring and providing feedback on children's responses.

Negative correlations highlight potential tensions. *Pedagogical Flexibility correlates negatively with Usability & Interface* (**r = -0.65**) and *Feedback & Evaluation* (**r = -0.68**). This may reflect that teachers who attempt to use all pedagogical features perceive certain interface limitations or evaluation constraints more acutely, pointing to areas where the tool could be improved.

3.2. Children's Interaction with Application

Qualitative data were analyzed thematically to identify patterns related to usability, engagement, and pedagogical potential. Five cathegories were derived from the data: Engagement, Task Performance, Usability Challenges and Motivation, with an additional category focusing on Pedagogical Potential to capture the educational value of children's interactions.

Engagement: the level of attention, enthusiasm and participation of children during activities. Observations included visible signs of concentration (eye contact with the screen, verbal responses or gestures) and sustained interest throughout the lesson. Overall, most children showed higher level of engagement in the early stages of the activities, with their attention tending to lower during repetitive or less interactive tasks.

Task completion: how independently and accurately children were able to complete the tasks. Most children were able to complete basic tasks such as clicking or tapping without difficulty, but more complex tasks – particularly those involving drag-and-drop functions – required teacher support initially. This was mainly due to the work with images and the more complex system of moving them around.

Usability issues: this section covered any design or technical difficulties observed during use. Common issues included accidental screen scrolling, unintended image selection, and overlapping audio recordings when multiple audio files were activated simultaneously (due to incorrect settings by the teacher when composing the task). In addition, the drag-and-drop feature was identified as problematic due to the small size of the images and the need for manual resizing, which hindered smooth interaction for younger children.

Motivation captured children's emotional responses to different types of activities. These included signs of joy, curiosity, or frustration. The level of motivation was highly dependent on the type of the tasks. While repeated clicking eventually led to a decrease in interest, children showed strong enthusiasm for activities that allowed them to interact with their surroundings, such as taking pictures or scanning QR codes, which required them to carry the tablet around the classroom and search the classroom space.

Pedagogical potential: observations focused on how well the tasks aligned with learning objectives, how they encouraged problem-solving, and how they supported multimodal engagement. Most activities successfully promoted visual recognition and basic language skills, although some – such as the logic puzzle game – were too complex for the preschool age group (the mode of moving the pieces depended on higher-order combinatorics skills, which preschoolers were not yet mature enough to handle).

4. DISCUSSION AND CONCLUSSION

RQ1: How do teachers perceive the usability of Glitr when designing activities for preschoolers? Educators reported that using Glitr is generally positive, mostly described as user-friendly and well-structured, allowing teachers to create digital education activities. The high average scores in Usability and Interface (M = 1.75) and Interaction Process (M = 1.75) indicate that the platform design effectively supports users, who have limited technical skills. Teachers appreciated easy navigation, clear task editor, and the available documentation, support from the developers, and tutorials. However, they also found small issues with the consistency of the layout and configuration of tasks, mostly from technical standpoint.

RQ2: What are possible strengths and weaknesses of Glitr in terms of pedagogical aspects in the context of preschool education? From a pedagogical perspective, the main strength of Glitr is flexibility and adaptability to different learning objectives and goals. Teachers appreciated that they could adapt activities to their topics and incorporate local or thematic content. The mean score of pedagogical flexibility (M = 1.36) indicates satisfactory support for instructions. However, several problems were identified. Glitr has feedback uniform for all users with limited option for adaptation, limited social interaction features, and insufficient differentiation of task complexity. These issues correspond to lower ratings in the categories Feedback and Assessment (M = 1.00) and Interactivity and Social Aspects (M = 0.30). As a result, although Glitter supports creative and individualized lesson design, its pedagogical potential is limited. Mostly by the absence of dynamic feedback mechanisms and cooperative learning opportunities.

RQ3: How do preschoolers engage with activities created with Glitr in terms of motivation, task completion, and interaction? Observational data revealed children's initial engagement, particularly with tasks that included tangible or exploratory elements (e.g., scanning QR codes or taking pictures) Thematic analysis identified five categories—Engagement, Task Completion, Usability Challenges, Motivation, and Pedagogical Potential. Most children completed simple tasks independently, although tasks involving dragging and manipulation with images required teacher assistance. Engagement decreased during repetitive clicking activities but increased when movement, discovery, or problem-solving were encouraged. It was found that not all activities offered by Glitr are appropriate for preschoolers.

RQ4: How are usability and interactivity related to teachers' overall satisfaction and perceived educational effectiveness of Glitr? Correlation analysis revealed a strong positive relationship between the interaction process and overall subjective rating ($r = 0.89$), suggesting that smooth task creation and intuitive interface design were key predictors of teacher satisfaction. Similarly, interactivity and social aspects were positively correlated with technological and commercial aspects ($r = 0.76$) and overall rating ($r = 0.56$), suggesting that technical reliability increases perceived educational quality. In contrast, pedagogical flexibility was negatively correlated with usability and interface ($r = –0.65$). Overall, the data suggest that usability and interactivity are central factors influencing educator satisfaction, and that balancing pedagogical depth with technical simplicity remains a critical design challenge.

This study examined the pedagogical potential, and user experience of the Glitr platform as a tool that could be used by teachers for creating educational applications in early childhood contexts. A human-centered design is crucial in development of an educational tool (Penz & Mäkiö, 2019). Findings indicate that Glitr offers an accessible and intuitive environment that empowers teachers to design digital learning activities without programming expertise (Oktavia et al., 2024; Sofi-Karim, Bali & Rached, 2023).

At the same time, several pedagogical and technical limitations were identified. Restricted interactivity types, limited adaptive feedback, and lower possibility for support of collaborative or multimodal activities reduce the depth of learning experience. Observations with children demonstrated strong engagement and motivation when tasks encouraged exploration and physical activity, highlighting the importance of designing age-appropriate, playful, and interactive content (Dimas et al., 2024)

5. LIMITATIONS AND FUTURE RESEARCH

The study was conducted on a small sample of teachers and children from a single preschool context, which limits the generalizability of the results. The evaluation relied primarily on qualitative methods and self-reported data from educators. This methodology may have conlcuded in subjective bias of the participants (Lefebvre et al., 2016). Future research should aim to include a larger and more diverse data samples. Longitudinal studies could explore how repeated use of Glitr influences children's cognitive and digital literacy development over time.

However, the comprehensive analytics capabilities of Glitr provide educators with a valuable tool for diagnostic assessment and evaluation in early learning contexts (Seaton et al., 2018). By tracking individual player performance (total scores, response times, and overall task completion duration) teachers can gain objective insights into each child's learning progress and their specific difficulties. Such data-driven feedback enables the identification of patterns in performance that may not be apparent through observation alone, helping to develop informed pedagogical decisions (Arnab et al., 2015). Consequently, Glitr serves not only as a platform for creating playful educational tasks but also as a practical instrument for evaluating learning outcomes and refining task design, allowing developers and educators to iteratively improve the educational effectiveness of the activities.

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Appendix A. Assessment Framework

Category	Criteria	2 – Excellent	1 – Satisfactory	0 – Poor
Pedagogical Flexibility	Learning goal definition	Tool allows clear definition, structuring, and linking of multiple goals for different age groups	Goals can be defined, but linking and structure are limited	Cannot define clear learning goals
	Support for meaningful learning	Tool allows creation of activities with real-life relevance for children	Activities are partially meaningful but not always connected to real-life context	Activities are purely mechanical, without context
	Problem-solving / reasoning activities	Easy creation of tasks that develop logical thinking, creativity, and problem-solving	Limited possibility to create challenging tasks	Tool allows only simple mechanical activities
	Differentiation / adaptive content	Automatic and manual adaptation based on child performance	Only manual difficulty settings	No possibility to adjust difficulty
	Language learning activities (Rosell-Aguilar)	Supports reading, writing, listening, speaking, vocabulary, grammar, pronunciation, and cultural content	Some language skills can be created, others limited	Tool does not support language learning activities
Interactivity & Social Aspects	Types of interaction	Tap, swipe, drag, trace, and voice activities can all be created	Only some types of interaction are possible	Very limited interaction options
	Social interaction	Easy insertion of characters/avatars that react to the child	Characters can be inserted, but reactions are limited	Cannot insert characters or social interactions
	Opportunities for exploration	Users can create open, non-linear activities	Limited freedom for exploration	Only linear structure possible
Multimodal & Visual Quality	Images, animation, video, sound	Full support for multimedia with high quality	Limited multimedia support	Minimal or no multimedia support
	Storyline / narrative support	Can create a coherent story linking activities	Partial support for storyline	Cannot create a storyline
	Media types	All media are supported	Some media are supported	very limited types of media are supported
Usability & Interface	Interface and navigation	Intuitive, clear, and consistent	Sometimes unclear controls, minor inconsistencies	Confusing and complex interface
	Instructions and help	Clear instructions with guidance and tutorials	Limited instructions	No instructions
	Stability & offline functionality	Stable and works offline	Occasional crashes or requires connection	Frequent crashes, requires constant connection

|				
	Gamification	Supports creation of game-like elements for motivation	Limited gamification support	Cannot create gamified activities
Feedback & Evaluation	Simulation of child response	Can simulate correct/incorrect answers and show impact of activities	Limited simulation	Tool does not allow simulations
	Support for evaluation	Tool allows tracking progress and activity quality	Partial evaluation possible	Cannot evaluate activities
Technological & Commercial Aspects	Licensing and cost	Clear, free creation options, flexible licensing	Limited license, partially paid features	Expensive, limited creation options
	Ads / distracting elements	No disruptive ads, clean environment	Some distracting ads	Ads significantly disrupt creation
	Sharing / export	Allows export of app and sharing of results	Limited export options	Cannot export or share
	Platform support	Multi-platform, compatible	Limited platform support	Single platform only, not transferable
Interaction Process	Navigation intuitiveness	Teachers can easily navigate between all functions, find features without guidance	Teachers can navigate most functions but occasionally need help	Teachers find navigation confusing and require frequent guidance
	Task creation workflow	The process of creating tasks and games is smooth, logical, and efficient	Task creation workflow is partially clear but includes some unnecessary steps	Workflow is confusing, inefficient, or illogical
	Learnability	Teachers can quickly learn to use new features without instruction	Teachers need some time or minor instructions to understand new features	Teachers struggle to understand features even with instructions
	Error recovery	Teachers can easily correct mistakes or undo actions	Limited options to fix errors, partially intuitive	No clear way to recover from mistakes
Overall Subjective Evaluation	Satisfaction	Teachers are highly satisfied with the tool and its overall experience	Teachers are moderately satisfied but note some frustrations	Teachers are dissatisfied or find the tool frustrating
	Ease of use	Overall, the application feels intuitive, simple, and accessible	Some features are easy, but others require effort or guidance	Application feels complex, cumbersome, or unintuitive
	Likelihood of future use	Teachers would readily use Glitr in their lessons and recommend it to colleagues	Teachers might use Glitr occasionally or with support	Teachers are unlikely to use or recommend Glitr

Appendix B. Glitr – User Environment
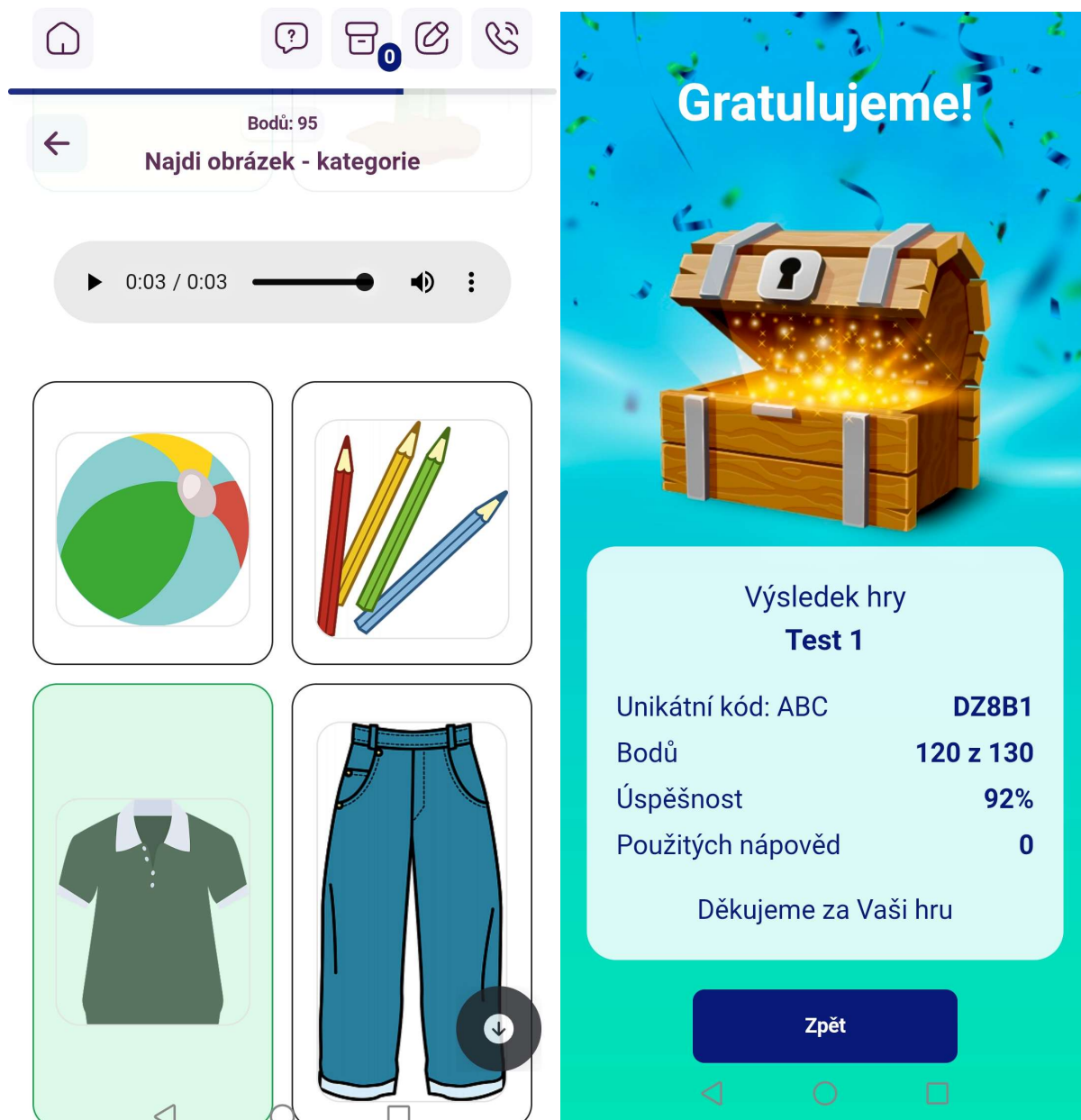
Fig. 3 (a) game task; (b) feedback screen

The Use of Online Applications in Teaching English as a Foreign Language

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Abstract

The use of online applications in the process of learning English as a foreign language is getting more popular among people these days. Therefore, using web-based applications can make the teaching process more attractive for learners. This study explores the advantages and disadvantages of several mobile and web-based applications through a content analysis, grounded in theoretical knowledge about language acquisition, teaching methodology, learning styles, and digital learning frameworks. The analysis focuses on six applications: Duolingo, Babbel, Memrise, WocaBee, ELSA Speak, and Rosetta Stone. Each application was assessed on its methodological foundation, supported language skills, accessibility, user-friendliness, and suitability for different types of learners. Additionally, the study includes recommended EFL classroom activities that can be implemented in the teaching process. Pedagogical elements included in all applications, such as gamification, communicative language teaching (CLT), artificial intelligence (AI), and mobile-assisted language learning (MALL), show the trends in education today. The results suggest that integrating online language learning software into traditional EFL teaching can significantly improve the teaching and learning processes. However, teachers must carefully select and customize such technological tools based on learning objectives, methods, skill levels, and individual learner profiles to get the most benefits and mitigate their drawbacks.

Keywords: EFL, online applications, web-based platforms, language acquisition, classroom activities,

1. INTRODUCTION

The rise of technology has influenced the way foreign languages are taught and learned. Mobile applications and web-based platforms have become common tools in the educational process, providing students with interactive, convenient, and personalized ways to study languages. English, as one of the most frequently taught and used languages, has notably benefited from these technological developments. Nevertheless, despite their widespread adoption, teachers continue to discuss concerns about the actual effectiveness, practicality, and educational value of these digital solutions. Clearly understanding the strengths and weaknesses of such applications helps teachers and students in making informed choices about their usage.

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English as a Foreign Language (EFL) has been greatly influenced by the proliferation of online applications that provide learners with opportunities for flexible, self-paced, and often gamified engagement with the language. Mobile and web-based language learning platforms have attracted millions of users worldwide and have become an integral part of the modern language-learning landscape (Loewen et al., 2019; Vesselinov & Grego, 2012; Kassim et al., 2024; Okyay & Zengin, 2025). Yet, the advantages and disadvantages of these platforms and their use in English classrooms have not been studied in detail.

Our study aimed to examine the positive and negative features of six language-learning applications: Duolingo, Babbel, Memrise, WocaBee, ELSA Speak, and Rosetta Stone. These applications were analyzed according to several criteria, including supported teaching methods, targeted language skills, suitability for various learning styles (according to the VARK model), incorporation of technological aspects (such as gamification and artificial intelligence), and overall ease of use.

Technological advancement has a significant influence on teaching and learning (Apoko et. al., 2023; Rouabhia & Kheder, 2024). Modernization and development of methods, tools, and technologies in the educational process represent ongoing pedagogical challenges. Educators are increasingly required to integrate innovative technologies into their instructional practices while ensuring the preservation of pedagogical effectiveness. Moreover, the continuous evolution of digital tools necessitates sustained professional development and adaptability among both teachers and learners.

1.1. Theoretical background

Traditional education generally uses outdated learning methods such as note-taking, textbook reading, lectures, memorizing facts, writing tests, and exams. Modern education is open to new ideas and techniques, discovering possibilities for making education more practical, engaging, interesting, interactive, and talkative. Thus, it emboldens students' unique characteristics and adapts to their needs. To be able to give more space to the rise of new methods and the use of modern technologies in teaching, it is necessary to analyze partial theoretical assumptions regarding the teaching process and methodology based on communicative competencies (language skills), teaching methods, introducing the role of technologies, and learning styles. By analyzing these theoretical parts, we can synthesize solutions, advantages, and disadvantages in the form of specific applications for different needs in the teaching process.

The integration of online applications into English as a Foreign Language (EFL) instruction must be understood within the broader traditions of language pedagogy, theories of learner differences, and the emergence of technology-enhanced learning.

1.2. Teaching Methods in EFL

Language teaching methodologies have undergone significant transformations over the past century. Early approaches such as the Grammar-Translation Method (GTM) emphasized written translation, memorization of vocabulary, and explicit grammar rules (Richards & Rodgers, 2014). While effective for developing reading skills, GTM often neglects oral communication, limiting learners' ability to function in real-world contexts.

The Audiolingual Method (ALM) emerged in the mid-20th century, grounded in behaviorist psychology. It relied on pattern drills, repetition, and habit formation, aiming to develop automatic responses in learners (Larsen-Freeman & Anderson, 2011). Though successful in fostering accuracy in controlled environments, it didn't provide opportunities for creative or authentic communication.

By the late 20th century, the emphasis shifted toward Communicative Language Teaching (CLT), which sought to develop learners' ability to communicate meaningfully. CLT prioritizes fluency over accuracy and situates learning in authentic, real-world contexts (Harmer, 2007). Task-Based Language Teaching (TBLT) further operationalized this principle by centering instruction around meaningful tasks, encouraging learners to use language as a tool for problem-solving and goal achievement (Ellis, 2024). Similarly, Competency-Based Language Teaching (CBLT) emphasizes the mastery of practical skills aligned with communicative competence (Richards & Rodgers, 2014). Richards and Rodgers (2014) also explain that Content-Based Instruction (CBI) integrates language learning with other content, which means that language is used for specific purposes. They describe the use, repetition, and recognition of lexical units or chunks within the teaching/learning process as the basis of the Lexical Approach (LA). Gamification has emerged as a transformative and innovative strategy in ELT, addressing the limitations of traditional approaches in engaging technically skilled learners. It integrates game elements like points, badges, and leaderboards into learning

to enhance student engagement (Bodyk & Karnoza, 2024). This approach plays an important role when talking about online applications in EFL classrooms, and it targets all language skills.

Online applications often blend these methods. For instance, Duolingo incorporates repetition and translation exercises reminiscent of GTM and ALM, while Babbel integrates structured dialogues in line with CLT. Memrise, with its vocabulary focus, aligns with LA, whereas WocaBee facilitates classroom-based task assignments that echo TBLT. Thus, understanding methodological roots provides insight into the pedagogical orientation of each application.

1.3. The role of technology

The world has witnessed a rapid development of technology, which is now part of everyday life. The spread of knowledge has been made easier and more convenient by the development of technology, which has transformed everything from laptop computers to mobile phones. Learning and teaching a foreign language through the adoption of mobile technology creates a new learning space for teachers and learners.

M-learning (Mobile Learning) is defined as any type of learning that takes place wirelessly via devices such as smartphones, PDAs (Personal Digital Assistant), and tablet PCs (Personal Computers). These gadgets may go with the learners, allowing them to learn anytime, anywhere. Computers were already prominent enough in this changing environment, either through personal use in dedicated classrooms or as devices for educational needs such as dyslexia. But smartphones and tablets have become prominent too, with consequences that school personnel are still tackling. Therefore, it was necessary to establish TELL (Technology-Enhanced Language Learning), which contains subcategories such as MALL (Mobile-Assisted Language Learning), CALL (Computer-Assisted Language Learning), and WELL (Web-Enhanced Language Learning) as complex approaches to the topic of alternative online learning (Bredo, 2023; Hidalgo, 2020).

MALL can be highly flexible and customizable in terms of using mobile devices as a significant help. For example, mobile devices can track learners' paths and help them focus on the materials and activities that meet their needs. Mobile technology can be an economically effective alternative to traditional educational approaches. It is not necessary to buy physical paper to be fully involved in the teaching process. Multimedia materials and mobile devices such as phones and tablets may often be bought at affordable prices.

Although CALL is not a new phenomenon, it has gained popularity in language education due to the growth of new technological paradigms like e-learning and virtual learning environments. Since CALL encompasses a wide range of activities, it is challenging to characterize it as a single concept of a straightforward research agenda. CALL has expanded to include instructional methods, pedagogical theories, technology, and materials design concerns. Materials specifically designed for language learning, as well as those that modify preexisting computer-based, video, and other resources, can be used for CALL. The traditional reading and listening foci of CALL have been expanded to include writing and speaking activities using multimedia and speech recognition technologies. As technology advances, the function of each of these abilities in CALL keeps evolving.

WELL refers to the integration of web-based resources into formal curricula, supporting blended learning environments (Levy & Stockwell, 2006). WELL was created to describe the use of the Internet as a teaching tool. The teaching method of web-based learning is thought to be more interactive than that of paper-based learning. It is a type of CALL that seeks to increase public awareness of the use of the web in school language instruction. Of the eight tools examined, the web-based tool was still thought to be the most beneficial for improving students' individual competency and teaching preparedness.

Collectively, these approaches form part of the broader field of TELL, which highlights the interplay between pedagogy and digital innovation. Importantly, these frameworks stress that technology is not inherently effective; rather, its success depends on how well it is integrated with pedagogical objectives and learner needs.

2. RESEARCH METHODOLOGY

2.1. Research objective and questions

The main research objective was to find out what are the advantages and disadvantages of using online applications in English language learning, and how these applications meet the needs of different learners and educators.

The research questions were formulated as follows:

1. What are the advantages and disadvantages of online applications from the learners' perspective?
2. What are the advantages and disadvantages of online applications from the teachers' perspective?

3. Which activities from the online applications can be used in the EFL classroom?

The questions were approached through several analytical lenses, including:
1. language skills (receptive: reading and listening; productive: writing and speaking),
2. teaching methods and approaches (CLT, GTM, TBLT, ALM, LA, CBLT, etc.)
3. learning styles (based on the VARK model),
4. integration of digital tools and AI (CALL, MALL),
5. gamification and user-friendliness from both learners' and teachers' perspectives.

2.2. Research methods

This study employed a qualitative research method, using content analysis as the primary methodological approach. Content analysis was chosen because it allows for the systematic examination of educational tools and materials to identify patterns, strengths, and limitations. Unlike experimental or survey-based studies, which focus on measuring learners' outcomes, content analysis is particularly appropriate for investigating the pedagogical underpinnings and design principles of online applications. Comparative analysis was used as a secondary methodological approach to highlight the specific strengths and weaknesses of the chosen applications in relation to various EFL contexts.

2.3. Data sources

The study draws on three primary sources of data:
1. Academic literature: Research in EFL teaching and learning methods, learning styles, language skills, and digital learning provided theoretical frameworks for evaluating the applications.
2. Official documentation: Each application's website, user guides, and promotional materials were analyzed to understand intended pedagogical strategies, supported skills, and design features.
3. Personal testing: Limited hands-on testing of the applications was conducted to experience the user interface, interactivity, and adaptability firsthand, to provide practical insights into usability and engagement.
Triangulating these data sources enhanced the validity of the analysis, ensuring that conclusions were not based solely on one perspective.

2.4. Limitations of the methodology

Several limitations must be acknowledged. First, the research did not include large-scale empirical testing with actual learners, which restricts the ability to draw conclusions about learning outcomes. Second, the rapidly evolving nature of online applications means that features may change after analysis, reducing the long-term applicability of findings. Finally, personal testing was limited in scope, providing only an initial experiential perspective rather than exhaustive coverage.

Despite these limitations, the chosen methodology provides a solid foundation for evaluating the pedagogical potential of widely used applications, offering insights relevant to teachers, learners, and language application creators.

2.5. Sampling strategy and sample

The selected applications – Duolingo, Babbel, Memrise, WocaBee, ELSA Speak, and Rosetta Stone – were chosen according to specific evaluation criteria: popularity and user base, support for various learning styles, balance of language skills, adaptability for classroom or self-study use, and pedagogical foundation. Each application was also linked with a recommended activity tailored to EFL teaching contexts, aiming to show its practical potential in real-life instruction. The applications were chosen because of their widespread global use and established reputation. Applications representing different methodological orientations (e.g., gamification, translation, pronunciation-focused) were selected to allow for comparative analysis. Together, they provide a representative sample of current trends in mobile- and web-based language learning.

3. RESULTS AND DISCUSSION

3.1. Analysis and comparison of online applications

Duolingo is among the most widely recognized language-learning applications worldwide. According to statistics on businessofapps.com, it has had 950 million downloads. It adopts a freemium model, offering free access supported by advertisements alongside a premium subscription version. Pedagogically, Duolingo relies heavily on gamification. Features such as streak counts, leaderboards, badges, and hearts for errors are designed to maintain learner motivation. Its methodology combines elements of GTM, LA, ALM, CLT, and TBLT through translation tasks, pattern drills, and repetition, while also incorporating communicative elements such as short dialogues. It uses AI-based repetition techniques, allowing students to acquire language by repeating patterns and vocabulary.

Advantages: multiple-platform accessibility (iOS, Android); offers a completely free version with no time limits; optional Super Duolingo version with no ads and offline learning; dynamic learning environment appealing to users of all ages and proficiency levels; activities cover different language skills across lessons (reading, writing, speaking, and listening); flexible learning activities (translating exercises, transcriptions); user-friendly interface – simple and intuitive design for easy navigation and appealing graphical look; AI voice recognition that helps students hear the correct answer (partially accurate); personalized review exercises for learner weaknesses; discussion forums for interaction with other learners or friends; suitable for beginners or intermediate learners; suitable for visual, auditory, and reading/writing learners; and accessibility of all materials at any time.

Disadvantages: no differentiation between American/British English; no offline access in the free version; repetitive question patterns multiple times can reduce engagement; lack of in-depth grammatical explanations; Slovak language not available as app-instruction language for beginners (only Czech); inconsistent speech detection (inability to recognize distinct accents); lessons mostly rely on translations; many phrases are unnatural or not commonly used in real life situations; and not ideal for advanced learners.

Babbel is a subscription-based platform that emphasizes structured, linguist-designed lessons. It is an interactive MALL and CALL application using a more traditional form of teaching compared to Duolingo. While Duolingo implements gamified components in the learning process, Babbel sticks with the approach using a simplified appearance of lessons. The application has had 16 million subscriptions since its launch in 2007, and offers around 15 languages, including beginner, intermediate, and advanced levels. It allows students to choose from various courses with different topics like family, food and drinks, sports, jobs, weather, and more. These topics differ from level to level, sometimes revising improved versions of older topics (Babbel, 2007). Babbel uses gamification, GTM, CBI, CLT, CBLT, LA, and TBLT methods and approaches, and provides effective and systematic courses for different levels of proficiency, focusing on everyday communication. Learners can attend classes with teachers and a small number of students in real-time, online. This provides an all-around method to language learning (Alisoy and Sadiqzade, 2024). Apart from teaching language, the application introduces users to the culture of the country whose language one is learning.

Advantages: multiple-platform accessibility (iOS, Android); targets both receptive and productive language skills; adapts courses to the learner's level of knowledge and progress; supports cross-device synchronization so learners can continue where they left off from anywhere on various platforms; simple appearance of lessons; includes grammar explanations in lessons; lessons can be downloaded for learning without an internet connection; uses interactive teaching aids such as flashcards; offers pronunciation exercises; suitable for visual, auditory and reading/writing learners.

Disadvantages: no differentiation between American and British English; Slovak and Czech language not available as a language of instruction; only the first 8 courses are free of charge; subscription cost may present barriers for some users; the AI sometimes struggles to accurately detect pronunciation; less engaging for younger learners; lack of gamified elements; more academic, can be boring and slow for some learners.

Memrise is an online MALL and CALL application for enhancing and strengthening vocabulary. It was launched in 2010 and now has over 70 million registered users. It targets ALM, LA, CLT, CBI, TBLT, and gamification methods and approaches. To make learning faster, Memrise uses flashcards, images, audio, and videos of native speakers, interactive recall exercises, and repetition techniques for vocabulary practice (Nushi and Eqbali, 2017). Its pedagogical orientation strongly supports visual and auditory learners by integrating images, sound, and video, while gamified recall tasks engage kinesthetic learners. It covers more than 20 languages, including varieties of languages (Memrise, 2010). Subhan et al. (2024) stated in their research that 60% of student respondents strongly agreed that

Memrise helped them master their vocabulary. Thus, we can say that Memrise is an online application that can be used in the teaching process to improve and practice vocabulary.

Advantages: multiple-platform accessibility (iOS, Android); differentiation and recognition of American and British English; real-life pronunciations from native speakers in video and audio recordings; supports listening, writing and speaking skills; simple and intuitive interface; adjusts difficulty based on the learner's progress; works well for visual and auditory learners; possible corrections on demand (practice with AI).

Disadvantages: no Slovak and Czech language of instruction; focus mainly on vocabulary; limited grammar coverage; teaching words without always explaining their usage; could be perceived as monotonous by advanced learners; limited free version; offline mode only for premium users; advertisements within the application could be disruptive for some learners; lack of proactive supported correction.

WocaBee is a Slovak-developed application designed primarily for classroom integration. It enables teachers to create vocabulary lists, assign tasks, and track student progress. The application is subscription-based, typically purchased by schools or institutions. It is a CALL and partially MALL online application that exploits ALM, LA, CLT, TBLT, and gamification methods and approaches. This application works on artificial intelligence that individualizes each learner's pace. Recently, it has promoted a new upgrade called BeeTalk, with the help of which learners can practice their speaking skills using an AI speech recognition tool. It is available in multiple European countries and offers 13 languages.

Advantages: no installation is needed, it is primarily available via laptop, mobile phone, computer, etc.; the language of instruction can be Slavic languages like Slovak, Czech, Ukrainian, and Polish; using vocabulary directly from student textbooks; a real teacher is communicating with the application and learners; teacher can customize lessons according to class needs; allows individual tracking of learners' progress; audio support for pronunciation; uses repetition technique; suitable for beginners to advanced learners; avoids excessive gamification and advertisements; suitable for visual and auditory learners; keeps learners engaged and reduces the workload for teachers.

Disadvantages: after the limited free trial version (one month), schools need to purchase licenses, which could be a financial consideration and may not be affordable for all schools; primarily focused on vocabulary acquisition, which may not suffice for comprehensive language learning needs; dependency and requirement of the internet access; limited grammar instruction; does not offer real-life speaking or interactive dialogues; lack of comprehensive skill development; limited utility for independent learners – designed mainly for classrooms (requires teacher setup); may become repetitive for some learners; no discussion forum or peer interaction; some teachers can struggle with the technical setup.

ELSA Speak (English Language Speech Assistant) is an application that focuses exclusively on pronunciation training. It employs artificial intelligence and speech recognition technology to provide learners with real-time, personalized feedback on their pronunciation accuracy. It uses GTM, CLT, TBLT, and gamification methods and approaches. This MALL and CALL technology, launched in 2015, involves students actively in the learning process, encouraging them to learn English skills in a meaningful and functional manner to achieve academic success. They can provide their own opinions freely and ask questions regarding the subject matters in question, hence making the experience effective and participatory (Karim et al, 2023; ELSA Speak, 2015). Its methodology reflects audiolingual principles through repetitive pronunciation drills but is enhanced by AI-based adaptability. It is particularly valuable for learners seeking to improve intelligibility and reduce accent interference.

Advantages: available for Android and iOS; differentiation and recognition of various English accents; AI-powered pronunciation analysis provides real-time detailed feedback; adapts to individual needs of learners; focus on speaking skills acquisition; a wide range of topics of daily conversations; detailed error feedback; immediate suggestions and corrections of pronunciation and grammar; offers progress tracking and daily streaks to monitor improvement; some lessons can be accessed offline; simple and intuitive interface; engaging for various age groups; ideal for independent learners; perfect for speaking fluency development; suitable for intermediate and advanced learners; provides new vocabulary explanations; can improve confidence in speaking; suitable for auditory learners.

Disadvantages: free version has restricted access and the premium subscription is required for full functionality, which can be overly expensive; AI may not always provide human-like feedback or understand specific context pronunciation; focus mainly on pronunciation, not on grammar or reading and writing skills; struggles to detect strong pronunciation accents; previous knowledge of a foreign language is required; not recommended for beginners; most features require a strong internet connection; repetitive exercises may become boring over time; learners with almost native speaker fluency may find the AI feedback rather useless; can be too sensitive or inaccurate with pronunciation.

Rosetta Stone, launched in 2003, is one of the earliest commercial digital platforms for language learning, based on a full-immersion approach, which means that it uses zero translation, helping to acquire the language naturally. It is a unique CALL and MALL application that presents learners with pictures, sounds, and words without translation, encouraging them to infer meaning through association (Kurniawan et al., 2021). The pedagogical approach aligns with NLA principles, seeking to replicate first-language learning environments. It uses its own speech recognition technology TruAccent. According to Rosetta Stone's webpage, this technology operates with data from millions of native speakers to analyze pronunciation. It is the only speech recognition device that provides customizable settings for children. Moreover, Rosetta Stone supports more than 25 languages, making it accessible for various language acquisitions (Rosetta Stone, 2003).

Advantages: available for Android and iOS – cross-platform compatibility; suitable for beginners; learners can download lessons and learn offline anytime, anywhere; lessons are built on previous knowledge; simple interface which is easy to follow; certain content free of charge; improves spelling, pronunciation, listening, and speaking; recommended for visual, auditory and partially for reading/writing learners.

Disadvantages: no differentiation between American and British English; lacks high-level or academic vocabulary and complex language structures; not ideal for advanced and some intermediate learners; minimal grammar explanations; does not improve writing skills; some learners may find lessons slow and repetitive; users cannot skip courses or modify lessons.

Table 1. A comparison of online applications

Feature / Application	Duolingo	Babbel	Memrise	WocaBee	ELSA Speak	Rosetta Stone
Type	Freemium app, gamified	Subscription, MALL, CALL application	MALL, CALL application, gamified	Classroom-focused, teacher-led, CALL, partially MALL	Pronunciation-focused, AI-based, MALL, CALL	Immersive, CALL, MALL
Languages offered	40+	15	20+	13	13, focus on English	25+
Pedagogy and methods	GTM, LA, ALM, CLT, TBLT, gamification	GTM, CBI, CLT, CBLT, LA, TBLT, gamification	ALM, LA, CLT, CBI, TBLT, gamification	ALM, LA, CLT, TBLT, gamification	GTM, CLT, TBLT, gamification	NLA, full-immersion, associative learning
Key features	Streaks, leaderboards, AI repetition techniques, multi-skills, easy interface	Structured, linguist-designed lessons, multi-skill, grammar explanations, live classes	Visual & audio focus, native speaker recordings, multi-skill	Vocabulary lists, AI speech recognition, teacher interaction	AI pronunciation, real-time feedback, various topics	Pictures, sounds, full immersion, TruAccent technology
Advantages	Free version, iOS, Android, engaging, personalized review, flexible learning, AI voice recognition, user-friendly interface	iOS, Android, cross-device synchronization, simple appearance, grammar explanations, cultural insights, pronunciation exercises, offline use	iOS, Android, native-like pronunciation, visual & auditory, adapts to progress	Textbook based, no installation, teacher tracking, classroom-ready	iOS, Android, accurate AI feedback, pronunciation focus, various accents, advanced learners, offline access	iOS, Android, cross-platform compatibility, Offline version, easy to use, suitable for beginners
Disadvantages	No British/American English differentiation, repetitive, limited grammar, no offline access in the free version, inconsistent speech detection,	No British/American English differentiation, only 8 courses free, less gamification, can be slow	Limited grammar, focus on vocabulary, monotony for advanced learners, limited free version, offline for premium users	Limited free trial, repetitive, focused on vocabulary, limited grammar, no real-time dialogues, costs	Premium needed, accuracy issues, focus mainly on pronunciation	No British/American English differentiation, repetitive, limited advanced content

unnatural
phrases

3.2. Recommended activities for EFL teaching and learning

Duolingo is primarily a self-study language learning tool. After a thorough analysis, we concluded that Duolingo is the most available application of all the studied applications. Their advertisement and notification system is one of the main sources of motivating learners to complete the lessons and keep them up daily. Despite being a highly engaging and gamified user-friendly application, it does not help to learn the language in depth. One of the recommended cross-curricular activities could be the creation of songs, rhymes, or chants after completing a few Duolingo lessons using acquired words or phrases. This activity can work for beginners and could be a fun activity for intermediate learners to create a relaxed atmosphere in the classroom. Thus, it is better to implement it as group work or project work to support the creativity and confidence of individuals within the team. While this activity focuses mainly on practicing learned vocabulary and phrases, learners can also have fun acting it out and performing it. Finally, Duolingo can be favorable for the teacher as a captivating home assignment tool, too.

Using **Babbel** can significantly enhance the development of language skills in English. The proposed activities offer enhancement of active communication, peer collaboration, creativeness making English language acquisition highly effective. For improving intermediate and advanced learners' speaking skills, we can suggest modified dialogue role-play practice where learners in pairs must select a random dialogue lesson from the app (shopping, travelling, etc.) and rewrite parts of the dialogue – changing location, characters, or gist. At the end, they perform their modified versions. It embraces teamwork, interaction, and the creativity of each learner. Another recommendation for intermediate and advanced learners could be a "find a grammar mistake" game. After completing a grammar lesson in Babbel (e.g., pronouns, tenses, sentence structures), learners create a set of sentences containing intentional grammar mistakes. Other learners must find the mistakes and correct them with an explanation. This application is truly beneficial for self-study purposes. It gives special emphasis and puts interactivity at the forefront while still maintaining logical progression. Besides that, Babbel is suitable for deeper self-study purposes, including grammar, speaking, listening, and writing practice.

Memrise is a highly effective tool for beginners and some intermediate learners. Recommended activities aim to improve learners' vocabulary, memorization, writing, and partially listening and speaking skills. By integrating Memrise into the classroom, teachers can provide learners with flexibility while maintaining the interactive nature of traditional classroom methods. However, it serves great as a self-study application and a helpful tool for homework assignments. For beginners, but also for intermediate learners, we could recommend more activities like storytelling, some homework for them like listening to new words, watching movie clips, completing scenario assignments, etc. For both beginners and intermediate learners, we can suggest a vocabulary team-run activity. Learners must divide into two, three, or more teams with three or more people in each team. Next, they open the app (one mobile device per team is enough) and the teacher selects the vocabulary set they want to cover, for example, greetings, ordering in the restaurant, where each learner in the team has 30 seconds to learn and memorize as many words as possible. After each learner's time limit has elapsed for the whole period, the teacher starts the run. Individuals of the team go to the blackboard and write one word of the given set. The part of the blackboard is not visible to the opponents, and they exchange until the teacher ends the run. The activity's aim is to learn as much vocabulary as possible in a short time. Another activity could be a visual dictionary, where learners select five to ten or more new words from given Memrise exercises (scenarios, videos, vocabulary practice). Their task is to combine photos, collages, or personal drawings representing each word. This activity embraces learners' creativity, cross-curricular learning, and supporting individual presenting skills.

WocaBee is a great application for the school environment. Typical activities using WocaBee are quizzes, listening and writing exercises, a speed race where learners should translate as fast as possible using a timer, and an everyday vocabulary kit, where learners get vocabulary practice every day. There is an option for teachers to create their personalized vocabulary competitions for learners or to be a part of a competition that their colleagues or other teachers prepared. This is an impressive opportunity to support other teachers' work or give the learners a chance to play games with their peers. Therefore, it gives an option to boost the teacher's creativity and gives them enough space to adapt homework and vocabulary practice. One interesting activity for kinesthetic learners could be an exercise in which the

teacher assigns a word or several words in the application, and learners must find the objects and upload the picture into the application. That could be an engaging game or activity to apply the Total Physical Response method within the teaching process.

ELSA Speak is a great application for self-study, offering personalized AI-driven feedback to help learners improve their English pronunciation and speaking skills. Thus, it can be integrated into classroom activities to enhance pronunciation and speaking fluency. Even though it can be challenging for beginners or those with very little or zero knowledge of English, for intermediate and advanced learners, ELSA Speak becomes a powerful tool. One effective activity for intermediate learners could be pronunciation/speaking analysis with peer feedback. In this activity, learners complete given exercises and then read aloud while peers or the teacher provide them with feedback on their pronunciation. The exercises can be done in the classroom or at home before reviewing them. Keeping a personal glossary can also be beneficial as a long-term classroom activity. Learners track difficult words and phrases identified by the application and then present their progress. This activity can also work for advanced learners. In conclusion, ELSA can be an enriching home-practice tool where you can create your own personal role-plays and conversations. Teachers can take great advantage of it, because it can help them with the workload and speaking proficiency of their students daily.

Rosetta Stone is recognized as a self-study tool for language learners, being a superior long-term solution for learners who want to acquire language outside the classroom, without textbooks. Nevertheless, it is also a powerful resource for classroom learning. Teachers can integrate the application to reinforce vocabulary, pronunciation, and sentence structure, allowing students to practice both in the classroom and at home. For beginners, we can recommend picture-word association, descriptions of pictures, simple role-plays, interactive pronunciation drills, and descriptions using movement activities. A truly effective technique for beginners is picture-word association, where learners match words to images, reinforcing their understanding of basic vocabulary in context without any direct translation. In a classroom setting, students can use Rosetta Stone individually or as a homework assignment. Since the entire application is based on this technique, it can help the teacher with the workload and make the lessons more engaging. The second utilization could be describing pictures. The entire application includes pictures as a part of each lesson, so teachers can use them as encouragement for learners to construct sentences, fostering sentence formation skills. Teachers can select flashcard images from the application exercises and ask students to describe them in full sentences, moving from basic to more complex ones. Simple role-plays can be used after using Rosetta Stone as a home practice tool to acquire new vocabulary. For example, after finishing the lessons about shopping and greetings, it allows learners to create small real-world scenarios. This exercise can improve their pronunciation, creativity, and boost their confidence in speaking. Describing pictures or listening comprehension using movement, also known as Total Physical Response, enhances comprehension by linking physical movement to verbal instructions, making language acquisition more dynamic and memorable. Teachers can display the application pronunciation or picture exercises and have learners physically act out commands or describe the picture, such as "Jump", "Sit down", "Eat", "Drink", or "Point to the window", or if the learners see a picture of children reading, they take their books and pretend to read, etc. Furthermore, interactive pronunciation drills, where students repeat words using the Rosetta Stone's speech recognition tool. A possible activity could involve practicing minimal pairs such as ship/sheep, and woman/women, using the app's feedback clarity. These activities, when they are integrated effectively with Rosetta Stone's immersive learning platform, provide EFL learners with meaningful opportunities to practice and internalize language skills. By combining the application's digital lessons with classroom reinforcement exercises, learners can experience a more comprehensive and engaging language learning process.

4. CONCLUSION

By conducting an extensive content analysis, it was discovered that applications such as Duolingo and Babbel are superior in developing basic language skills like vocabulary learning, listening, and reading comprehension using interactive and game-based learning platforms. But these kinds of applications do not handle more sophisticated speaking and writing skills. These apps, like ELSA Speak, are designed to tackle pronunciation and speaking skills directly with cutting-edge AI technology and are therefore particularly helpful for intermediate to advanced students, but not necessarily for total beginners.

Memrise and Rosetta Stone use repetition and immersion, respectively, each blending new methods into language learning. Memrise's strengths are maintaining vocabulary through multimedia content, whereas Rosetta Stone's

complete immersion technique makes language learning a natural experience without translation. Despite being very effective, both are deficient in full language learning, specifically writing practice and grammatical explanation.

WocaBee is an effective tool for learning, especially suited for formal classroom incorporation, due to its adaptability to satisfy learners' individualized needs and align with specific curriculum goals. Its potential is to some extent diminished by its use of teacher-driven instruction and classrooms, limiting its use as a tool for individual learners.

In all the applications, pedagogical elements such as gamification, communicative language teaching (CLT), artificial intelligence (AI), and mobile-assisted language learning (MALL) show the trends in education today. These elements enhance learner motivation, provide personalized learning experiences, and greatly increase accessibility and flexibility for learners.

These results suggest that integrating online language learning software into traditional EFL teaching can significantly improve the teaching and learning processes. However, teachers must carefully select and customize such technological tools based on some learning objectives, methods, skill levels, and individual learner profiles to get the most benefits and mitigate their drawbacks. Besides that, they are not meant to replace teachers but to enrich the learning experience.

In the future, this analysis could serve as an inspiration for teachers and as a basis for expanding this topic and researching other publicly available applications. Also, it may answer the question in the future of whether these applications could be our future in the teaching process, and to what extent they are integrable in current school settings.

Acknowledgements

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Metacognitive Predictors of Teacher Self-Efficacy

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Abstract

The aim of the study was to examine the extent to which metacognitive factors predict the self-efficacy of future teachers (N = 127). The Slovak version of the OSTES scale (Gavora, 2011) was used to assess teacher self-efficacy. Metacognition was assessed using the Metacognition Awareness Inventory (MAI) (Schraw, Dennison, 1994). Hierarchical multiple regression analysis was used to analyze the data. Model 1 included variables from the area of "Knowledge of cognition," which explained 19% of the variability in teacher self-efficacy (R^2 = .19, p < .001). However, Model 1 showed that none of the three components of knowledge of cognition was statistically significant on its own. After adding variables from the area of "Regulation of cognition", the explained variability of the model increased significantly to 43% (ΔR^2 = 0.24, p < 0.001). Two aspects of regulation of cognition were significant positive predictors of teachers' self-efficacy: planning (β = 0.24, p = 0.018) and monitoring comprehension (β = 0.29, p = 0.004). These findings suggest that the regulation of cognition has a stronger influence on teacher self-efficacy than knowledge about cognition.

Keywords: teacher self-efficacy, metacognition, future teachers

1. INTRODUCTION

1.1. Metacognition

Metacognition is generally defined as "thinking about thinking," i.e., an individual's ability to reflect on and regulate their own cognitive processes (Flavell, 1979). When measuring metacognition, we will draw on the theoretical division of metacognition into two areas: knowledge of cognition and regulation of cognition. This structure of metacognition is widely accepted in metacognitive research (e.g., Veenman, van Hout-Wolters, & Afflerbach, 2006; Efklides, 2008; Karably, & Zabrucky, 2009).

According to Schraw & Dennison (1994), the first area includes declarative knowledge (what I know), procedural knowledge (how I do it), and conditional knowledge (when and why to use a strategy), and the second area includes several subprocesses that facilitate the control aspect of learning. The individual sub-areas that fall within these two areas of metacognitive abilities will be described in more detail below in the description of the measurement tool (MAI) used in the research.

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Metacognition is important in the teaching profession in the planning, implementation, and evaluation of the educational process, when teachers reflect on their cognitive processes. Only in this way can the educational process be productive and deliver the desired results.

1.2. Teacher self-efficacy

The term self-efficacy was introduced by Albert Bandura (1997) and refers to an individual's belief in their ability to achieve the desired performance in specific situations ("I can do it"). In the teaching context, it refers to a teacher's belief that they can positively influence student learning, manage classroom challenges, and adapt teaching strategies (Tschannen-Moran, & Woolfolk Hoy, 2001; Poulou, 2007; Mojavezi, & Tamiz, 2012). This is a perspective that differs from theoretical models of teacher competencies and objectively assessed teacher characteristics. This theory emphasizes the role of self-efficacy beliefs, which determine the subjective assessment of what an individual believes they can and cannot do.

According to Bandura (1997), four sources – mastery experiences, vicarious experiences, social persuasion, physiological and emotional states enter into the process of forming self-efficacy.

Dvorská (2020) describes the phases that occur simultaneously in the formation of teacher self-efficacy:

- To complete the task, it is necessary to analyze the requirements that are essential for completing the task. The teacher considers what will be needed to complete the task and what opportunities and pitfalls may arise when performing the task;

- Along with the analysis of requirements, an attribution analysis of the teacher's previous experience is also carried out, i.e., a reflection on previous educational activities;

- In addition, the teacher assesses personal and situational resources and limitations.

Through these three phases, the teacher gains confidence in their potential to solve a particular pedagogical task. This conviction represents the degree of their teacher self-efficacy. This is followed by the specific solution of the pedagogical task, which brings with it certain consequences that are the subject of feedback. Feedback influences and shapes the degree of the teacher self-efficacy (Dvorská, 2020).

Teacher self-efficacy is an important indicator of professional engagement, innovation in teaching, and resilience to stress. Previous research on self-efficacy has supported the thesis that assessing a person's self-efficacy in a specific activity is a good predictor of performance in that activity (Bandura 1997; Savia, 2008; Cheng, & Chiou, 2010). Research confirms the influence of teacher self-efficacy not only on the performance of the teacher themselves, but also on the performance of their students, because teachers with a high level of teacher self-efficacy believe in their abilities in educational activities to such an extent that they have no problem setting higher goals, are tenacious and motivated for the activity. They demonstrate a higher level of planning and organization, apply more demanding work practices, but at the same time are able to adapt these elements to the abilities and skills of their students (Mojavezi, & Tamiz, 2012; Künsting, Neuber, & Lipowsky, 2016; Shahzad, & Naureen, 2017). Teacher self-efficacy also shows a positive correlation with factors that influence teachers' psychological well-being, including personal achievements, job satisfaction, and commitment to remain in the profession (Wang, Hall, & Rahimi, 2015; van Rooij, Fokkens-Bruinsma, & Goedhart, 2019). Conversely, teachers with low levels of teacher self-efficacy have reduced levels of motivation, quickly lose energy and effort when overcoming obstacles, quickly succumb to stress and exhaustion, and associate their work with negative emotions (Zee, de Jong, & Koomen, 2016; Skaalvik, & Skaalvik, 2017; Ghasemzadeh, Nemati, & Fathi, 2019).

1.3. Relationship of metacognition and teacher self-efficacy

Empirical research points to a positive correlation between metacognition and teacher self-efficacy. For example, Bars, & Oral (2017) conducted research on 1,475 future teachers, which showed that metacognitive awareness is a significant predictor of teacher self-efficacy. Further research among teachers of English as a foreign language in China and Hong Kong confirmed that metacognition acts as a mediator between teacher self-efficacy and work engagement. The authors state that these findings underscore the importance of fostering self-efficacy and grit, alongside enhancing metacognitive practices, to bolster teacher engagement (Zhou, & Hou, 2025).

Cera, Mancini, & Antonietti (2013) present a study that confirmed the correlation between high levels of self-efficacy and high levels of metacognitive abilities. This relationship helps to strengthen self-confidence in

performing tasks, as only one of these abilities is not sufficient to achieve adequate performance. A high level of self-efficacy stimulates students to persevere and motivates them to achieve their planned goals even in the face of obstacles, leading them to make strategic use of all their abilities, which are encompassed by their metacognitive abilities. Prat-Sala, & Redford (2010) describe how metacognitive processes stimulate the cognitive side of teachers, while their teaching self-efficacy regulates motivational processes.

Based on their study, Wibowo, Sihaloho, & Rahayu (2018) conclude that teachers who demonstrate good abilities have a higher level of teacher self-efficacy and are more successful in monitoring and implementing their goals using metacognitive skills in their educational activities. This enables them to confidently face tasks and difficulties in the educational process and to realize their own abilities. Arianto, & Hanif (2024) also state that metacognition and teacher self-efficacy have a positive influence on each other. Teacher self-efficacy is the basis of motivation and self-actualization. Zhang, & Tsui (2025) emphasize the importance of promoting self-efficacy along with improving metacognitive processes in order to strengthen teachers' work engagement. Metacognitive strategies are tools that aid in education by encouraging teachers to ask questions and engage in systematic internal dialogue. These strategies increase teacher self-efficacy in completing learning tasks and provide confidence in one's abilities. Similarly, according to Aurah (2013), metacognitive strategies can help teachers identify areas that need to be addressed and plan specific steps for improvement, thereby promoting the growth of teacher self-efficacy. This can increase teachers' motivation to use and develop metacognitive strategies, as their implementation in the educational process will be successful and bring positive results. We can thus see a positive relationship between these two psychological constructs, which influence each other. Together, they support teachers in their professional growth, improve their teaching skills, and positively influence the educational process of students.

2. RESEARCH METHOD

2.1. Research design and instruments

The aim of the study was to examine the extent to which metacognitive factors predict the self-efficacy of future teachers. The following eight metacognitive factors were tested as potential predictors of teacher self-efficacy: declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, comprehension monitoring, debugging strategies and evaluation. Hierarchical multiple regression analysis in two steps was used to verify the predictors of teacher self-efficacy.

The data collection was conducted between February and March 2025 in print form among students of pre-school and elementary pedagogy. Two research instruments were administered:

Teacher self-efficacy was assessed by Slovak version of The Ohio State Teacher Efficacy Scale (OSTES), and to measure metacognition we used Metacognition Awareness Inventory (MAI) – it was an author's translation followed by basic reliability verification (Cronbach-α for individual dimensions - see Table 1 in the results section).

Slovak adaptation of The Ohio State Teacher Efficacy Scale (OSTES)

The Ohio State Teacher Efficacy Scale (OSTES) (Tschannen-Moran, & Woolfolk Hoy, 2001), the instrument to measure teacher self-efficacy was translated into Slovak version by Gavora (2011). Good reliability of the instrument was found - Cronbach's alpha coefficient was 0.94. The scale is unidimensional and consists of 24 items. The questions focus on what the teacher (or preservice teacher) is able to do in a given situation. For example, „What are you able to do to help students better understand the curriculum?", or „How much can you do to get children to follow classroom rules?" Respondents select an answer on a 9-point scale, ranging from 1 = „nothing at all" to 9 = „very much". The higher the score on the questionnaire, the better the respondent's teacher self-efficacy.

Metacognition Awareness Inventory (MAI)

The authors of the Metacognition Awareness Inventory (MAI) are Schraw and Dennison (1994). The MAI covers two areas of metacognition: knowledge about cognition (3 subscales) and regulation of cognition (5 subscales). Respondents rate 52 items on a scale from 5 to 1, where 5 = completely true for me, 3 = I don't know, and 1 = completely untrue for me. Schraw and Dennison (1994) describe the individual subscales as follows:

Knowledge about cognition:

  1. Declarative knowledge (8 items):

- The factual knowledge the learner needs before being able to process or use critical thinking related to the topic;

- Knowing *about, what, or that;*

- Knowledge of one's skills, intellectual resources, and abilities as a learner;

- Students can obtain knowledge through presentations, demonstrations, discussions.

2. Procedural knowledge (4 items):

- The application of knowledge for the purposes of completing a procedure or process;

- Knowledge about *how* to implement learning procedures (e.g., strategies);

- Requires students know the process as well as when to apply process in various situations;

- Students can obtain knowledge through discovery, cooperative learning, and problem solving.

3. Conditional knowledge (5 items):

- The determination under what circumstances specific processes or skills should transfer;

- Knowledge about *when* and *why* to use learning procedures;

- Application of declarative and procedural knowledge with certain conditions presented;

- Students can obtain knowledge through simulation.

Regulation of cognition:
1. Planning (7 items):

- Planning, goal setting, and allocating resources *prior* to learning.

2. Information management strategies (10 items):

- Skills and strategy sequences used to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing).

3. Comprehension monitoring (7 items):

- Assessment of one's learning or strategy use.

4. Debugging strategies (5 items):

- Strategies to correct comprehension and performance errors.

5. Evaluation (6 items):

- Analysis of performance and strategy effectiveness after a learning episode.

2.2. Research sample

The research sample consisted of 127 second-year students studying preschool and primary education. The average age of the students was 20.8 years (range 19.09 – 22.5). Among the participants, there were 123 women (96.9 %) and 4 men (3.1 %).

2.3. Ethic statement

The aims and objectives of the research were explained to the students. Written informed consent was obtained from all participants involved in the study.

3. RESULTS

The data was processed using the SPSS 25 statistic program. The descriptive characteristics of the examined variables are shown in Table 1.

Table 1. Descriptive analysis of the examined variables (N = 127)

	AM	Median	SD	Min	Max	α
Teacher self-efficacy	7.16	7.45	0.89	4.42	8.96	0.88
Declarative knowledge	3.94	4.00	0.49	2.13	5.00	0.80
Procedural knowledge	3.55	3.50	0.61	2.00	5.00	0.77
Conditional knowledge	3.76	3.80	0.48	2.60	5.00	0.78
Planning	3.77	3.71	1.81	0.86	3.86	0.80
Information management strategies	3.96	4.00	0.50	2.60	4.90	0.85
Comprehension monitoring	3.51	3.43	0.96	2.00	4.86	0.86
Debugging strategies	4.08	4.20	0.57	1.80	5.00	0.78
Evaluation	3.61	3.67	0.63	1.67	4.83	0.75
Knowledge about cognition	3.79	3.82	0.44	2.29	5.00	0.90
Regulation of cognition	3.76	3.80	0.48	2.23	4.71	0.93

Note: AM = arithmetic mean, SD = standard deviation, Min = minimal value, Max = maximal value, α = Cronbach´s alpha

Correlation analysis of the mutual relationships between the monitored metacognitive factors and teacher self-efficacy in teachers in undergraduate training pointed to a significant positive correlation between teacher self-efficacy and all metacognitive factors ($p < .01$) except for two factors: conditional knowledge and evaluation.

Table 2. Correlations between teacher self-efficacy (TSE) and metacognition

	1	2	3	4	5	6	7	8	9	10	11
1. TSE	-										
2. Declarative knowledge	.370**	-									
3. Procedural knowledge	.245**	.504**	-								
4. Conditional knowledge	.161	.589**	.641**	-							
5. Planning	.523**	.517**	.484**	.477**	-						
6. Information management strategies	.326**	.631**	.606**	.578**	.590**	-					

7. Comprehension monitoring	.554**	.560**	.554**	.545**	.662**	.668**	-			
8. Debugging strategies	.360**	.516**	.499**	.543**	.415**	.666**	.525**	-		
9. Evaluation	.122	.423**	.407**	.442**	.591**	.659**	.658**	.525**	-	
10. Knowledge about cognition	.324**	.843**	.817**	.851**	.586**	.721**	.671**	.613**	.501**	-
11. Regulation of cognition	.421**	.664**	.645**	.634**	.787**	.891**	.837**	.741**	.823**	.770**	-

The aim of the regression analysis was to determine which aspects of metacognition significantly contribute to the prediction of teacher self-efficacy in students – future teachers.

The predictors were divided into two groups:

1. knowledge about cognition (declarative knowledge, procedural knowledge, conditional knowledge);

2. regulation of cognition (planning, information management strategies, comprehension monitoring, debugging strategies, evaluation).

Hierarchical multiple linear regression was performed to compare the relative contribution of both groups of variables to teacher self-efficacy. In the first step (Model 1), only factors from the knowledge about cognition group were included in the model; in the second step (Model 2), factors from the regulation of cognition group were also added.

The first model examined the influence of three factors of knowledge about cognition on teacher self-efficacy. The model was statistically significant ($F_{(3,123)} = 18.354$, $p < .001$) and explained 19% of the variability in the dependent variable ($R^2 = 0.19$). However, as Table 3 shows, none of the three components of knowledge about cognition emerged as a significant predictor.

In the second step of the analysis, factors from the area of regulation of cognition were added to the model. The expanded model was statistically significant ($F_{(8,118)} = 26.094$, $p < .001$) and explained 43% of the variability in teacher self-efficacy ($R^2 = 0.43$), which was a significant improvement over the first model ($\Delta R^2 = 0.24$, $p < .001$).

Table 3 shows that two variables variable achieved statistical significance – *planning (β = 0.24, p = .018)* and *comprehension monitoring (β = 0.29, p = .004)*. Both variables have positive beta coefficients, which means that higher levels of these variables are associated with higher levels of teacher self-efficacy.

In terms of model diagnostics, multicollinearity analysis confirmed that all VIF values were below 3, which means that there is no excessive linear relationship between the predictors. The assumptions of normality of residuals and homogeneity of variance (homoscedasticity) were met ($p > .05$). The model can therefore be considered statistically stable and interpretable.

Table 3. Results of hierarchical regression for predicting teacher self-efficacy

Variable	β (standard.)	SE	t	p	95 % CI for β	VIF
Model 1 (R^2 = .19, $F_{(3,123)}$ = 18.354, p < .001)						
Declarative knowledge	.112	.085	1.32	.191	[-.057, .279]	1.45
Procedural knowledge	.098	.089	1.10	.273	[-.078, .274]	1.56
Conditional knowledge	.125	.081	1.55	.125	[-.035, .286]	1.69
Model 2 (R^2 = .43, $F_{(8, 118)}$ = 26.094, p < .001; ΔR^2 = .24)						
Declarative knowledge	.087	.078	1.12	.265	[-.067, .240]	1.68
Procedural knowledge	.063	.080	.78	.438	[-.095, .221]	1.71
Conditional knowledge	.095	.077	1.24	.217	[-.057, .247]	1.89

Planning	.241	.098	2.42	.018	[.042, .440]	2.11
Information management strategies	.114	.087	1.31	.193	[-.058, .286]	2.24
Comprehension monitoring	.292	.096	2.93	.004	[.098, .486]	2.03
Debugging strategies	.086	.082	1.05	.295	[-.076, .247]	2.38
Evaluation	.071	.081	.87	.386	[-.089, .231]	1.95

4. DISCUSSION

The aim of the research was to verify the extent to which metacognitive variables contribute to predicting the level of teacher self-efficacy. In the first model, three subscales of "knowledge about cognition" (declarative, procedural, and conditional knowledge), were included in the analysis. The second model was then supplemented with five components of "regulation of cognition" – planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation.

Model 1 (influence of "knowledge about cognition") explained 19% of the variability in the dependent variable ($R^2 = .19$), which can be considered a moderately strong effect in the field of psychological and pedagogical research. However, none of the three subscales represented a statistically significant predictor of teacher self-efficacy on its own. The highest, albeit still insignificant, value of the standardized coefficient was achieved by conditional knowledge ($\beta = .125$, $p = .125$), which expresses an individual's ability to know when and why to use certain learning or problem-solving strategies. This trend is consistent with the assumption that the ability to adaptively apply learning knowledge is linked to self-confidence in pedagogical practice (Bandura, 1997; Schraw, & Dennison, 1994), although it did not reach statistical significance in our sample.

Declarative and procedural knowledge ($\beta = .112$ and $\beta = .098$) contributed only minimally to the prediction. This result suggests that simply "knowing about" or "knowing how" may not be a decisive factor for feelings of effectiveness if this knowledge is not accompanied by active regulation and monitoring. In the theoretical framework of Schraw, & Dennison (1994), metacognitive knowledge represents a more static component of metacognition, while regulatory processes are more dynamic and closely linked to the current learning situation.

Model 2 (added effect of "regulation of cognition") yielded a significant increase in explained variability ($R^2 = .43$; $\Delta R^2 = .24$), meaning that metacognitive regulatory processes added an additional 24% of explained variance in teacher self-efficacy. This result confirms theoretical assumptions (e.g., Efklides, 2008; Veenman, 2012), according to which planning, monitoring, and evaluation processes are key to effective self-regulation and perceived teacher competence.

Of the five components of regulation of cognition, planning ($\beta = .241$, $p = .018$) and comprehension monitoring ($\beta = .292$, $p = .004$) were significant predictors. Teachers who declare a higher ability to plan their cognitive processes, set goals, and anticipate possible difficulties also tend to evaluate themselves as more competent and effective in their professional role. This relationship is consistent with the concepts of self-regulated learning (Zimmerman, 2000), which emphasize that planning and goal setting form the basis for adaptive regulation of behavior and perceived efficacy.

An even stronger relationship was found in comprehension monitoring, i.e., the ability to continuously monitor one's own understanding and performance. This factor is considered a central element of metacognitive regulation in theory (Schraw, 1998). Teachers who feel that they can identify gaps in understanding or strategies during teaching and adapt their approach accordingly also seem to feel greater control over their students' learning and their own work, which translates into higher teacher self-efficacy.

Conversely, the variables information management strategies, debugging strategies, and evaluation did not enter the model as significant predictors, although their partial correlations with self-efficacy were moderately strong. This may indicate that these aspects of regulation of cognition are positively associated with teacher self-efficacy, but their contribution overlaps with other processes (e.g., planning and monitoring). Multicollinearity was low (VIF < 2.5), confirming that these components are related but each captures a different dimension of regulatory processes.

The results support the model according to which regulatory aspects of metacognition are a stronger predictor of self-efficacy than metacognitive knowledge itself. This trend is consistent with the research of Efklides (2008) and Kramarski, & Michalsky (2010), which emphasize the importance of "online" metacognitive processes in teaching and real-time decision-making. Teachers who are able to plan, monitor, and continuously adjust their teaching practices have a greater sense of control and success, which increases their self-efficacy according to Bandura's social cognitive theory.

On the other hand, the absence of a significant impact of metacognitive knowledge may be related to the fact that it is a declarative self-assessment that may not accurately reflect the actual use of this knowledge in practice. As Veenman (2012) points out, the difference between "knowing" and "doing" in the field of metacognition is often significant – many respondents know what they should do, but do not always apply it.

From a practical point of view, the results suggest that developing metacognitive regulatory skills, especially planning and monitoring, could contribute to strengthening teacher self-efficacy. Interventions focused on metacognitive training, lesson planning, and reflection on one's own practice appear to be appropriate ways to support teacher self-efficacy in both novice and experienced teachers.

The identified relationships between metacognition and teacher self-efficacy provide potential implications for teacher education and professional development. Prospective and novice teachers may find it useful to develop metacognitive processes, for example, in the form of lesson planning, post-lesson reflection, and systematic monitoring practices to increase their teacher self-efficacy. Courses and training should emphasize not only teaching methods themselves, but also the development of metacognitive strategies: how future teachers/teachers become aware of their teaching, monitor it, and adjust their practice based on feedback. From a research perspective, it is recommended to pay attention to the fact that not all components of metacognition have the same impact – for example, regulatory processes (planning, monitoring) may be more strongly associated with teacher self-efficacy than knowledge of what to do.

Metacognition and teacher self-efficacy are interdependent: teachers with higher metacognitive competence are better able to control the teaching process, learn more effectively, and adapt their practice, which supports their teacher self-efficacy. Empirical evidence supports this relationship, although further research is needed, such as longitudinal or intervention studies, focusing on individual components of metacognition in teaching practice.

The limitations of this research study lie in the small number of respondents in the sample and the absence of responses from students from other universities, meaning that the results cannot be considered representative. One of the limitations of the research is that self-assessment scales were used to measure teacher self-efficacy and metacognition. We therefore relied exclusively on the personal statements of future teachers about what they think of themselves and how they perceive themselves. The disadvantage of this method is that respondents may present a better image of themselves when completing the questionnaire, i.e., they are prone to giving desirable rather than authentic answers, which distorts the results. Furthermore, the situations and examples given in the questionnaires are not personalized; each respondent encounters different problems and situations (e.g., a future teacher during an internship at an elementary school or kindergarten). Each situation has broader contexts, and each respondent is capable of introspection to a different degree.

5. CONCLUSIONS

To examine the relationship of metacognitive factors to the teacher self-efficacy, a multiple hierarchical linear regression analysis was carried out. Results showed that *knowledge about cognition* alone explained 19% of the variability in teacher self-efficacy, but none of the three subscales represented a statistically significant predictor of teacher self-efficacy on its own. After adding *regulation of cognition*, the explained variance increased significantly. The most significant predictors were planning and comprehension monitoring.

These results emphasize that the development of teacher self-efficacy should be based on training in regulation of cognition , i.e., the ability to plan, monitor, and evaluate one's own activities. In pedagogical practice, this points to the importance of self-reflection, strategic thinking, and systematic preparation as key factors in the professional growth of future teachers.

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**Engineering, Transport, IT and Artificial Intelligence
(IAC-ETITAI)**

Using Technology in Higher Education: A Convergence of AI, Simulations, and Digital Transformation

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Abstract

The rapid emergence of artificial intelligence (AI) and advanced digital technologies is fundamentally changing higher education. This synthesis paper summarises the findings of recent studies, focusing on the integration of AI tools such as ChatGPT, the innovative use of business simulations, changing preferences in examination formats, and the transformation of teaching and learning in the post-COVID-19 era. All stakeholders in the educational process are taken into account. On the one hand, there are university lecturers, whose working environment has been massively affected in recent years (COVID-19, digitalization of public administration and higher education), but who also have to integrate technical challenges and opportunities into teaching and examining students (simulation and artificial intelligence). The students' views are compared with those of the lecturers, enabling areas for action and problems to be identified. At the same time, the discussion examines whether these challenges and opportunities for teachers and learners can be solved organizationally (support, structure) by the higher education institutions. Finally, the discussion highlights opportunities and challenges in improving student engagement, learning effectiveness and pedagogical practices, and underscores the transformative impact of digital technologies and interdisciplinary approaches. This article is based on empirical research conducted in the European Union between 2022 and 2025.

Keywords: Digital learning, E-Assessment, student requirements, Artificial Intelligence, AI, transformation of teaching

1. INTRODUCTION

Higher education is undergoing fundamental change under the influence of AI and digital technologies [1,2,3]. As institutions increasingly focus on technology-supported pedagogy, it is crucial to understand the impact and potential of these changes. The authors of this publication actively accompanied and shaped this transformation process as

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members of higher education institutions. They experienced the social and cultural changes in their own everyday teaching and sought a way to reflect on their own actions and gain scientific insights. This motivation led to the formation of a cross-university research group with participants from West Saxon University of Applied Sciences Zwickau, Merseburg University of Applied Sciences, Berlin University of Applied Sciences and Berlin University of Applied Sciences.

This article summarises and correlates the results of the past few years. In addition to a focused look at the individual areas of study. The research work is expected to build on each other. The research group was founded during the coronavirus pandemic and began with its first research project. This examined how the COVID-19 crisis is affecting the everyday working lives of university lecturers. Among other things, this study found that students are often less motivated as a result of the digitalisation of teaching, since only online courses were possible during this period. Based on these findings, further research was initiated to build on these results. The research group investigated how student engagement could be increased again. Students enjoy the opportunity to engage in online learning, but not as the sole and permanent form of teaching. Teachers and learners are aware that digitalisation can lead to a decline in performance and student engagement. Furthermore, these first two studies showed that students increasingly want to see digital media in teaching design and the use of AI in teaching and research, or are already using it. The research group therefore launched a third project to investigate the use of AI in a business simulation. Previous studies had shown that simulation games have a positive influence on student engagement and performance. The third project investigated the extent to which generic AI can be used effectively in a business simulation game and what challenges arise. After completing the first three research projects, the researchers gained a broad but somewhat diffuse insight into the digitalisation of university teaching, particularly with regard to the use of AI. This prompted the researchers to launch a fourth project examining the current status of AI use in teaching and research among university lecturers in Germany.

The individual projects are briefly mentioned below and are presented and discussed in more detail in section 2 of this article.

- Impact of the Covid-19 crisis on university lecturing [4], this research works leads to the research question

- Increasing engagement through realistic simulations [5], this research works leads to the research question

- The role of AI in business simulations [6], this research works leads to the research question

- Challenges in integrating AI into education [7]

These 4 research projects cause the here presented paper, which concludes a global and connecting discussion of the results and findings.

2. RESULTS, FINDINGS AND VERIFICATION WITH CURRENT STUDIES

The following section presents the past research work of the research group described above from 2022 to 2025. It outlines the methodological approach, summarises the results and findings, and links them to current research results.

2.1 Impact of the Covid-19 crisis on university lecturing

The aim of the study was to analyse how teaching and the working environment for lecturers at German universities have changed since COVID-19. The study, conducted in May 2022, surveyed 62 full-time lecturers from various German universities and universities of applied sciences. The average age of the participants was 51.1 years, with most having extensive teaching experience. The data was collected using an online questionnaire with 48 questions on six scales, focusing on current teaching practices, interactions with students and future teaching strategies after COVID-19. The data collected provided a rich mix of quantitative and qualitative insights into the challenges and opportunities faced by lecturers during and after the pandemic.

The majority of participants (83%) regularly used multiple teaching formats (lectures, seminars, tutorials). When universities lifted strict COVID-19 restrictions, 60% resumed face-to-face teaching, while only 8.3% taught exclusively online. This shift underscored the continuing preference for face-to-face interactions after a prolonged period of exclusively digital teaching methods. A significant number (31.7%) used a hybrid model, reflecting the desire of teachers to balance traditional and digital methods.

Participants reported a positive adjustment to the mixed teaching environments. On a Likert scale (1 to 5), lecturers rated their ability to cope with the current situation positively at 4.2. They attributed this ability to the acquisition of digital skills and access to adequate technical resources. However, the study revealed inconsistencies in the way support services met the needs of teachers, suggesting a need for improvement in institutional support systems.
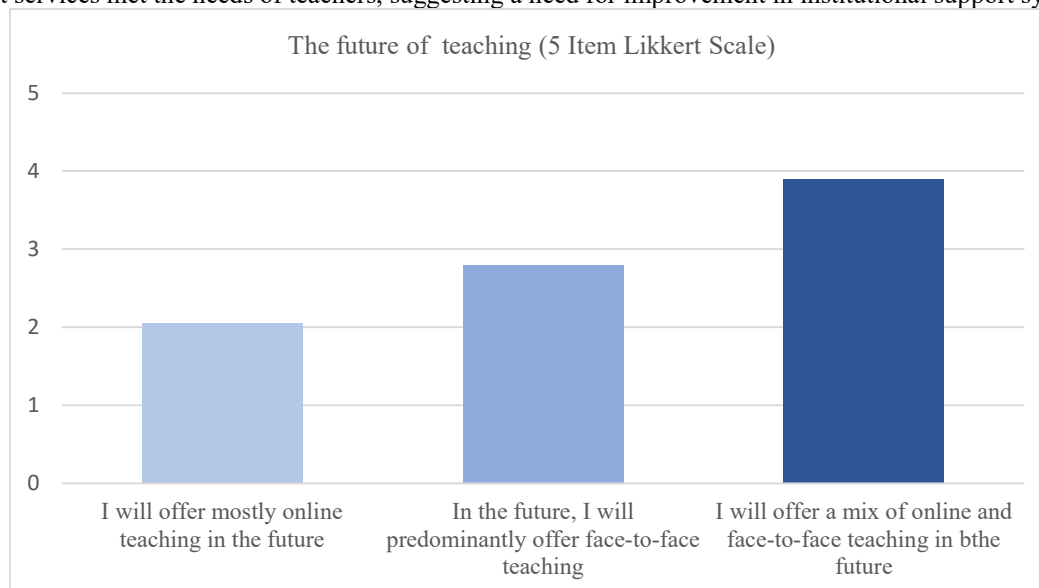

Figure 1: The future of teaching

Despite the challenges posed by the pandemic, the majority of lecturers reported finding fulfilment in their work. Correlation analysis revealed that those who already possessed digital skills and those who had acquired new skills during the pandemic enjoyed teaching more. Interaction with students, even in virtual formats, contributed positively to job satisfaction. These findings underscore teachers' continued enthusiasm for exploring different teaching methods.

Looking ahead, 52% of respondents said they would like to maintain their current digital practices, while only 8.2% saw a need to improve their digital skills. Interestingly, purely online teaching was less preferred (8%), while a majority favoured a mix of online and face-to-face teaching for future courses. This preference for hybrid models indicates a continuing shift towards more flexible and adaptable forms of teaching (figure 1).

But how has the teaching situation developed and what has become of the universities' aspirations? Recent studies show that the combination of traditional teaching and digital media is at the centre of internal university discussions. Teachers and students prefer this variant of blended learning. These demands from teachers and learners have also reached the administrative management of the universities. The Centre for Higher Education Development [9] has found that enriched face-to-face teaching and blended learning elements are at the core of strategic developments at universities, even though face-to-face teaching remains the predominant format. However, from the authors' point of view, these statements are not contradictory but underline the desire for digital enrichment, for example through online knowledge transfer and in-person in-depth discussions on these topics.

A look at other universities in Germany shows that the standard has developed such that lecturers can conduct up to 30% of their teaching online [10]. "The highest proportion of digital or blended learning formats is found in the faculties of biology and medicine. Digital formats are also increasingly being used in economics, sports science, law and linguistics,' summarises Beate Suppinger in the journal [10].

The COVID-19 pandemic has significantly accelerated the adoption of digital teaching methods and prompted educators to quickly adapt and expand their digital skills. This study highlights the need for universities to continue to support this transition by developing a robust digital infrastructure and offering targeted training for educators. By promoting an environment that supports both face-to-face and online teaching, educational institutions can better support teachers and improve the overall learning experience for students. Given the changing higher education landscape, further research, including student-centred studies, will be critical to understanding the broader implications of these changes. This ongoing exploration will help ensure that educational strategies align with both the goals of educational institutions and the needs of students, ultimately leading to a more dynamic and resilient education system.

2.2 Increasing engagement through realistic simulations

Various studies show [11,12] that student engagement [13,14] has declined in the wake of the Covid-19 pandemic and the increased introduction of online teaching. Various studies show that the use of simulation software can counteract this [15,16,17]. Taking into account the aforementioned findings of the authors' publication, they conducted a study on the use of simulation software in the industrial engineering programme at HTW Berlin in the winter semester 23/24.

The study examines the integration of real simulations, particularly in the context of the sports betting market, into business administration teaching and their influence on learning effectiveness and student engagement. The study aims to improve the effectiveness of prediction methods based on key performance indicators (KPIs) for decision-making in management accounting.

The discipline of management accounting, particularly the components of predictive analytics and AI-supported data management, has become more complex in recent years. Despite these developments, student performance, especially in the management accounting module of the bachelor's programme in industrial engineering at HTW Berlin, has declined, influenced by the pandemic and the associated changes in teaching methods. To address this, a study project was initiated that applies complex predictive methods in real-world contexts, such as the sports betting market, to increase student interest and motivation.

The project was divided into six phases, ranging from an introduction to data-based predictions to the analysis and documentation of results from real-world football events. During these phases, extensive data on European football was collected and implemented by the students in prediction models with the aim of achieving and possibly exceeding the accuracy of professional betting providers.

The study is based on a mixed-methods approach, with qualitative and quantitative data collected through semi-structured interviews and surveys. These aimed to examine not only academic performance, but also the qualitative motivation and engagement of the students.

The study shows that real-world simulations significantly increase learning effectiveness (figure 2). In particular, motivation, the ability to apply new content and understanding benefit from the integration of real-world contexts. The survey revealed that all measured aspects of learning effectiveness were above 4.0 on the Likert scale, with motivation ranking highest at 4.72. Qualitatively, aspects such as problem-solving skills and the optimisation of work processes emerged as decisive factors for increased engagement. Statistical analysis of the data (Cronbach's alpha and correlations) confirms that the internal consistency of the data is high, which underscores its reliability. A correlation was found between motivation and openness to future professional requirements, but the significant correlations were low overall.
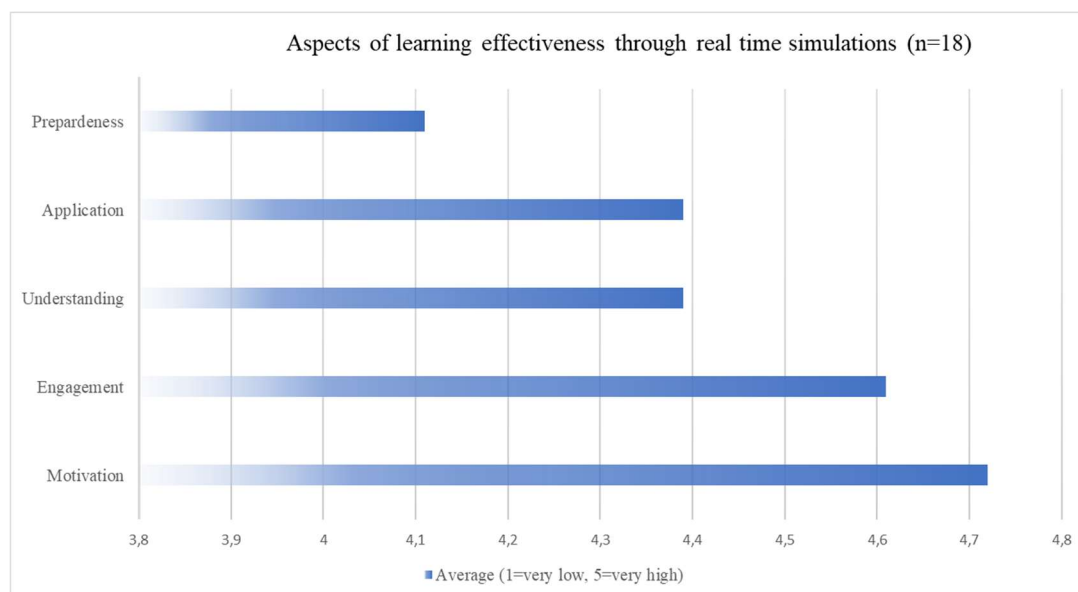

Figure 2: Aspects of learning effectiveness through real time simulations (n=18)

The research project confirms that realistic simulations can significantly promote competence development. The results suggest that incorporating interdisciplinary and exciting contexts, such as sports analysis, into curricula can increase students' motivation and analytical skills. These approaches could be extended to other disciplines, for example through simulations in the field of stock market analysis, to teach the application of advanced data-based decision-making skills. Overall, the study shows that the use of realistic simulations in education is a valuable strategy for promoting learning effectiveness and skills development and is therefore of considerable value in the context of modern educational approaches.

2.3 The role of AI in business simulations

As already presented in the study in section 2.2, the use of simulation software and the didactic approach with the help of gamification is a suitable means of increasing the quality of teaching in online and offline teaching. Among other things, this is achieved through greater student engagement. Current social debate and scientific publications by [18,19,20] raise the question of the extent to which AI can be used in teaching.

ChatGPT is a much-discussed platform, especially in the field of education. There are various attempts to support learning by integrating ChatGPT or to restrict its use. Business simulations are a popular tool that allows students to play through realistic and interactive business scenarios, gaining practical experience in decision-making, problem-solving and strategic planning. Business simulations have been known as an effective learning method for decades. However, little is known about the interaction of artificial intelligence, and ChatGPT in particular, in the context of business simulations.

The authors investigated the integration of ChatGPT, a widely discussed tool in the field of education, into business simulation games as a method of promoting critical thinking and decision-making among students. Little is known about the specific role of ChatGPT in interacting with such simulations, which is why this case study highlights the potential benefits and challenges of incorporating ChatGPT into the decision-making process during a multi-period business simulation.

The study was conducted during the winter semester of 2023/24 at HTW Berlin. It focused on an established, software-based business simulation that is part of the MBA&E programme. Students were divided into groups, each of which ran a virtual company. An additional group was controlled by the course instructor using decisions generated by ChatGPT. The data was obtained by asking ChatGPT (version 3.5) specific questions. The questions began with general inquiries and became more specific as the study progressed to see how ChatGPT supports strategic and operational business decisions.

The general questions posed to ChatGPT primarily yielded general recommendations on business management, comparable to didactic advice from a course instructor, but not specific instructions for the simulation. More specific questions also did not lead to precise strategic insights that could offer a competitive advantage. For example, the use of a simple cost-plus pricing method in a highly competitive technology market was not effective. Despite generalised answers, the ChatGPT-controlled company managed to take third place out of five in periods 2 and 3, which was an improvement over the first round but still fell short of expectations.

The study shows that while ChatGPT has the potential to play a supporting role in the learning process, it currently offers only limited applicability in the complexity of business decisions. The biggest challenges for implementation in educational processes are the need for specific questions and the critical evaluation of the answers given. The findings suggest that ChatGPT can be used more as a complementary tool to relieve the burden on teachers and promote critical thinking, while the simulation itself and the traditional role of the lecturer remain central. Long-term implications suggest that broader integration of artificial intelligence into simulation programmes may be necessary to determine the conditions under which interaction with ChatGPT can be used productively in real-time learning environments. Further research could also investigate what happens when multiple teams use ChatGPT for decision-making in a simulation.

In conclusion, AI can be used to improve and enhance educational offerings in the modern age by enriching the ongoing discussion about the relationship between AI, education and corporate strategies. Similar findings and opportunities were also identified in the research work of G.P. Bharathi [21] and Chen [22], which also highlight the lack of research on this topic [23,24].

2.4 Challenges in integrating AI into education

Based on the findings from previous studies, the authors decided to conduct a comprehensive analysis of the current situation at German universities. They examined how lecturers assess the dawn of the AI era and what influence AI

has on teaching, lesson preparation and examination formats. In addition, the focus was once again placed on the work of lecturers. What influence does AI have on the future of teaching in general, the enjoyment of teaching and motivation for working at university? This inevitably raises the question of what other variables may have an influence.

The article examines the impact of artificial intelligence (AI) on the role of university lecturers in Germany and analyses how their working environment is changing as a result of the integration of AI. The focus is on the extent to which AI influences and potentially replaces current teaching and examination formats in higher education institutions. In addition, the digital transformation of higher education institutions is examined at the organisational level

The study collected data from 166 lecturers at German universities and universities of applied sciences between April and May 2025. The participants consisted of 53% men, 42.8% women and 4.2% diverse individuals, with an average age between 41 and 45. An online questionnaire was used to collect data and comprised 41 items spread across six scales to analyse aspects such as teaching efficiency, professional development and challenges posed by AI. The authors analysed the data using SPSS and MS Excel, performing correlations and cluster analyses. The following findings were identified

- Role perception: Despite having a basic understanding of AI, many university lecturers are reluctant to fully integrate its potential. The study shows that over 60% of participants have completed less than 10 hours of training on the subject. Only about 25% have adapted their teaching or examination approaches, despite empirical evidence of student use of AI.
- Improvement of teaching methods: Around 20% of respondents do not use AI in teaching, preparation or examinations. Those who do use AI mainly do so for lesson preparation.
- Professional development: Respondents rate their digital skills as good, but their AI skills as only average. Around 53% plan to expand the use of AI in teaching and research, while a quarter do not plan to do so.
- Challenges: Many teachers are unable to assess whether students are using AI for tasks and do not adapt their examination formats accordingly.
- Organisational aspects: The majority of participants feel well equipped with technical infrastructure, but organisational development and support from institutions are stagnating.
- Job satisfaction: While 88% enjoy their work, 58% say they enjoyed it more three years ago.
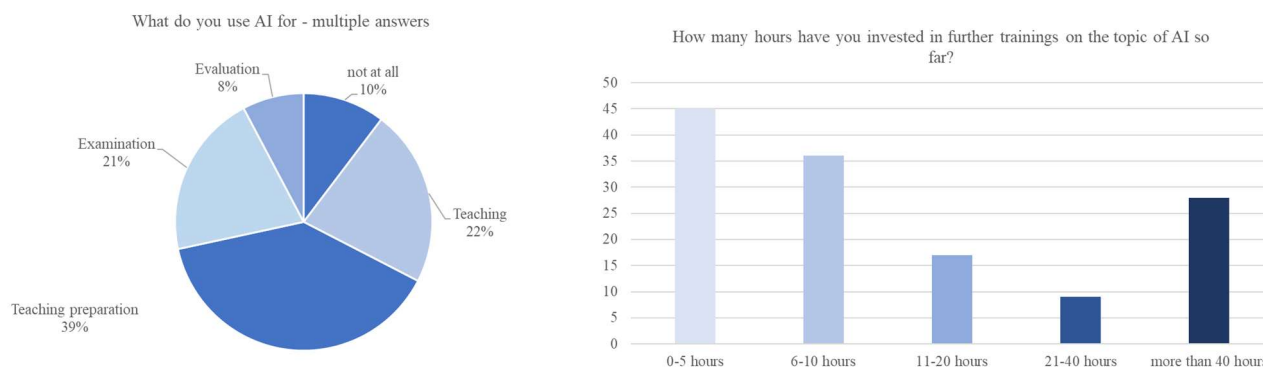

Figure 3: Using and training of AI

The study highlights the discrepancy between awareness of the potential of AI and its practical use in teaching. University lecturers should receive targeted training on the integration of AI and adapt curricula in innovative ways. Universities should develop support programmes to promote new teaching methods with AI support. Local dialogue platforms could reduce uncertainty and contribute to innovation in the teaching experience. Finally, longitudinal studies should be conducted to understand the long-term effects of AI on learning behaviour and teaching methods.

3. DISCUSSION

The results of the study presented here provide a comprehensive picture of the challenges and opportunities arising from the introduction of digital technologies and artificial intelligence (AI) in higher education. While the integration

of AI and digital tools has proven to be potentially transformative for education, there are significant discrepancies between the theoretical potential and practical implementation in teaching and learning processes.

The majority of lecturers surveyed demonstrated a basic awareness of the possibilities of AI, but there was a clear reluctance to integrate these technologies comprehensively into everyday teaching. This reluctance can be explained by a lack of targeted further training and insufficient adaptation of curricula. Although 60% of lecturers had completed less than 10 hours of further training in AI, they were aware of its potential applications. This reveals a contradiction between the recognition of the importance of AI and its actual integration into the curriculum. An analysis by TU Berlin [25] shows that didactic competence and academic media literacy have an influence on university lecturers' satisfaction with digital teaching. Based on the results, development opportunities can be identified and appropriate further training legitimised.

Despite the potential value of digital tools, organisational aspects lag behind requirements. The study found that the technical infrastructure proved to be functional, but institutional support stagnated. This points to a discrepancy between technical availability and organisational adaptation, which requires a deeper institutional commitment to promoting digital transformation. As a result, German universities are currently missing out on the opportunity to provide more efficient higher education and attract new students. This is because students want more digital media support and more digital offerings. In some cases, these digital offerings are preferred over traditional offerings such as laboratory practicals [25]. This raises the question of how to increase engagement and enthusiasm for studying and the respective content.

The use of real simulations to increase engagement proved to be a useful approach to increasing student motivation. The application of complex predictive models in real contexts, such as the sports betting market, has sparked interest in analytical skills. However, the challenge here was to expand these approaches across disciplines and apply them to other subject areas, such as stock market analysis, in order to increase students' analytical skills.

The case study on the integration of ChatGPT into business simulations showed that, although the platform has the potential to serve as a supportive tool in the learning process, it currently offers only limited applications in the complexity of business decisions. A critical issue remains the need to formulate specific questions and critically evaluate the answers provided. Long-term research should investigate how AI-supported decision-making can be incorporated more productively into real-time learning environments. However, it should be noted that there are positive effects when using AI in higher education, but the general state of research in this area is still limited. Existing studies show rather short-term effects and are therefore only partially reliable.

This raises the question of the current situation at German universities and the attitudes of university teachers towards the use of AI. The studies presented here are comparable to other European studies, even if they depend on the field of study in detail [10,12].

To overcome identified discrepancies between the potential and application of AI, university lecturers should receive targeted training measures aimed at integrating AI into education, examination and research. Universities must promote the development of support programmes to strengthen the use of innovative teaching methods with AI support and establish a continuous dialogue on the role of AI in education. Longitudinal studies could help to better understand the long-term impact of AI on learning behaviour and teaching methods and to align university strategies accordingly.

Overall, the study shows that stronger institutional support and targeted training for teachers are needed to successfully shape the digital transformation. This would not only improve teaching, but also help to create a dynamic and adaptable education system that meets the demands of the modern learning landscape. This ongoing research should promote the development of innovation-driven, technology-supported teaching that reflects both the needs of students and institutional goals.

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Acceptance and Success Factors in the Organizational Implementation of AI-based Chatbots in Customer Communication

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Abstract

AI-based chatbots have become central instruments in customer communication, offering companies new possibilities for automation, efficiency, and service personalization. However, successful implementation requires more than technical deployment. Acceptance among customers and employees depends on a complex interplay of transparency, usability, trust, organizational support, and cultural adaptation. This paper investigates these dynamics by combining insights from academic literature with qualitative interviews. Results show that adoption is not a linear process but emerges at the intersection of technical innovation, organizational practices, and socio-cultural expectations. The study contributes to theory by extending acceptance models with organizational and cultural dimensions, and to practice by outlining strategies for sustainable chatbot implementation.

Keywords: AI, chatbots, customer communication,success factors

1. INTRODUCTION

Chatbots are increasingly integrated into customer communication processes, from handling frequently asked questions to supporting technical troubleshooting. While their diffusion has accelerated over the past decade, adoption trajectories vary considerably across organizations and markets [1, 2].
Existing literature highlights clear benefits such as efficiency gains and cost reduction [3, 4], but emphasizes that challenges of acceptance, trust, and user experience remain significant barriers [5, 6]. Research often frames acceptance through models such as the Technology Acceptance Model [7] or the Unified Theory of Acceptance and Use of Technology [8]. However, these frameworks tend to focus on individual perceptions, while organizational and cultural dynamics remain underexplored.

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The aim of this paper is to contribute to this gap by examining success factors and challenges in the organizational implementation of chatbots. Specifically, we ask:

1. Which factors foster or hinder acceptance of chatbots in customer communication?
2. How can organizations actively shape these factors to ensure sustainable implementation?

2. THEORETICAL FOUNDATIONS

2.1. Chatbots in customer communication

Chatbots are dialogue-oriented AI systems that simulate conversation by processing and generating natural language. Their design ranges from simple rule-based applications with predefined scripts to sophisticated systems based on large language models (LLMs) capable of dynamic and context-sensitive responses. In customer communication, their typical functions include automating frequently asked questions, processing simple transactions, and providing first-level technical support. Increasingly, advanced forms such as multimodal agents and retrieval-augmented generation (RAG) architectures extend their potential by integrating external knowledge bases and enabling more personalized interaction.

While the technological capabilities of chatbots have expanded, research emphasizes that functionality alone is insufficient to ensure adoption. Hill et al. [3] showed that while users appreciated efficiency gains, they often perceived chatbot interactions as less authentic than human contact. Similarly, Araujo [6] demonstrated that anthropomorphic design cues can enhance acceptance but also risk raising unrealistic expectations. These findings suggest that organizations must balance automation benefits with the need to maintain credibility and user satisfaction.

2.2. Technology acceptance and conversational AI

The Technology Acceptance Model [7] and its successor, the Unified Theory of Acceptance and Use of Technology [8], have long provided the dominant frameworks for understanding adoption. They identify perceived usefulness and ease of use as the primary drivers of acceptance. In the case of chatbots, however, additional factors are relevant. Luger and Sellen [5] highlight the "expectation gap" between what users believe a chatbot can deliver and what it actually achieves, often leading to frustration. More recent studies emphasize trust, transparency, and explainability as crucial dimensions for AI acceptance [9, 10]. Thus, while classical acceptance models remain useful, they require extension to account for the distinct socio-technical character of conversational agents.

2.3 Organizational implementation perspectives

From an organizational standpoint, chatbot projects are not merely IT rollouts but part of larger digital transformation processes. Kotter's [11] work on change management underlines the importance of communication, employee involvement, and leadership commitment for successful innovation. Applied to chatbots, this implies that organizations must not only provide the technical infrastructure but also invest in training, align chatbots with strategic goals, and manage expectations internally and externally. Adam et al. [12] further argue that compliance with ethical standards, data governance, and fairness principles are becoming central to organizational legitimacy in AI deployment.

Empirical studies reinforce this view. [13] showed that response time, error handling, and conversational flow significantly affect user experience, but that these design elements must be embedded in a supportive organizational environment to create sustainable value. In practice, this means that chatbots function most effectively when they are positioned as complementary tools integrated into customer service ecosystems, rather than as isolated technical add-ons.

2.4 Towards an integrative perspective

Bringing these strands together, chatbots should be conceptualized as socio-technical systems in which technology, organization, and culture interact [14]. Acceptance is not only about the user's individual attitude but emerges from systemic interactions shaped by training, transparency, and cultural norms. This broader view forms the conceptual lens for the empirical analysis presented in this paper.

3. METHODOLOGY

The empirical analysis builds on expert interviews with professionals involved in chatbot implementation and management across industries. Respondents were selected based on their experience with AI-supported customer communication and their role in organizational deployment processes. Interviews were conducted using a semi-structured guide covering technical, organizational, and cultural aspects.

Data were analyzed through qualitative content analysis [15], combining inductive coding with deductive categories derived from the literature review. To ensure robustness, findings were triangulated with existing studies on acceptance and organizational innovation.

4. RESULTS

The analysis of the interview data reveals that the acceptance of AI-based chatbots in customer communication cannot be explained by technological efficiency alone. While automation and 24/7 availability were acknowledged in nearly all interviews as major benefits, participants consistently stressed that adoption depends on whether users perceive the system as trustworthy, transparent, and responsive to their needs. This confirms earlier literature showing that acceptance emerges at the intersection of technical quality, perceived usefulness, and socio-cultural expectations [1, 4].

4.1 Drivers of acceptance

Transparency was the most frequently mentioned driver of acceptance. In almost every interview, respondents emphasized that customers expect clarity about whether they are interacting with a chatbot or a human agent. Several participants also pointed out that transparent communication about data usage increases credibility and mitigates concerns about surveillance. Usability was another recurring theme. About two-thirds of the interviewees underlined the importance of intuitive design and one-step solutions, especially in contexts where customers interact frequently but expect quick results. When systems required too many dialogue steps or produced long response times, interviewees reported frustration and abandonment as common reactions. Trust was highlighted by a majority of respondents as directly linked to privacy protection and the accuracy of responses. In particular, those working in sectors with sensitive data noted that acceptance will not develop without robust privacy assurances and consistently reliable outputs. Efficiency was described as a baseline condition by most participants. Several interviewees emphasized that without clear time savings or added convenience, customers see little reason to shift from human interaction to automated services (see Tab. 1).

Table 1. Central drivers

driver	
Transparency	Users must understand when they interact with a chatbot and how data is processed.
Usability	Intuitive design and quick, error-free responses foster positive experiences.
Trust	Data protection and reliability are essential for credibility.
Efficiency	Clear value in terms of time savings or convenience increases willingness to adopt.

4.2 Organizational success factors

When asked about factors under organizational control, participants pointed most often to training and internal communication. In roughly half of the interviews, respondents described that employee awareness campaigns, onboarding sessions, or explanatory workshops had improved internal acceptance and facilitated external rollout. Interviewees stressed that employees who understand chatbot functions and limitations are more likely to recommend them to customers and to intervene effectively when problems arise.

Change management also emerged as a repeated theme. Several participants explained that projects accompanied by structured communication campaigns and stakeholder involvement were more successful than those introduced

without preparation. This suggests that organizational readiness is a crucial determinant of implementation outcomes, in line with earlier research [11, 12].

Cultural adaptation was mentioned in nearly all interviews, though with varying emphasis depending on regional focus. Respondents highlighted that systems adapted to local communication norms—whether in terms of tone of voice, politeness conventions, or privacy-sensitive phrasing—were better received by customers.

Technological reliability was treated as a precondition across interviews. Participants repeatedly stressed that errors, irrelevant answers, or breakdowns quickly eroded trust, whereas advanced features such as retrieval-augmented generation (RAG) or multimodal inputs were seen as enhancing credibility and user satisfaction.

4.3 Barriers and challenges

Interviewees also pointed to persistent barriers. Privacy concerns were mentioned in almost every conversation, particularly in regulated industries or among user groups highly sensitive to data handling. A second barrier, raised by about half of the respondents, was customer preference for human interaction in situations perceived as complex or emotionally charged.

Limited digital literacy appeared in several interviews as a challenge, especially in contexts where users or employees lacked experience with AI systems. Participants explained that this often resulted in confusion, underuse, or outright rejection.

Finally, a number of respondents warned about the risk of overpromising. They argued that organizations sometimes market chatbots as more capable than they actually are, leading to dissatisfaction and a widening expectation gap when the systems cannot deliver as promised [5].

4.4 Synthesis of findings

Taken together, the interviews provide a nuanced picture of chatbot implementation. On the user level, acceptance hinges on transparency, usability, trust, and efficiency. On the organizational level, training, communication, cultural adaptation, and technological reliability function as decisive enablers. On the systemic level, barriers such as privacy concerns, preference for human interaction, limited digital literacy, and inflated expectations must be carefully managed.

The frequency with which these themes appeared across interviews suggests that they are not isolated observations but consistent patterns. While the relative importance of factors varied between industries, the overall results reinforce the view that chatbots must be treated as socio-technical systems [14], where adoption outcomes depend on the interaction of technical features, organizational practices, and cultural norms.

5. Discussion

The findings of this study underline that the acceptance of AI-based chatbots in customer communication cannot be reduced to a purely technical question. While efficiency and automation are necessary conditions for implementation, they are not sufficient for sustainable adoption. Instead, acceptance is shaped by an interplay of transparency, trust, usability, and cultural expectations. This corresponds with existing research that highlights the socio-technical nature of digital innovations [14, 2]. By situating chatbots within organizational and cultural contexts, the study contributes to extending technology acceptance models toward a more comprehensive framework that accounts for systemic dynamics.

A central theoretical implication concerns the role of trust and transparency. While classical models such as TAM [7] emphasize perceived usefulness and ease of use, our data demonstrate that these factors alone do not explain acceptance of AI-based systems. Instead, transparency about chatbot functionality and data processing is indispensable to bridge the expectation gap [5]. This finding resonates with Shin's [9] work on fairness and explainability in algorithmic systems, suggesting that acceptance models must integrate trust-related constructs more systematically.

Another contribution lies in highlighting the organizational dimension of chatbot adoption. The results show that training, communication, and change management substantially affect whether chatbots are perceived as legitimate and credible. This confirms earlier work on digital transformation, which stresses that employee engagement and organizational readiness are key determinants of innovation outcomes [11, 12]. In practical terms, this means that companies cannot rely solely on technical deployment but must actively invest in organizational processes that foster

acceptance. Extending existing frameworks with these organizational variables thus enriches the theoretical understanding of chatbot adoption.

The analysis further reveals the importance of cultural adaptation. Chatbots that align with local communication norms—such as politeness strategies, tone of voice, or sensitivity to privacy—achieve higher levels of user acceptance. This insight adds to the literature on human–computer interaction, which emphasizes the need for contextualized design [6, 10]. From a theoretical standpoint, it suggests that acceptance models should not be universalized without considering cultural variability. Rather, cultural factors should be treated as moderating variables that shape the relationship between perceived usefulness, trust, and actual adoption.

Finally, the study highlights the ambivalent role of regulation. On the one hand, strict data protection laws and compliance requirements can slow down the pace of implementation. On the other hand, they serve as an important trust-building mechanism, reassuring users that their rights are safeguarded. This dual role of regulation supports the argument that governance structures are not merely external constraints but integral components of the socio-technical system of chatbot adoption. It also resonates with current debates on AI governance that stress the balance between innovation and legitimacy [9, 10].

Taken together, these findings demonstrate the need for a more integrative perspective on chatbot acceptance. Instead of focusing solely on individual perceptions or technological performance, future research should adopt multi-level frameworks that account for user, organizational, and cultural factors simultaneously. Such an approach not only provides a more realistic picture of adoption processes but also helps practitioners and policymakers design strategies that enhance both effectiveness and legitimacy of AI-based customer communication (see Fig. 1).
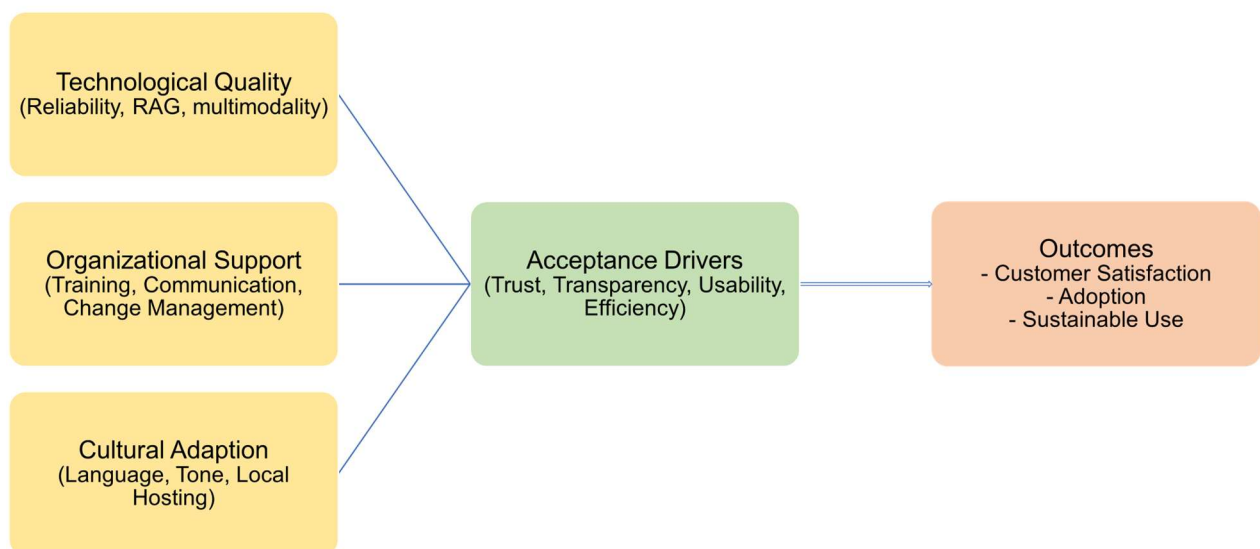

Fig. 1. Model of Success Factors for Chatbot Acceptance in Customer Communication

6. CONCLUSION

This study set out to explore acceptance and success factors in the organizational implementation of AI-based chatbots in customer communication. The findings highlight that adoption cannot be explained by technological performance alone. While speed, availability, and efficiency remain important, they must be complemented by trust, transparency, and usability on the user side, as well as by training, communication, and cultural adaptation on the organizational side. This multi-dimensionality demonstrates that chatbots function as socio-technical systems, where successful use depends on the alignment of technical, organizational, and cultural elements.

From a theoretical perspective, the results contribute to extending classical models of technology acceptance. The Technology Acceptance Model [7] and the Unified Theory of Acceptance and Use of Technology [8] provide useful baselines but are insufficient to capture the complexity of AI-based systems. Our findings suggest that these frameworks should be expanded to integrate trust, transparency, and cultural adaptation as core variables. Moreover, the organizational dimension—particularly the role of training and change management—emerges as a central

determinant of sustainable adoption. In this way, the study helps bridge the gap between individual-centered acceptance models and systemic perspectives from organizational and innovation research.

For practitioners, the study underscores that successful chatbot projects require active management rather than passive rollout. Organizations must invest in employee training, establish clear communication strategies, and align chatbots with broader service strategies. Without these measures, users may perceive chatbots as cost-cutting tools rather than value-adding innovations, thereby undermining long-term adoption. In addition, organizations should treat cultural adaptation as an ongoing process rather than a one-time design decision, ensuring that chatbots reflect evolving customer expectations and communication norms.

For policymakers, the findings suggest that regulation plays an ambivalent but crucial role. Strict data protection laws and ethical standards can slow down adoption but simultaneously build long-term trust in AI-based communication systems. Regulatory frameworks should therefore aim to strike a balance between enabling innovation and safeguarding fundamental rights. By doing so, they contribute not only to market efficiency but also to the legitimacy and sustainability of digital services.

Looking forward, several avenues for future research emerge. Longitudinal studies are needed to examine how trust in chatbots develops over time and whether repeated interaction leads to habit formation or continued scepticism. In addition, the rise of multimodal and embodied conversational agents raises new questions about anthropomorphism, empathy, and the blurring boundaries between human and machine communication. Finally, the ecological footprint of large-scale AI systems should be addressed more systematically, as the energy demands of chatbot infrastructures pose important challenges for sustainable digital transformation.

In sum, this study demonstrates that the acceptance of chatbots in customer communication is not a self-evident outcome of technological availability. It must be actively shaped through organizational practices, cultural sensitivity, and responsible governance. By integrating these dimensions, both researchers and practitioners can contribute to developing chatbot systems that are not only efficient but also trustworthy, legitimate, and sustainable.

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Design and Evaluation of a Portable ESP8266-Based IoT Tool for Wi-Fi Signal Monitoring

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Abstract

Internet of Things (IoT) implementation for smart homes, workplaces, and educational centers requires very efficient Wi-Fi networks to function. Unlike conventional Wi-Fi analyzers, which require cumbersome devices and manual operation, IoT-based devices can autonomously detect access points and automatically upload IP addresses, Service Set Identifier (SSID), Received Signal Strength Indicator (RSSI), and other metrics to cloud dashboards for visualization. In this paper, a low-cost Wi-Fi scanner with real-time monitoring of network availability and RSSI based on the ESP8266 microcontroller has been presented. From the experiments carried out, it can be seen that the system can effectively perform weak signal detection, coverage trend analysis, and optimization of IoT device placement. The proposed system is more efficient and portable than legacy tools, and is also energy-efficient and cloud-enabled. This makes it very suitable for educational prototyping, field testing, and light diagnostics. AI-based signal prediction, network clustering, and GPS-based spatial mapping will be the focus of future work to improve scalability and contextual intelligence.

Keywords: ESP8266; Wi-Fi Scanning; SSID, RSSI; IoT Diagnostics; ThingSpeak; Cloud-Based Visualization

1. INTRODUCTION

All regions face similar challenges in delivering sustainable transport solutions to meet their current and future mobility requirements. Transport authorities are aware of the real needs specific to their region but often find it difficult to identify detailed information on targeted solutions that would deliver direct and tangible positive outcomes.

The Internet of Things (IoT) has changed connectivity between the digital world and the physical world. IoT is facilitating the revolution of modern houses, retail businesses, and urban areas with the help of real-time data and cooperation. The amazing world of IoT is heavily reliant on broadband Wi-Fi and secure and fast data transfer. It is also the technology that can deal with complex infrastructure like skyscrapers, factories, and warehouses [2].

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IoT has gained traction in manufacturing and is on the road to development in smart housing, where cost matters the most, and scalability is the second. The research on IoT smart home control systems emphasizes the need for low-cost solutions that meet the locality's requirements to steer clear of the exorbitant prices of commercial systems [15]. The same issues are raised in wireless diagnostics, where the current analyzers are usually very expensive, bulky, and not suitable for minimalistic or portable applications.

A combination of wireless technologies like Wi-Fi, LPWAN, and 5G has been able to offer different IoT shapes through their various attributes such as range, power consumption, and scalability [14]. The installation of new transmission protocols and the advancements made in 5G networks have led to the birth of IoT solutions that mainly target monitoring and control systems [10]. It has become mandatory to collect and process various data streams even with the use of sophisticated data analytics in order to realize the objectives of scalable, energy-efficient, and context-aware IoT systems. In this regard, the demand for low-cost, smart, and wireless diagnostic devices that operate in real-time has been raised, particularly in mobile and resource-constrained settings.

The ongoing miniaturization of microelectronic circuits and the advent of embedded systems have paved the way to easily deploying IoT systems for every user. To illustrate, the ESP8266 Wi-Fi microcontroller is a small, cheap, and energy-saving device that provides data gathering and remote communication solutions [1]. The device's low price and versatility have been some of the factors behind its widespread use in consumer and industrial settings.

The established methods, on the contrary, are not applicable to traditional Wi-Fi device scanning technologies. Laptops, USB adapters, and specialized analyzers are the most common equipment for regular Wi-Fi device scanning, but they are bulky, costly, and require other power-hungry hardware, which makes them impractical for use on the move or in real-time diagnostics. NetSpot and Wireshark, for instance, have highly advanced features, yet they are intended for usage with desktop computers and not with lightweight IoT devices [11].

Throughout these findings, we tried to make a Wi-Fi scanner that was "mobile" and "inexpensive" at the same time. The device, which uses the ESP8266 NodeMCU microcontroller, can do the needed Wi-Fi scans in an efficient manner. Our device can not only detect the Wi-Fi networks close by but can also gather their important information like encryption type, SSID, and RSSI, as a part of the scan. Moreover, the data that is collected is sent to the ThingSpeak cloud platform automatically, where it will be further processed and visualized in real-time [3][4].

The device is created with consideration of mobile nature, low cost, and low power consumption as it is aimed at 'in-motion' testing, light diagnostics, and academic use. The system is also designed in such a way that it can 'harmlessly' be extended in the future with things like robotic and unmanned platforms for autonomous deployment, GPS-based heat mapping, and AI-based signal forecasting, which is currently not confirmed in the design.

2. SYSTEM DESIGN

In order to carry out wireless diagnostics in real time, we required a tool that was light, inexpensive, and could be readily used in outdoor places. For this purpose, a microcontroller with integrated Wi-Fi, a cloud data analysis platform, and firmware modules for scanning, data transmission, and visualization were selected. These components are illustrated in Fig. 2, which depicts the modular architecture consisting of three layers: data acquisition, data transmission, and cloud analytics and visualization.

2.1 Hardware Components

To optimize cost and space, the ESP8266 NodeMCU was adopted because it is a Wi-Fi-enabled microcontroller that is both compact and low-cost. The functionality of the device includes continuous scanning of nearby wireless networks, as well as the SSID, RSSI, and encryption type of the devices. To maintain the portability of the system, it is designed to be powered by either a USB battery or a standard 5 V USB power supply, facilitating both field and laboratory use. To support various stages of the development and debugging process, a serial/USB interface is also included that allows serial communication and firmware flashing.

2.2 Software Components

The library Arduino ESP8266Wi-Fi.h has been used for performing Wi-Fi scans and getting network parameters for the firmware which was made and uploaded using the Arduino IDE. The data collected gets sent to the cloud using HTTP POST requests to the IoT analytics platform ThingSpeak that is a cloud service provider. Every RSSI value is mapped to a separate channel field (Field1-Field4), thus several access points can be monitored at the same time [3]. ThingSpeak with its in-built MATLAB environment supports extra analysis like trend analysis, clustering, and visualization. Although the features have not been fully covered yet, still they present possibilities for more investigations [8].

2.3 Data Flow and Architecture Diagram

As shown in Fig. 1, the architecture is divided into three functional layers:

1. Data acquisition – The ESP8266 NodeMCU collects information on all around access points. It then stores each SSID and RSSI in local memory [9].

2. Data transmission – Using the Wi-Fi of the local network, the information is uploaded to the cloud of ThingSpeak using HTTP POST requests. A different AP is handled on an additional field, allowing simultaneous tracking.

3. Cloud-based analytics and visualization – The user can make use of coverage maps in different weak areas and placement of devices, thanks to the functionality of IoT that allows the real-time display of RSSI charts on the ThingSpeak. Further advanced analysis and MATLAB support are offered, allowing sophisticated plotting, reviewing old data, and grouping.

This modular design ensures flexibility, scalability, and easy adaptation for a wide range of IoT diagnostic applications
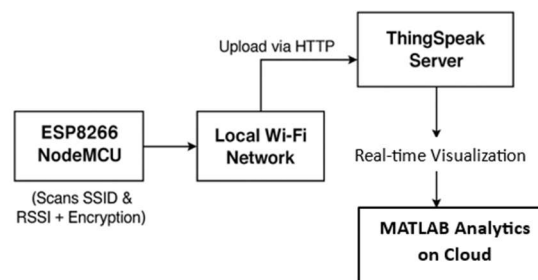
Fig. 1: Workflow of ESP8266-Based Wi-Fi Scanning and Cloud Analytics System

2.4 Device Suitability for IoT Applications

IoT devices are gaining popularity in various sectors of the economy. They provide the necessary connectivity to smart parts and machines in production based on Industry 4.0 and ensure connectivity in production. Integration often becomes more problematic and requires additional gateways due to the wide range of communication protocols. The direct connection of devices to existing Wi-Fi systems, which extends low-latency communication and reduces system costs, is a significant advantage of using IEEE 802.11 (Wi-Fi).

For devices to be independent and battery-powered, conventional Wi-Fi modules are known to be quite power-hungry. In this niche, the low-cost ESP8266 module is known to stand out due to its designation as an ultra-low power device. Despite this, some relevant recent studies have shown its viability. According to experiments, a 1000mAh battery can support transmissions with intervals of a few seconds and allows 2 to 4 days of operation between charges. Its suitability for low-cost, battery-powered IoT deployments is further confirmed by the fact that its received signal strength and packet delivery ratio stay constant across a range of distances and antenna orientations [1].

3. IMPLEMENTATION AND EXPERIMENTAL EVALUATION

Along with the implementation of the ThingSpeak analytics platform, cloud visualization platform, real-time data acquisition, and data analytics, the embedded firmware for the ESP8266 microcontroller was written. In order to test the system, it was set to collect, transmit, and analyze Wi-Fi signal data coming from multiple access points in a real indoor environment.

3.1 Wi-Fi Scanning Process

The ESP8266 NodeMCU was programmed to conduct Wi-Fi scans via the Arduino IDE and the ESP8266Wi-Fi.h library. In each of the scan cycles, the Wi-Fi.scanNetworks() function was called to search for access points (APs). The following information was procured for each AP:

   • SSID (network name)

   • RSSI (Received Signal Strength Indicator, in decibels)

Wi-Fi scanning with the ESP8266 has been studied in earlier research in probe-based detection systems for low-cost network surveillance and retail data collection [5].

3.2 Data Transmission and Visualization

The ESP8266 used pre-configured network credentials to connect to the Internet and sent RSSI values to specific ThingSpeak fields via HTTP POST requests in order to send the scanned data. For every field, ThingSpeak automatically produced time-series plots, allowing for the real-time visualization of signal fluctuations. The integrated MATLAB analytics environment could be used to access historical data or export it in CSV or JSON format.

3.3 Experimental Setup

The indoor device data collection is part of the experimental phase. Wi-Fi signals are impacted by various factors such as walls, furniture, electronic devices, and user moving around. Mostly, indoor Wi-Fi usage of the users gives the wireless network the day-to-day performance scenario. In our investigation, there were four different access points or networks that were all within the range, and they were identified as field1, field2, field3, and field4. The device gets a different Wi-Fi signal from each of these fields. In this manner, the analysis done indicates how different networks perform in the same place by mapping these fields separately so that the relative signal strength and stability of the networks can be directly compared.

About 200 separate RSSI data points were taken during the experiment, which was a very large data set that was further drawn, tested, and applied to the artificial intelligence models. The analysis conducted this way makes it possible to secure the system when tested in real-world scenarios of indoor deployments with different conditions of signal strength and interference.

3.4 Visualization Results

Based on the outcome of the study, ThingSpeak created visual representations that showed constant changes of the RSSI values at all the monitored access points. The scatter plot of RSSI measurements with trend lines for four access points is shown in Fig. 2 and it shows both the stable and unstable signal behaviors that indoor wireless environments typically have. The results obtained corroborate the functionality of the ESP8266-based Wi-Fi scanning system and the capability of the presented system for capturing and visualizing real-time signal fluctuations over multiple networks.

When the captured results were analyzed, the conclusion was drawn that the stable connections in Field 2 and Field 3 were signal-wise relatively consistent while the weaker or unstable connections in Field 1 and Field 4 presented a larger signal fluctuation range including sudden drops. By this comparative visualization the system, on one hand, confirms its capability and, on the other hand, it is also confirmed that it tracks multiple APs in parallel, allows to spot areas with poor coverage and gives valuable guidance for IoT devices' location. Fig. 2, directly linking the theoretical design of the system with practical performance, serves as the backbone of the experimental evidence in this study.
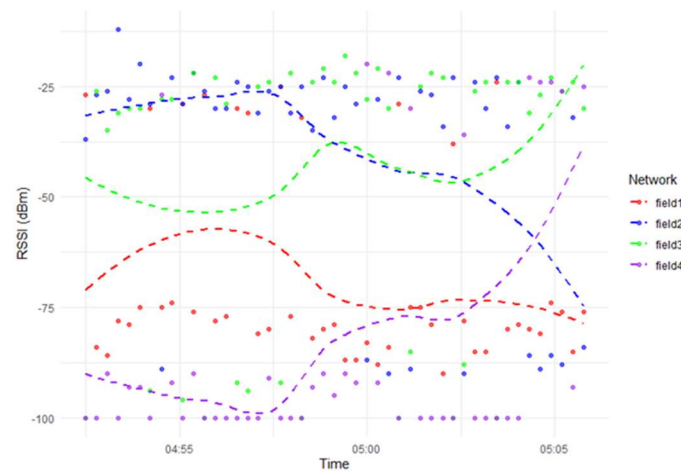
Fig. 2: Scatter plot of RSSI signal strengths with trend lines across four Wi-Fi networks

In order to analyze the performance of individual networks more thoroughly, ThingSpeak graphs were employed for the simultaneous monitoring of each access point. Figure 3 illustrates four time-series plots representing Fields 1-4, with each one linked to a different AP. These charts clearly indicate the changes in signal strength over time within the area under surveillance:

- Field 1 (RSSI 1): Overall, the values were lower from the beginning to the end, and the average strength was –68.30 dBm.

- Field 2 (RSSI 2): The signal was initially good but then gradually declining, with an average of –39.91 dBm. This particular field experienced the least loss when compared to its initial conditions.

- Field 3 (RSSI 3): The signal was stable and positive in trend, with an average of –44.91 dBm.

- Field 4 (RSSI 4): The signal was characterized by frequent drops and instability, with a high average of –81.94 dBm, suggesting the connectivity was unreliable.
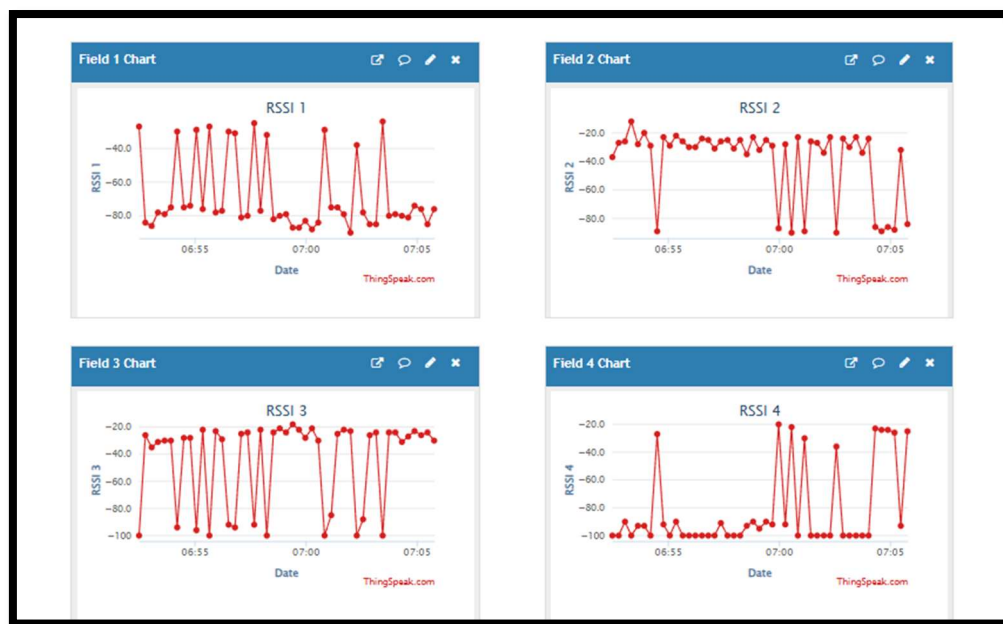
Fig. 3: Real-time ThingSpeak visualization of RSSI values for four monitored Wi-Fi access points (Fields 1–4)

To interpret the data correctly, it was not only essential to visualize the RSSI values but also to identify the wireless networks corresponding to each measured field. The ThingSpeak channel status log in Fig. 4 shows that the SSID of every detected app is tied to the field which holds its RSSI values. This connection makes the monitoring process clearer and easier to interpret as the users are able to know which network each time-series plot refers to directly. Fig. 4 not only integrates SSID metadata with numerical signal strength values but also proves the system's capability of providing context-aware diagnostics. This property enlarges the use of the ESP8266-based scanner, as it not only measures and visualizes the signal strength changes but also provides important insights for network management, covering assessment, and IoT devices deployment.

The mentioned visualizations together give actionable information for diagnosis, thus making it possible to carry out activities like the evaluation of coverage, the detection of weak signals, and the planning of the redundancy of IoT devices located in a particular area.

Fig. 4: ThingSpeak channel status log associating detected SSIDs with RSSI fields.

3.5 Performance Evaluation

The reliability, responsiveness, and energy efficiency of the Wi-Fi scanning system were verified through testing in an indoor multi-room setup. The ESP8266 NodeMCU not only receives the parameters of the Wi-Fi signal but also sends them to the ThingSpeak cloud platform with almost no delay, thus proving the possibility of monitoring in real-time.

The built system had a scan refresh rate of about two scans/second that allowed the changes in the signal strength between the areas to be monitored in real-time. The total delay from the time the signal was acquired to the time it was displayed on the ThingSpeak dashboard was measured and never surpassed 1.2 seconds. The total latency includes time for local scanning (~200 ms) and time for cloud upload (~1s), thus marking the system as ideal for real-time IoT diagnostics.

For energy efficiency, the system exhibited very low power consumption across various operating modes. When powered by USB, the current draw was under 100 mA. Using a 1000 mAh Li-Po battery, the device survived active scanning for approximately 22 hours, and using deep sleep mode reduced consumption to an average of 3.2 mA, providing an operating time of almost 13 days.

These results validate the system for handheld, long-term IoT use, where low power consumption and latency are most critical. Table 1 shows the key performance metrics.

Table 1: Summary of Key Performance Metrics

Evaluation Metric	Result
RSSI scan refresh rate	~2 scans per second
Data transmission latency	< 1.2 seconds
Power consumption (USB)	< 100 mA

Evaluation Metric	Result
Power consumption (LiPo, active)	45 mA avg. (~22 hours)
Power consumption (LiPo + deep sleep)	3.2 mA avg. (~13 days)

3.6 Limitations and System Robustness

Despite its advantages and great promise for easy IoT deployment, the system described in this paper has a number of technical limitations that need to be considered.

First, at the hardware level, the ESP8266 can only see a few nearby access points in each scan cycle - about four access points in real tests - and this may be insufficient in very dense environments with overlapping AP networks. If the design is supplemented with powerful microcontrollers such as the ESP32, which has more processing power, more memory, and built-in dual-band Wi-Fi, then the previous limitation can be overcome. Alternatively, software filtering can be used, whereby the device would select only those access points (APs) that meet predefined conditions - for example, having a signal stronger than a certain RSSI threshold or belonging to predefined SSID networks.

Second, signal stability is very sensitive to environmental factors. Attenuation is the result of physical barriers— reinforced concrete walls, metal doors, or large pieces of furniture—that lie across the propagation path. Furthermore, temporary RSSI deviations are often the result of interference from common 2.4 GHz devices, such as microwave ovens and Bluetooth peripherals. These effects were partially mitigated during testing by using techniques that reject the deviations and by averaging multiple scans. Also, to ensure stability even in changing conditions, the system could be improved by automatic interference detection and dynamic switching of wireless channels. It would also be good to consider peer-to-peer mesh networks, as well as scanning algorithms that adapt to the quality of the connection. All of this would allow the system to scale more easily and be more resistant to interference. Similar studies have already been conducted on the ESP8266 painfulMesh library, where it was shown that networks with a small number of nodes have very low latency, but with larger networks, scalability issues arise [17]. These results confirm that mesh approaches can significantly extend the functionality of simple IoT devices like the ESP8266.

Other parameters, such as encryption type, can be extracted using the ESP8266, but were not analyzed in this study because signal strength and network availability are areas of interest. There are opportunities for future studies to extend the comparison to include encrypted data, allowing network security capabilities to be examined alongside performance factors.

Third, the existing system does not have spatial awareness, which is the reason why it is less suitable for applications such as outdoor diagnostics or mobile signal mapping. In the absence of GPS, geotagged RSSI readings cannot be collected, and consequently, spatial heatmaps over larger areas, which can be as large as a campus or city, cannot be created. The integration of low-power GPS modules is a future improvement that will make it possible to use the system in mobile and geospatial applications.

Finally, various robustness features have been incorporated to make the system more reliable in harsh conditions. The main features are:

- Connection recovery: Automatic Wi-Fi reconnection with exponential backoff (5, 10, 20 seconds).

- System monitoring: A hardware watchdog with a timeout of 3 seconds and a software-level timeout for scans.

- Power management: Monitoring of voltage levels and activation of deep sleep mode when supply voltage falls below 3.3V.

The aforementioned mechanisms, although they result in an increase of about 12% in the size of the firmware, experimental validation has shown that the system only loses less than 0.5% of its data during the long tests, indicating that the system is still reliable even though it is limited by the hardware. It is also possible that future research will investigate peer-to-peer mesh networking and adaptive scanning algorithms that will automatically regulate their adjustment according to the quality of the connection, thus further enhancing scalability and robustness.

3.7 Comparative Evaluation with Traditional Wi-Fi Scanning Systems

In large-scale and professional settings, Wi-Fi analysis tools such as NetSpot, inSSIDer, and Wireshark are still prevailing within the Wi-Fi analysis category and these tools are very diverse in application ranging from intrusion detection, wireless diagnostics to very detailed packet-level inspection [11-13]. One of the reasons why these platforms are so powerful is that they feature a wide range of protocol-level analysis and advanced visualization techniques at the same time. Nevertheless, the drawbacks mentioned above are also very much pronounced for mobile and low-resources IoT applications. The need for laptop hardware, high computing power, manual setup, and limited mobility makes these tools less suitable for being used in embedded and outdoor deployments.

On the other hand, the proposed Wi-Fi scanning system based on ESP8266 gives a chance to the stacking of a lightweight, portable, and low-power solution that is tailored for IoT use cases. It doesn't necessitate any external hardware barring the microcontroller, works independently, and connects straight to the cloud for real-time data visualization and analysis. All these attributes make it highly suitable for school settings, prototyping, and mobile diagnostics, where low cost and simplicity of installation are key factors.

The system suggested comes with several benefits when compared to traditional Wi-Fi analyzers such as:

- No intervention required for real-time RSSI monitoring.

- ThingSpeak cloud integration for storage, visualization, and analytics has been done autonomously.

- Plug-and-play usability, so it can be quickly set up in either field or educational environments.

In Table 2, the comparison of the ESP8266-based scanner with conventional Wi-Fi analysis tools is presented directly in terms of price, portability, energy consumption, and user-friendliness.

Table 2. Comparison of ESP8266-Based Scanner vs. Traditional Wi-Fi Scanning Tools

Feature / Metric	ESP8266-Based IoT Scanner	Traditional Tools (e.g., NetSpot, inSSIDer)
Hardware Cost	<$5 (ESP8266 module only)	$500+ (laptop) + $50–$200 (software/license)
Portability	Pocket-sized, battery-powered	Laptop-dependent, limited field mobility
Power Consumption	<100 mA (USB or battery)	High (typical laptop power usage)
Ease of Use	Plug-and-play, minimal setup	Requires manual configuration, GUI setup
Cloud Integration	Native support (ThingSpeak API)	Needs external tools or scripts
Automation & Scalability	Fully autonomous operation	Manual operation, limited automation
Deployment Suitability	Ideal for embedded/remote/mobile use	Designed for on-site diagnostics
Data Visualization	Real-time cloud dashboards	GUI-based, often lacks cloud connectivity
Customization	Fully open-source firmware	Often proprietary and closed-source
Primary Use Cases	IoT prototyping, education, mobile scanning	Enterprise planning, advanced diagnostics

4. FUTURE WORK

The present Wi-Fi scanning tool, which measures signal strength and visualizes data in real time, is still very basic in its functions; its use in complex IoT applications can be increased through the implementation of better features.

The first thing that can be done to the system is the integration of predictive analytics driven by AI. Such support can be chiefly in the forms of anomaly detection, zone classification, and performance forecasting. The presence of these algorithms will mean that the weak areas of the network can be automatically identified or the network deterioration can be anticipated which would result in the increase of diagnostic precision and the provision of autonomous decision-making. The previous studies have pointed out that context-aware computing is the predominant factor for the detection of sensor data in IoT systems and is the basis for adaptive and intelligent diagnostics [18].

Secondly, the addition of GPS functionality would be a great step in the geotagging of scan data, plus it would also help in the production of spatial signal-strength heatmaps. Such a development would mean that the whole process can be carried out in mobile platforms such as drones, service robots, or smart city deployments, and, in addition, the mapping of large areas would be possible even in places that are hard to reach with signals of the right strength.

Lastly, the research in the future should consider the use of cloud-based dashboards and lightweight edge analytics to make it easier for non-specialist users. The presence of a web or mobile interface would mean the possibility of seamless configuration, real-time monitoring, and automated reporting. The features mentioned above would

contribute significantly to the tool's responsiveness, adaptability, and integration into the IoT infrastructures of the future.

5. CONCLUSION

In order to monitor wireless signal strength and network availability in real time, this paper presents the design and implementation of a portable, low-cost Wi-Fi scanning system based on the ESP8266 microcontroller. Key parameters—including RSSI, SSID, and encryption type—were reliably captured and transmitted for remote analysis using the ESP8266's onboard Wi-Fi capabilities and cloud-based visualization through the ThingSpeak platform.

The validation conducted in an indoor environment with multiple rooms showed the system's good performance, accuracy in signal logging, and successful cloud integration, which meant it was suitable for different applications like diagnostics in the field, rapid prototyping, and educational usage. Due to its low cost and modularity as well as easy deployment, the system is very accessible to a wide range of users.

Artificial intelligence has not been included yet, but the architecture is still flexible. The future improvements will be GPS-supported spatial mapping, use in mobile scanning platforms, and connection with on-site or cloud-based AI for the purposes of anomaly detection and predictive analytics. More importantly, earlier researchers have pointed out that context-awareness enabled computing as an IoT system is one of the most critical factors since it makes sensor data easily understandable and available for adaptive decision-making [18]. The mentioned improvements will give the system the ability to progress from merely a signal monitor to an advanced diagnostic tool for the entire IoT.

The focus on being inexpensive and versatile goes hand in hand with the findings in smart home IoT systems where having cheap solutions is a prerequisite for the technology's widespread acceptance [15]. To sum up, the proposed ESP8266-based Wi-Fi scanner not only offers a great starting point for providing inexpensive wireless monitoring but also has good chances of becoming an AI-assisted, context-aware diagnostic tool that is capable of managing IoT infrastructures of the next generation.

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Analysis of EL Image Resolution on Photovoltaic Modules Defect Detection

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Abstract

Electroluminescence (EL) has become an important tool for photovoltaic (PV) failure detection. However, there are some drawbacks. For example, high-resolution cameras are expensive, and it is difficult to capture high-resolution images of large PV panels. This is especially challenging when imaging from drones, as the distance from the panel significantly affects the image quality. Our work is focused on EL imaging to evaluate the effect of images resolution on defect classification in photovoltaic (PV) cells. To determine a resolution beyond which image size does not yield significant accuracy improvement and computational efficiency, multiple image sizes, i.e. resolutions were processed. Classical machine learning algorithms (Logistic regression, random forest and SVM) and a lightweight convolutional neural network (CNN) were tested to see how they performed under different image resolutions. The findings indicate that increasing image dimensions does not always improve accuracy, as critical fault details can be recorded adequately at intermediate resolutions. Furthermore, some deep learning architectures demand fixed input sizes; therefore resolution analysis is very important for model compatibility and computational performance optimization.

Keywords: Photovoltaic defect detection, electroluminescence imaging, classical machine learning, image resizing

1. INTRODUCTION

The swift global shift towards clean energy has positioned photovoltaic (PV) technology as a leading force in renewable power generation. However, their performance and long-term reliability are hindered by undetected physical and electrical issues. Among these, cracks in the cells represent one of the most frequent and detrimental issues, because they disrupt the uniform flow of current within the cell, causing localized resistive losses that

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ultimately reduce power output, create current mismatch, and accelerate long-term degradation. [1], [2]. Besides cracks, PV cells can be affected by other structural defects, including Finger breaks, often caused by metallization failures, soldering stress, or corrosion, leading to increased series resistance and reduced charge collection. While inactive areas defect generally result from severe structural damage, delamination or broken interconnections, appearing as large dark patches reflecting loss of local electrical activity. dislocation clusters that appear as small, irregular dark spots caused by distortion in the silicon crystal lattice and grain boundaries. and the grain boundaries naturally arise during solidification of multicrystalline silicon as independently oriented crystal grains merge; they manifest as long continuous dark lines separating adjacent grains in multicrystalline wafers. These defects collectively degrade the efficiency, durability, and cost effectiveness of the PV cells. To enhance these performance factors, an early and reliable detection of such defects is crucial. Among the available diagnostic tools, Electroluminescence (EL) imaging has emerged as most effective non-destructive techniques for identifying structural defects within PV cells, exemplary EL images typically show a uniform bright background corresponding to healthy cell regions, while the irregular structural patterns appear as localized dark contrasts [3], [4]. In EL imaging, the PV module emits infrared radiation when forward biased, allowing cracks and fracture patterns within the cells to be clearly visualized.

To automate and enhance defect detection accuracy, recent research has shown a strong focus on integrating machine learning (ML) and deep learning (DL) techniques with El image analysis. [6], [7]. Thus, the effect of image processing steps – such as image scaling – on the model performance and efficiency remain underexplored. Since resizing changes the pixel density representing fine features like cracks, it can directly impact both feature extraction and classification results. Moreover, deep learning architecture often requires fixed input dimensions, making scaling a critical step for model compatibility and performance optimization [8].

This study investigates how image resolution affects defect classification accuracy using classical ML algorithms (logistic regression, random forest, and SVM) and a lightweight CNN model. Because resolution is directly influenced by the image-scaling parameter, we applied different scaling levels to generate multiple resolutions of the original EL images. The objective is to determine an optimal resolution threshold balancing accuracy and efficiency.

2. METHODOLOGY

2.1. Overview

The methodology followed in this study consists of three main stages: **data preparation, image scaling, and defect classification**. Electroluminescence (EL) images of photovoltaic (PV) cells were processed and resized to multiple resolutions to analyse how image scaling parameter -used to modify the spatial resolution- influences defect detection accuracy and computational efficiency across classical and deep learning algorithms. Because certain defects manifest their occurrence in EL images. Cracks appear as dark linear traces in the EL images, Finger breaks as interrupted, missing or discontinuous bright lines, and large dark patches or zones represent inactive areas.

The workflow is illustrated in Fig 1, showing the process of evaluating the EL images resizing influence on defects classification.
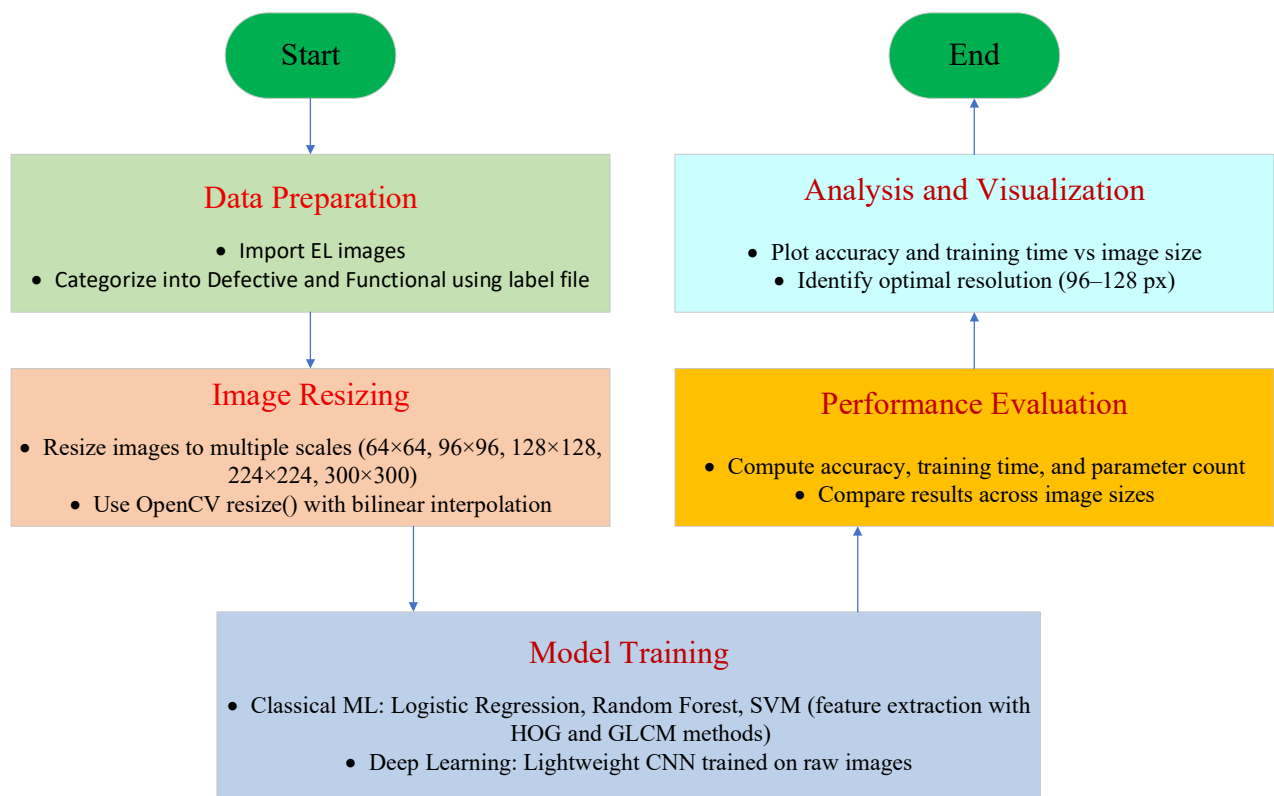
Fig. 1. Workflow of the Proposed Method for Evaluating Image Scaling Effects on PV Cell Defect Detection.

Fig. 2. Represent the appearance of defects (crack, Inactive area, and Finger break) at Electroluminescence (EL) Images.
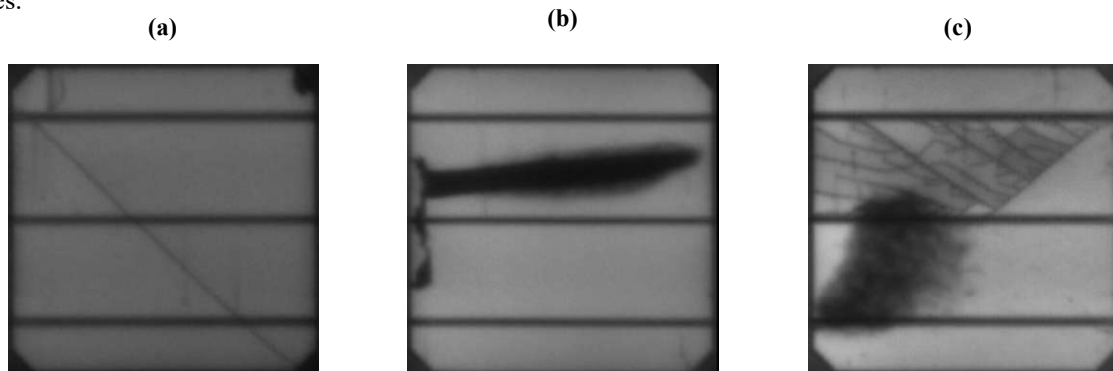

Fig. 2. (a) Cracks, (b) Inactive area, (c) Finger break

2.2. Dataset and Preprocessing

The dataset used in this study obtained from a prepared and published benchmark for defect detection in photovoltaic module research [9], [10]which includes a total of 2,624 grayscale with an initial size of 300 x 300 pixels EL images of solar cells acquired under controlled laboratory conditions exhibiting various defect types such as cracks, inactive areas, and broken fingers. Each image corresponds to a single solar cell and is accompanied by metadata specifying a *defect probability* value. Based on this information, the dataset was transformed into a binary classification problem, where images with a defect probability equal to or greater than 0.5 were labelled as *defective* (label 1), and those with a value below 0.5 were labelled as *functional* (label 0).

Resizing an image modified the number of pixels representing each solar cell, consequently affecting both, the level of visual details available to the learning model and the computational load of it. To evaluate this influence, each image was resized

to four dimensions (64×64, 96x96, 128×128, and 224×224 pixels), allowing an evaluation of how resolution affects the visibility of cracks and the performance of classification algorithms.

Table 1 summarizes the main properties of the dataset, including the total number of samples, image characteristics, and defect categories.

Table 1. Overview of the ELPV dataset

Property	Description
Total samples	2,624 EL images
Image type	Grayscale (single channel)
Original size	300 × 300 pixels
Classes	Functional (0), Defective (1)
Label source	defect probability ≥ 0.5
Main defects	Microcracks, finger breaks, inactive areas

2.3. Image Scaling and Model Compatibility

Higher image resolutions expand computational cost and training time, requiring a balance between accuracy and efficiency. Consequently, resizing an image modifies the number of pixels representing each solar cell, which can influence the level of structural detail available to the learning model. However, since most deep learning architectures require fixed input dimensions, scaling becomes a critical preprocessing step to maintain model compatibility and performance optimization [10], [11]. The objective was to determine an optimal resolution threshold beyond which further increasing image size yields no significant accuracy gain.

All images were rescaled into four resolutions beside the original: 64x64, 96x96, 128x128, 224x224 and 300x300 pixels, and stored into separate folders (each folder contains two subfolders: defective and functional), to evaluate the influence of image size on accuracy and efficiency of ML (logical regression, SVM, random forest) and a lightweight CNN. The resizing process was performed using OpenCV's resize function with bilinear interpolation, which estimates new pixel values from neighboring pixels to preserve structural details. This method offers a balance between image smoothness and computational efficiency during scaling.

2.4. Classification Framework

This work implements two categories of algorithms involved: classical machine learning (ML) and deep learning (DL).

- **Classical Machine Learning (ML):** Logistic Regression (LR), Random Forest (RF), and RBF-kernal SVM. each resized grayscale EL dataset (64, 96, 128, 224, and 300 px) were loaded from the *functional* and *defective* folders, flattened into one-dimensional feature vectors, and divided into training and testing subsets using an 80/20 stratified split
- **Deep Learning (DL):** A lightweight Convolutional Neural Network (CNN) was trained directly on image data. Datasets were automatically loaded from the processed folder. The CNN architecture consisted of three convolutional–pooling layers followed by global average pooling and a sigmoid output layer for binary classification. The same hyperparameters (ADAM optimizer, binary cross-entropy loss, batch size = 32, epochs = 5) were applied for all image sizes to ensure fair comparison.

Performance and computational cost for both categories were assessed using standard metrics—Accuracy, Precision, Recall, F1-score, and AUC—which collectively measure correctness, reliability, and discriminative ability. Each scale's results were tabulated and compared to identify performance trends. Training time as well were recorded.

3. RESULTS AND DISCUSSIONS

Tables 2 and 3 present the performances of the ML models and lightweight CNN across different image resolutions, showing how the accuracy, training time, and feature size change as the image size increases. In both the ML models and the CNN, the accuracy remained within a narrow range across all tested resolutions, as shown in Figure 3.

Alternatively, the training time increases steadily, and sharply in the case of CNN, as the image size increases, as shown in Figure 4.

Table2: Performance of Machine Learning across different image Scales

Image Size (Pixel)	Model	Accuracy (%)	Training Time (s)	Features
64 × 64	Logistic Regression	79.6	5.42	4,096
	Random Forest	81.9	23.91	4,096
	SVM (RBF)	83.0	4.50	4,096
96 × 96	Logistic Regression	80.2	4.24	9,216
	Random Forest	83.6	19.73	9,216
	SVM (RBF)	83.0	8.67	9,216
128 × 128	Logistic Regression	81.1	8.10	16,384
	Random Forest	82.7	28.95	16,384
	SVM (RBF)	83.2	14.15	16,384
224 × 224	Logistic Regression	80.8	23.23	50,176
	Random Forest	83.2	52.35	50,176
	SVM (RBF, raw)	83.2	51.46	50,176
	SVM (PCA-256)	83.0	0.31	256
300 × 300	Logistic Regression	79.6	39.58	90,000
	Random Forest	82.3	66.30	90,000
	SVM (RBF, raw)	83.2	78.13	90,000

Table3: CNN performance across different image sizes

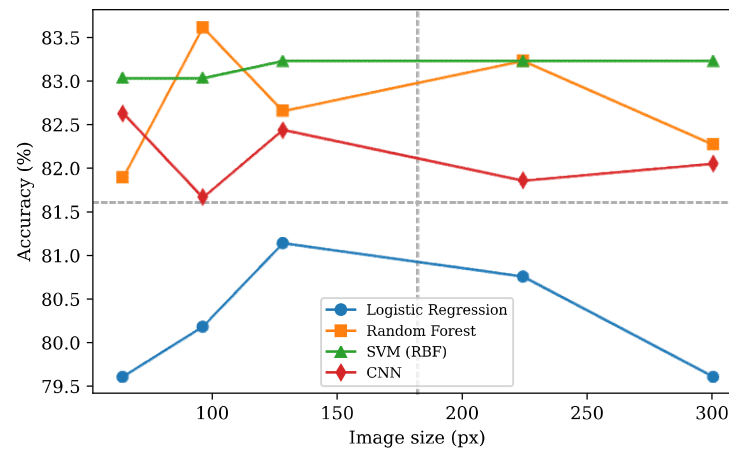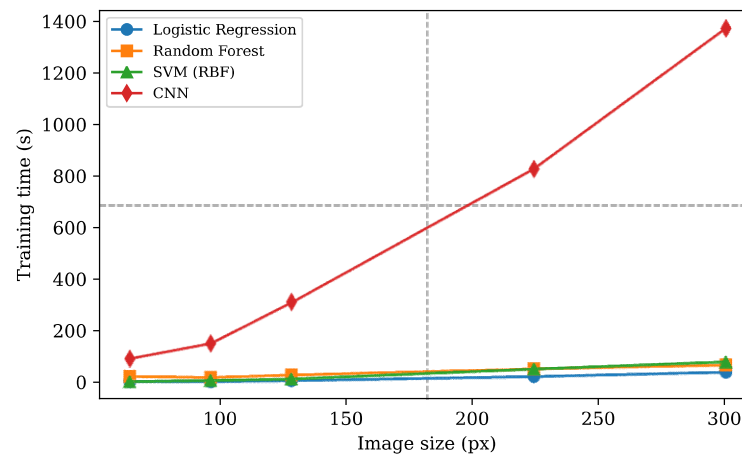| Image Size (px)	Validation Accuracy (%)	Training Time (s)	Parameters	Epochs
64 × 64	82.6	94.5	92,801	5
96 × 96	81.7	152.8	92,801	5
128 × 128	82.4	311.1	92,801	5
224 × 224	81.9	829.1	92,801	5
300 × 300	82.1	1373.4	92,801	5

Fig. 3. Accuracy vs Size

Fig. 4. Training Time vs Image Size

The results presented in Table 1 and Table 2 show that image scaling strongly influences computational cost, because larger images contain more pixels, causing higher feature dimensionality, leading to longer processing times for all implemented models. while having only a minor effect on classification accuracy. Classical machine learning models achieved accuracies between **79–83%**, with Random Forest performing best and Logistic Regression being the fastest. Accuracy improved marginally by about 1.9% up to 96x96 pixels and then plateaued, whereas training time rose sharply with image size. Applying PCA to the SVM drastically reduced computation time with negligible accuracy loss. The CNN model reached a comparable validation accuracy of around 82% for all image sizes, confirming that resolutions beyond 128×128 pixels offer limited benefit, that is, increasing computational cost without enhancing classification. However, its training time increased exponentially—from 94 s at 64×64 to over 1300 s at 300×300 pixels. Fig.2. highlights the steep rise in computation time for larger images. While Fig.3. illustrate the model

accuracy stabilizes beyond 128×128 pixels, Overall, both approaches indicate that intermediate resolutions (96×96–128×128) provide the best trade-off between preserving defect details and maintaining computational efficiency. For comparison, the reference study reported an SVM accuracy of 82.44% on the original images size 300×300 pixels, which is nearly identical to the accuracy achieved by our SVM model, despite using substantially lower-resolution inputs

4. CONCLUSION

This study investigates the influence of image resolution on defect classification -namely microcracks, finger breaks and inactive areas- accuracy and computational efficiency in photovoltaic (PV) cells using electroluminescence (EL) imaging. Both classical machine learning models and a lightweight convolutional neural network (CNN) achieved comparable accuracy levels (≈82%) within deferent resolutions (64, 96, 128, 224, and 300 pixels). However, results shows that accuracy improves marginally -by about 1.9%- up to 96x96 pixels then stabilizes, demonstrating that higher image scale do not necessarily enhance classification performance. However, computational cost increased significantly with image size, particularly for the CNN. To conclude that intermediate resolutions between **96×96 and 128×128 pixels** provide the optimal balance between accuracy and efficiency, effectively capturing defect-related features such as cracks while minimizing processing time. These results highlight the importance of selecting an appropriate input resolution to ensure model compatibility, reduce computation, and maintain robust defect detection performance in PV quality inspection. Nevertheless, the results suggest that using lower-resolution sensors can provide substantial cost savings in large-scale PV inspection systems without affecting diagnostic reliability.

Future work will build on these conclusions and focus on improving classification accuracy within integrating advanced deep learning architectures and transfer learning techniques.

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Assessment of Logistically Generated Carbon Emissions Avoided Through Local Community Initiatives

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Abstract

Reducing carbon dioxide emissions is one of the most important goals of our time. According to the Paris Agreement, carbon neutrality should be achieved by 2050, a distant goal. What can be done to minimize CO_2 emissions? It is not always necessary to think on a large scale, at the level of industry and services (e.g., transportation). Can small actions also be taken for the sake of our planet? The answer is clearly yes. In this publication, the power of community is demonstrated through the activities of a group that exchanges products locally rather than buying them. The product's carbon footprint is calculated based on the transport and packaging of the items in the group, using a hypothetical model that assumes they are delivered to us from their original place of origin. Based on the packaging size and weight of the goods, calculations are made of the CO_2 impact of transporting the product over different distances. The results are also analyzed by examining the activity of the local community using three distinct modes of transport and then comparing the amount of CO_2 emitted with the population of a city. The research demonstrates that freight transport is a significant source of greenhouse gas emissions and identifies opportunities to reduce carbon footprints through community initiatives. Although the product data related to the group's activities is based on a hypothetical model in some cases, our theoretical assumption—that significant carbon dioxide emissions can be saved through the exchange of goods within a community—can be confirmed. The research shows that even local community trade can significantly reduce global CO_2 emissions. Therefore, in addition to measures to reduce greenhouse gas emissions, applying the "Think globally, act locally" attitude would significantly reduce CO_2 emissions.

Keywords: carbon emission, local community, sustainability, logistics, packaging

1. INTRODUCTION

Global trade and consumption have grown exponentially over the past few decades, and transportation and packaging activities have been significant sources of environmental pollution. Local communities are beginning to evaluate their logistics and packaging practices as part of broader sustainability efforts. The purpose of this publication

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is to provide insight into various aspects of carbon footprint reduction initiatives, such as social, economic, and environmental.

Growing concerns about climate change and environmental sustainability have made reducing carbon emissions a top global priority [1]. While industries and governments struggle with large-scale solutions, the potential of local communities to contribute significantly to this effort remains largely untapped. Local communities are small communities of around 100-200 people who are connected by a common trait. There are several examples of local communities, such as colleges, sports communities, neighbourhoods, etc. Local communities are organized spontaneously and are controlled by all members of the community, unlike industries (which are organized on the initiative of individuals to achieve a specific goal) and government (which is controlled by a select few). Sharing within communities is a phenomenon as old as humanity itself, while collective consumption and the "sharing economy" are phenomena of the Internet age [2].

This community was chosen for the case study because it is a functioning, active community and the data were available to us, allowing us to demonstrate the "power of community."

This study focuses on the role of community-led initiatives in reducing carbon emissions, specifically in relation to logistics and packaging practices. These practices, which are often overlooked in broader discussions of carbon footprints, can contribute significantly to greenhouse gas emissions [3], [4]. The research aims to highlight the importance of bottom-up efforts, namely local community initiatives, in achieving global sustainability goals by examining the impact of local actions.

The research has several objectives, including a comprehensive examination of CO_2 emissions from traditional logistics and packaging processes, a listing of the basic strategies used by local communities, and an examination of the impact of sustainability initiatives. The study offers comprehensive insights into the benefits and challenges of community-led carbon footprint reduction programs based on quantitative data analysis and qualitative assessment.

Logistics, a multifaceted process involving various resources, inherently influences sustainability. As the global economy expands, so do logistics and supply chains, increasing resource use and environmental damage. The term "carbon footprint" refers to the environmental impact in terms of greenhouse gas (GHG) emissions, for which logistics and supply chain activities contribute significantly [5].

In logistics, the carbon footprint refers to the total GHG emissions generated by the movement of goods and people within the transport chain. Key greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and others, measured in carbon dioxide equivalents (CO_2e) to aggregate their impact [6].

Logistics activities such as transportation, manufacturing, distribution, warehousing, and last-mile delivery all contribute to the overall carbon footprint [7]. Factors influencing this footprint include mode of transport, distance travelled, fuel efficiency, and energy sources.

Calculating carbon dioxide emissions involves various methods, notably the Global Logistics Emissions Council (GLEC) Framework and the Greenhouse Gas (GHG) Protocol [7]. The GLEC framework, which is aligned with the GHG Protocol, provides recommendations for quantifying emissions from freight transport. The GHG Protocol, developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) [7], standardizes carbon accounting across sectors, ensuring transparency and credibility in reporting.

The research first presents CO_2 emission data for each logistics sub-process and the methodology used to calculate CO_2 emissions for the products. This is followed by an analysis of a marketplace created by a local community.

The novelty of the research lies in the use of a hypothetical model to quantitatively assess the carbon reductions achieved through a specific community initiative: a "Avoiding Waste" exchange group in the dormitories of the Széchenyi István University, in a local community of about 200 members. This unique approach enables tangible measurement of the environmental benefits of reduced packaging and transportation associated with exchanging goods within the community. By quantifying these reductions, the study provides concrete evidence of the positive impact of local measures on reducing carbon dioxide emissions.

The research questions guiding the study are as follows:
- How many carbon dioxide emissions can be saved by reducing transportation in a local community initiative?
- What are the implications of these results for regional and global sustainability efforts?

By answering these questions, this article aims to contribute to the knowledge base on community-led sustainability initiatives and their potential to drive significant change in the fight against climate change [8].

2. LITERATURE REVIEW

To introduce the literature, it is essential first to define what sustainability means.

Sustainable development is an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations [9].

The three dimensions of sustainability [10]:

- Economic
- Social
- Environmental.

One of the cornerstones of sustainability is community thinking. This can take many forms, from the cohesive power of the family, which helps its members survive, to joint activities in larger communities that promote sustainability.

This research presents the activities of a small community, based partly on real data and partly on estimated data. The accuracy of the data is not relevant to this research; rather, it is more important to present activities that show that even a small community can make a significant contribution to reducing CO_2 emissions.

A preliminary overview of the literature on ScienceDirect, Scopus, and Web of Science was conducted for the analysis. The keywords "local community" and "emission reduction" were used for the search. On ScienceDirect, 5480 publications; on Scopus, 1230 publications; and on Web of Science, 1071 publications were retrieved for these keywords on 07 September 2025. However, most publications focused on energy efficiency and agriculture-related activities. A more in-depth literature review has selected publications on sharing surplus products within the community. A summary of these publications is presented in Table 1.

Table 1. Relevant publications on the topic

Authors, year	Title	Details of the publication
Julsrud 2023	Sustainable sharing in local communities: exploring the role of social capital [11]	Traditionally, traditional forms of local sharing have recently been complemented by internet-based peer-to-peer sharing applications. This paper applies the perspective of social capital to explore the relational foundations of different forms of sharing in local communities. It provides a basis for discussion on how to increase local sharing [11].
Nadeau and Koebele 2023	Collaborating to reduce food waste: building collaborative advantage in local food systems [12]	Food loss and waste in the food supply chain is a growing problem with significant economic, social and environmental consequences. Due to the large number of stakeholders involved in the food supply chain and the complexity of their relationships, there is a growing interest in addressing food waste issues through collaborative governance approaches such as Food Policy Councils (FPCs) [12]
Biglan et al. 2020	The State of Experimental Research on Community Interventions to Reduce Greenhouse Gas Emissions - A Systematic Review [13]	This study reviews research on Community efforts to reduce greenhouse gas emissions. It conducts a systematic search of the relevant literature and complements its findings with an analysis of previously published review studies on the subject [13].
Arcidiacono, Gandini and Pais 2018	Sharing what? The 'sharing economy' in the sociological [14]	The first part of this publication presents the development of the concept of the 'sharing economy' and its main analytical implications. The second part outlines the main findings of a systematic review of the literature, which indicates that academic research on the sharing economy has expanded significantly since 2013 [14]
Hamari, Sjöklint and Ukkonen 2016	The sharing economy: Why people participate in collaborative consumption [15]	Information and communication technologies (ICTs) have enabled the spread of so-called collaborative consumption (CC): the coordinated acquisition, transfer or sharing of goods and services between peers through community-based online services. Collaborative consumption (CC) is expected to alleviate social problems such as overconsumption, pollution, and poverty by reducing the costs of economic coordination within communities. This paper investigated the motivations behind people's engagement in collaborative consumption [15].
Belk 2014	You are what you can access: Sharing and collaborative consumption online [2]	This study compares sharing and collaborative consumption and finds that both are increasingly popular today. It provides examples and assesses the reasons for the current growth of these practices and their impact on businesses that still use traditional sales and ownership models [2].

| Albinsson and Yasanthi Perera 2012 | Alternative marketplaces in the 21st century: Building community through sharing events [16] | They examined alternative consumption, including co-consumption, sharing, and non-consumption (i.e. post-consumption activities such as reuse, recycle, reuse, recycle, etc.) at non-monetary private and public sharing events, including Really Really Free Markets (RRFM). Today, many consumer groups use this model to organize public sharing events to raise awareness on various issues, including sustainability and overconsumption. Participants bring, share, and buy goods without expecting to exchange money or anything else [16]. |

Afterwards, the 1230 publications in the Scopus database were visualised using the VOSviewer program [17], which shows the co-occurrence of keywords and the direction in which a term has moved and is heading for a given keyword.
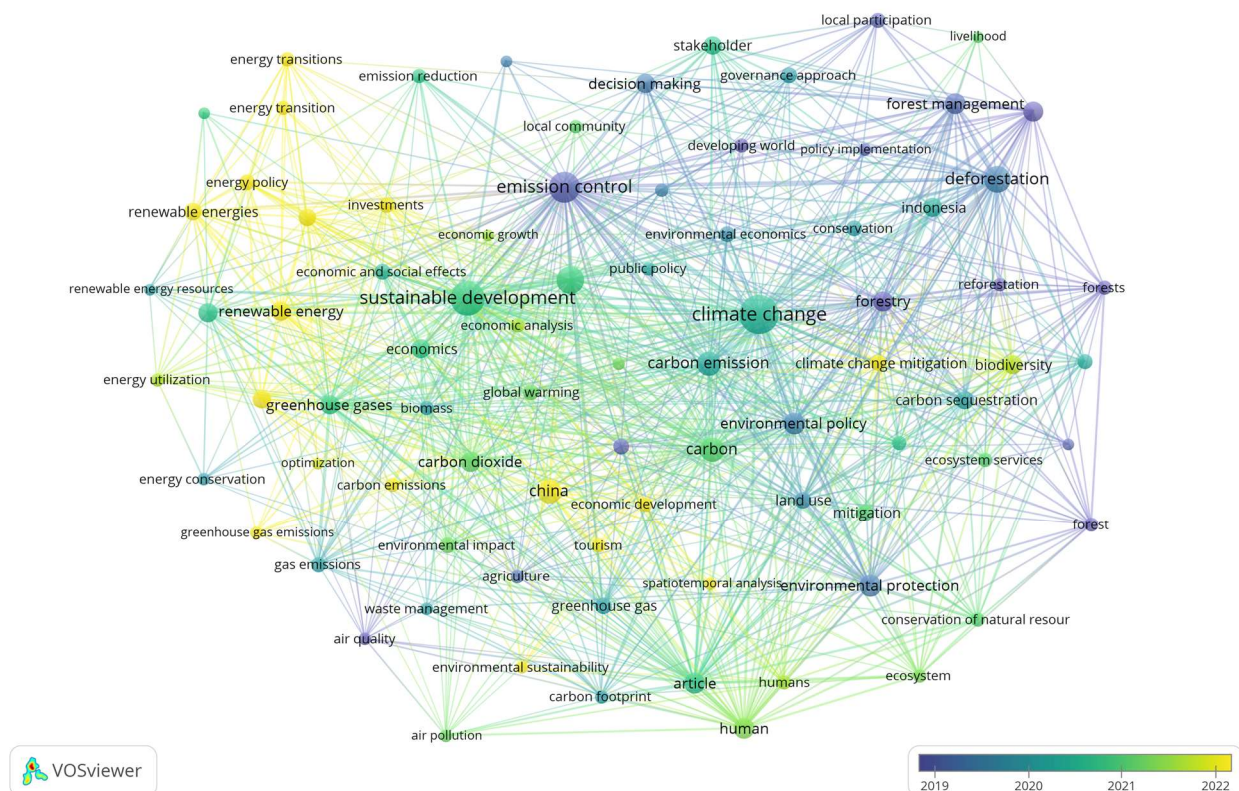

Fig. 1. Overlay Visualisation by VOSViewer from the Scopus research results of keywords: "local community" AND "emission reduction" on 07 September 2025. Minimum number of occurrences: 20

As shown in Figure 1, in 2018-2019, the focus was on the keywords "climate change" and "emission control". In 2020-2021, the keywords "sustainable development" and "economics and social effects" were added, indicating that experts already recognize the role of humans in reducing emissions. The keyword 'community' is absent from the figure, underscoring the understudied role of communities in sustainability.

3. THEORETICAL BACKGROUND: THE RELATIONSHIP OF LOGISTICS SUB-SECTORS WITH CO₂ EMISSIONS

This chapter describes the relationship between logistics sub-sectors and CO_2 emissions.

Supply chain: Estimating CO_2 emissions from supply chains is complex and is influenced by industry, modes of transport, and production processes. According to a 2016 McKinsey report, supply chains account for approximately 40% of total U.S. emissions. The Carbon Trust suggests that supply chain emissions can be four times greater than a company's direct operational emissions. The 2020 CDP Global Supply Chain Report indicates that supply chain emissions are, on average, more than 11 times higher than companies' operational emissions [18].

Transportation and freight: Freight transportation has a significant impact on carbon emissions. Air freight generates 30 times more emissions per kilometer than sea freight. In 2017, the US transportation sector accounted for 29% of total GHG emissions. Studies show that freight transport, especially trucking, contributes significantly to emissions, with trucks accounting for 29.4% of freight transport emissions. Empty miles in freight transport, where trucks operate without cargo, exacerbate inefficiency and pollutant emissions, as 36% of heavy-duty trucks in the United States run empty [19].

Warehousing: It accounts for significant carbon emissions, second only to transportation. Material handling in logistics buildings accounts for 13% of total supply chain emissions. In the United Kingdom, warehouses are responsible for 10.2 million tons of CO_2 equivalent emissions, which can be reduced through simple changes [20].

Packaging: European manufacturing capacity has increased the role of cardboard in packaging containing primary and recycled fibres. The carbon footprint of cardboard production and conversion is 964 kg/tonne of fossil CO_2 equivalent emissions. The environmental impact of packaging materials varies: cardboard and paper emit 0.94 kg/kg of CO_2, while plastic emits 3.50 kg/kg [7].

Table 2. Carbon footprint of packaging material Source: own compilation based on RISE Bioeconomy [21]

Packaging Material	Carbon Footprint (kg CO_2 /kg)
Carton Board Production & Conversion	0.96 kg
Cardboard & Paper	0.94 kg
Plastic	3.50 kg
Cartonboard (Total Carbon Footprint)	0.26 kg
Amorphous PET Granulate	3.09 kg
PP (Polypropylene)	2.11 kg
PVC (Polyvinyl Chloride)	2.12 kg
LDPE Granulate	2.30 kg
HDPE Granulate	2.11 kg

Packaging tape: Packaging tape also significantly contributes to shipments' carbon footprint. Emissions from packaging tape can reach 19 grams of CO_2 equivalent per shipment, representing a significant portion of an average shipment's packaging foot-print [22].

Efforts are being made at various levels to mitigate the environmental impact of logistics [23].

- At the international level, the 2015 Paris Agreement committed the EU to reducing emissions by at least 55% by 2030 compared to 1990 levels [24].
- At the national level, countries such as Denmark and Sweden have adopted carbon tax policies to reduce CO_2 emissions, which has a significant impact on reductions [25, 26].
- Companies in the logistics industry are optimising routes, using fuel-efficient vehicles, and implementing sustainable practices to reduce harmful emissions [27].

Most experts think only on a professional level, but we believe community initiatives also play a significant role in reducing CO_2 emissions, as shown in this publication. Inspired by the "Think globally, act locally" attitude, local initiatives involve community efforts to address environmental problems. An example from Győr introduces how international student initiatives at Széchenyi István University are reducing logistics emissions.

4. METHODOLOGY

The EcoTransIT World emissions calculator [28] uses a detailed methodology to estimate emissions from different modes of transport, namely:

- Data collection: The methodology accounts for several parameters, including load weight, load factor, empty run ratio, fuel type, and biofuel ratio.
- Distance calculation: It calculates the distance for each section of the transport route.
- Fuel consumption and emission factors: The tool uses fuel consumption and emission factors determined based on vehicle characteristics.
- Energy and emission calculation: Emissions are calculated using formulas that incorporate the collected data and factors.

This approach ensures a comprehensive and accurate estimate of greenhouse gas and exhaust emissions across different transport scenarios, with abbreviations provided.

The principal calculation rule for the calculation of vehicle emissions is:
- WTW (Well-to-Wheels) energy consumption or emissions per transport = Transport Distance * mass of freight transported * (TTW energy consumption or vehicle emissions per net tonne km + WTT energy consumption or emissions per net tonne km) [29].
- TTW (Tank-to-Wheels) Vehicle emissions per net tonne-km = specific energy consumption of vehicle or vessel per net tonne km * energy-related vehicle emission factor per energy carrier [29]
- WTT (Well-to-Tank) Upstream energy consumption or emissions per net tonne-km = specific energy consumption of vehicle or vessel per net tonne km * energy-related upstream energy or emission factor per energy carrier [29]

The corresponding formulas are:

$$EMT_i = D_i * M * (EMV_{tkm,i} + EMU_{tkm,i}) \quad ECT_i = D_i * M * (ECF_{tkm,i} + ECU_{tkm,i}) \tag{1}$$

Table 3. Abbreviation for Energy and Emission Calculation [26]

Abbreviation	Definition	Unit
EMT_i	WTW emissions of transport	[kg]
ECT_i	WTW energy consumption of transport	[MJ]
D_i	Distance of transport performed for each energy carrier i	[km]
M	Mass of freight transported	[net tonne]
$EMV_{tkm,i}$	TTW Vehicle emissions for each energy carrier i	[g/tkm]
$ECF_{tkm,i}$	TTW energy consumption for each energy carrier i	[MJ/tkm]
$EMU_{tkm,i}$	WTT (upstream) emission factors for each energy carrier i	[g/tkm]
$ECU_{tkm,i}$	WTT (upstream) energy consumption for each energy carrier i	[MJ/tkm]
i	Index for energy carrier (e.g., diesel, electricity, HS)	

The properties of the items taken into account in the calculations are as follows: height (cm), width (cm), length (cm), volume (m3), the dominant material and weight of the item.

The dimensions of the items (height, width, and length) were estimated by comparing the items to products published in the group sold by Amazon's e-commerce seller. Certain items were estimated visually because no similar items were available online. The dimensions are measured in centimeters.

The volume of each item is calculated by multiplying the previously estimated height, width, and length. The volume is measured in m3.

Items in the "Clothing" category are calculated using a different approach due to packaging requirements and the research's purpose. The volume used in the research is not the item's actual volume, but the volume when packaged and shipped. Items in this category are usually folded and packaged. For the purposes of analysis, we have assumed that these items will be folded in half, so the height of the packaged item is twice its actual height, while the length of the item intended for packaging is calculated as half its actual length.

The weight of the items was estimated in a similar way to their size. The weight of some items was indicated on their packaging, so we used this for our calculations.

Although the methodology was developed using inaccurate data, it is not necessary to use accurate data to support the theory, as the estimated data also show the volume of CO_2 emissions that a local community initiative can save.

5. ANALYSIS AND DISCUSSION

This study is based on data from a WhatsApp group called "Avoiding Waste." The group was created on March 17, 2021, to avoid waste among foreign students living in the dormitories of Széchenyi István University. Items were shared free of charge among group members.

The mechanism for sharing items within the group involves uploading photos with concise comments such as "free" or "giveaway," indicating that the item is available to all members. At the same time, notifications indicating

that a member has requested a particular item are also posted to the group. Communication regarding item requests takes place either through personal messages or via the group's collective forum.

It is noteworthy that the turnover of items within the group is relatively fast, with an average of 3 minutes and 23 seconds elapsing between the posting of a photo and the subsequent item request.

At the time of writing, the group has 206 members. Since this fluctuated several times over 3 years, for simplicity, the calculation is based on 200 students. Given that the number of foreign students living in the dormitory is approximately equal to the total student population, the proportion of foreign students participating in the group's activities ranges from 58% to 80%.

This figure will be helpful for extrapolating CO_2 emissions from non-logistical activities to higher levels (dormitory, city, county, country).

The total number of shared items is 660. To facilitate the analysis, all items were classified into 12 groups: cosmetics, electronics, shoes, stationery, bags, household items, books, sports, clothing, accessories, kitchen utensils, and food.

The "Food" group contains one-fifth of all items published in the group (162 items), but is not included in the research analysis. The decision not to include these items in the research was justified by the impossibility of estimating the various values required for packaging and logistics. Since this paper aims to assess the avoided logistics costs, we do not include items in the "Food" category.

Therefore, the analysis is based on 498 items.

As mentioned earlier, the weight and size of some tools and products in the group were estimated based on identical or similar products available online. Although this does not provide accurate data, presenting the methodology can support our theoretical assumption that significant carbon dioxide emissions can be saved by exchanging goods within a community.

Limitation: This research focused on the activities of the "Avoiding Waste" group, formed at Széchenyi István University (in Győr). The data related to the research is from October 2023; therefore, data from approximately three years were analyzed. The final calculation results would differ for groups with various data and participants.

5.1. Corrugated paper, cardboard emissions calculations

The largest group among the analysed items is "Clothes", accounting for 208 of 498 items. In second place is the group "Kitchenware" with 76 items. The third group is "Cosmetics" with 60 items.

To calculate the weight of a corrugated cardboard box based on the dimensions (height, length, and width) of the item packed inside, we need to consider the thickness of the cardboard material used for the box. The weight of the box itself is the cardboard material's weight per unit area multiplied by the box's surface area.

Assuming a cardboard material density of 150 g/m², the surface area (SA) is computed as follows. The weight of the box (WB) can be expressed as:

Weight of Box = Surface Area × Weight per Unit Area   (2)

Upon computation, the corrugated cardboard box's mean weight is 0.016 kg, with the highest value in the Sport category at 0.2 kg. Individual calculations for each item indicate a cumulative weight of 30.66 kilograms, assuming discrete packaging.

5.2. Transportation emissions calculations

Local level:
The majority of shipments to Győr are transferred from the logistics hubs in Budapest. We can model the situation by choosing a logistics hub in Budapest as the reference point for the distance between Budapest and Győr, the delivery point.

The calculation details are as follows:
Starting point: Airport, Budapest, Hungary
Delivery point: Győr, Hungary
Transportation method: Truck
Distance: 141.1 km.
Weight: 267kg+30.66kg=297.66kg.

Calculated CO_2 for the given distance and weight: 3.4 kg.

Therefore, it can be concluded that during the calculated freight transport, about 200 people saved approximately 3.4 kg of CO_2 from being emitted into the atmosphere.

Intercountry level:
Most of the items sold in Hungary are produced in Asia and then delivered to one of the main transport hubs in Western Europe. These hubs are strategically located at the economic heart of Europe, spanning the conurbation of cities stretching from the Netherlands and Belgium, through Western and Southern Germany, down to Switzerland and Northern Italy. Antwerp tops the list, followed closely by Rotterdam, Brussels, Düsseldorf and Hamburg. Only after being processed at a relatively large hub are items distributed to various points in other parts of Europe.
We can model the situation by selecting a logistics hub in Western Europe and calculating the distance to Budapest as the delivery point. As a result, we will be able to determine CO_2 emissions for this part of the logistics process.

The calculation details are as follows:
Starting point: Airport, Rotterdam, Hollandia
Delivery point: Airport, Budapest, Hungary
Transportation method: Truck
Distance: 1421.2 km
Weight: 267kg + 30.66kg = 297.66kg.
Calculated CO_2 for the given distance and weight: 31.3 kg.

Intercontinental level:
The last leg that we can model is the leg between the European logistics hub and the global goods manufacturer in Asia.

The calculation details are as follows:
Starting point: Pingzhou Port, Shenzhen
Delivery point: Rotterdam, Hollandia
Transportation method: Sea
Distance: 20766 km
Weight: 267kg+30.66kg=297.66kg.
Calculated CO_2 for the given distance and weight: 21.7 kg

Table 4. The total emissions of the example

Level of delivery	CO_2 in kg
Local level - Truck	3.4
Intercountry level - Truck	31.3
Intercountry level - Truck+Air	21.7
Total from Shenzhen to Győr	**55.77**

Table 4 indicates that if this 297.66 kg product were transported from Shenzhen to Győr, it would generate 55.77 kg of CO_2 emissions. However, as this community is located in Győr and the products are also exchanged here, this amount could only be avoided through the activities of the Avoiding Waste group. It can be considered adequate, as the minimal effort of only 200 people helped save as much carbon dioxide as one person emits annually in some countries (Guardian) [30].

5.3. The extrapolation effect

By performing these simple calculations, the extrapolated impact of a local initiative involving only 200 people was determined. The hypothetical extrapolated effect on the population of the selected areas can also be estimated (to

calculate CO_2, the average value of 18.8 kg is used, as this is the average amount of CO_2 per year, and this is divided by 498, as this is the number of products for which the calculation was made) [28].

Population of Győr: 124287 people

$$(124\ 287 * 18.8) / 200) = 11\ 682.97\ \text{kg } CO_2 / 498 = 23.46\ \text{kg } CO_2 \tag{3}$$

Population of Budapest: 1782240 people

$$(1\ 782\ 240 * 18.8) / 200 = 167\ 530.56\ \text{kg } CO_2 / 498 = 336.40\ \text{kg } CO_2 \tag{4}$$

Population of Vienna: 2005500 people

$$(2\ 005\ 500 * 18.8) / 200 = 188\ 517\ \text{kg } CO_2 / 498 = 378.54\ \text{kg } CO_2 \tag{5}$$

Based on the ratio of the cities' populations, as calculated earlier. The population figures are based on the World Population Review Database [30] and Hungarian Central Statistical Office data [31].

Overall, even if only half of the hypothetical model presented were implemented, it would represent a significant change in global emissions strategies.

Moreover, since only the emissions saved from logistical processes have been estimated, it is impossible to assess the extent of emissions saved from items not produced, or from their use and disposal.

If this initiative were extended to larger cities, assuming that each person exchanges or sells one product in a similar group, this would mean that for the entire population of Budapest, the activity could save approximately 336.40 kg CO_2, while extending it to the whole population of Vienna would save 378.54 kg CO_2.

The success of the "Avoiding Waste" initiative adequately represented the value of community participation in sustainability efforts. Promoting reuse and sharing can significantly reduce waste and emissions. Policymakers and academic institutions can support such initiatives by providing incentives and further research into innovative solutions to reduce the carbon footprint of logistics and packaging.

6. CONCLUSIONS

This hypothetical model-based assessment highlights the environmental impacts of the entire life cycle of goods across different geographical scales. As the world grapples with sustainability challenges, such analyses are becoming increasingly important in identifying areas for improvement and in shifting logistics and goods consumption towards more environmentally friendly practices.

The hypothetical model was developed based on activity in the "Avoiding Waste" WhatsApp group, focused on international students, and revealed significant environmental benefits.

Emissions from transport were examined at local, cross-country and intercontinental levels.

The hypothetical model estimates the extrapolation effect of the population ratio of the selected areas, which means that if this initiative were extended to larger cities, it would mean that for the entire population of Budapest this activity could save approximately 336.40 kg CO_2, while if extended to the whole of population of Vienna it would save 378.54 kg of CO_2, if we compare the savings of 200 people to the size of the population and take into account that one person exchanges or sells 1 product in a similar group. Of course, this is impossible to give as an exact number, since not everyone can or is willing to participate in communities that exchange unwanted products. However, it is enough to support the idea that "community power" is significant in sustainability.

This analysis showed that "if even half of this estimate were to become a reality", it would represent a significant change in global emissions strategies.

In conclusion, the "Avoiding Waste" initiative not only promotes sustainability but also significantly reduces carbon emissions from packaging and transportation. This study provides valuable insights into understanding the global environmental impacts of community-led waste reduction efforts.

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Measurement Platform for Generating and Acquiring Signals from Sensors - Application Scenarios

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Abstract

Modern measurement systems are particularly well suited to the trend of digital economy development. Microelectromechanical systems (MEMS) play an important role here. They constitute an alternative in the design and implementation of measurement tasks, offering a wide range of applications. MEMS sensors make it possible to create flexible measurement systems. These features, combined with low weight and low power consumption, make them attractive for use in a variety of scenarios, such as process control, robotics, biomechanics, and the automotive, marine, aerospace and space industries. In this elaboration, the Objectives and Key Results (OKR) method was applied, which is recognised by experts worldwide. The main goal of this work is to present the results obtained using a measurement platform for generating and acquiring signals from sensors, as well as to present potential application scenarios. The solution was based on the graphical environment Laboratory Virtual Instrument Engineering Workbench (LabVIEW). To achieve the main goal, sensors with different frequency characteristics were adopted. The elaboration of this topic has shown that the measurement platform is highly versatile, allowing the characteristic properties of the sensors to be presented. The interface of the measurement platform provides signal modification, acquisition and graphical visualisation. With regard to the sensors employed, attention was paid to the characteristics of their signals, including their advantages and limitations. The authors highlight potential engineering and technological application scenarios that are important from the perspective of the digital economy. The elaboration was prepared under the research subvention of the AGH University of Krakow, No. 16.16.150.545 in 2025.

Keywords: sensors, signals, microelectromechanical system, MEMS, measurement platform, LabVIEW, measurement interface, graphical environment, graphical programming language

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