



FSH-PH Publication

Evidence-Based Perspectives on Artificial Intelligence and Emerging Digital Technologies in Education, Business, and Society

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Author Information

Chapter 1

Hyper-Personalization in the Age of AI: A Literature Review on Security, Transparency, and Compliance Challenges

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Gabriel Asturias, John Mark F. Francisco, Bryan Russell F. Ocampo, Mark Joshua O. Orcullo, Mark David P. Saquilayan & Cereneo S. Santiago Jr

Chapter 2

Gamification in Computing and Information Technology Education at the Tertiary Level: A Literature Review

Authors: James Nicolo M. Berongoy, Marc Johnvel I. Ofalza, Carl Jamie T. Posion, Marclain James M. Samson, Christian Jericho M. San Agustin & Cereneo S. Santiago Jr

Chapter 3

The Role of Prompt Formulation in Shaping ChatGPT- A Review on Response Quality and Efficiency

Authors: John Paul A. Baluyot, Dave A. Billona, Kurt Andrew T. Cinco, Vaughn Zen G. Centeno, Amiel Ian C. Mendoza, & Cereneo S. Santiago Jr

Chapter 4

Virtual Reality vs. Traditional Online Learning: A Comparative Review on Engagement and Retention

Authors: Symon A. de Gala, Jhay Vic G. Ambata, Aaron Jovanne C. Sarmiento, Karl Angelo C. Curiano, John Dale V. Sagayno, & Cereneo S. Santiago Jr

Chapter 5

Social Media in Business: A Review of Its Strengths, Challenges, and Marketing Practices

Authors: Pia Paula C. Guillen, Andrea A. Minerva, Neil Agnes S. Pimentel, Joannah Marie P. San Agustin, & Cereneo S. Santiago Jr.

Chapter 6

Literature Review on AI-Enhanced Augmented Reality for Real-Time Language Translation in Multicultural Classrooms

Authors: Aurora Marlon Caleb, Jhan Clarenz O. Broqueza, Angelito B. Cabeltes, Harman Jot, Jaykee C. Faderogao & Cereneo S. Santiago Jr

INTRODUCTION

The development of artificial intelligence (AI) and new digital technologies has changed the situation in the field of education, business, and society as a whole. With the fourth and fifth industrial revolutions, the combination of AI, virtual reality (VR), augmented reality (AR), gamification, and similar innovations is changing the way we teach, learn, work, and interact. The book is a compilation of evidence-based views on these revolutionary technologies and how it can transform and revolutionize various fields.

Digital technologies are growing more complex and more integrated, and are causing major changes in the way organizations work and the way societies operate. The connection between technology and business is two-way and growing stronger; employees who are well-prepared, have a sufficient level of digital literacy and competencies have become the key assets of organizational success and economic prosperity. Organizations all over the world are realizing that the implementation of innovative technologies such as AI, blockchain, cloud computing, IoT, and immersive technologies is not only not optional but, instead, a critical necessity in order to stay competitive in a knowledge-based economy.

Technological disruption presents unprecedented challenges and opportunities to educational institutions as they adjust to the disruption. The introduction of new technology in teaching and learning setting is transforming pedagogical practice, student interaction and learning outcome of students. AI-based personalization, gamification, and immersive technologies promise a future of increasing student motivation, better knowledge retention, and 21st-century skills needed to be part of a digital workforce. Nevertheless, teachers and policy makers will have to work around serious impediments such as lack of proper training, financial constraints, ethical issues and the necessity of developing digital literacy in a comprehensive way.

The field of AI and other digital technologies is transforming the relationships with customers, the efficiency of business operations, and the competitive edge. AI-based analytics enabled by hyper-personalization can enable organizations to provide personalized experiences at scale. Social media marketing, electronic commerce and chatbot-based customer care are only a few examples of how business-consumer interactions are being transformed. But these innovations require close attention to the ethical aspects of the issue, such as privacy of data, transparency of algorithms, and responsible implementation of AI.

The six chapters of this volume cover the important aspects of this digital transformation:

Chapter 1 discusses hyper-personalization in the era of AI and how organizations should approach the security, transparency, and compliance concerns when implementing personalized marketing and service programs.

Chapter 2 explores the concept of gamification in computing education, and examines how the elements of game-design can be used to promote increased student engagement, motivation, and skill development in information technology programs.

Chapter 3 compares prompt formulation and ChatGPT and presents the evidence about how the input quality determines the effectiveness and efficiency of the generative AI response and has implications not only in education but also in the application of generative AI.

Chapter 4 contrasts virtual reality and traditional online education and provides the insights to engagement, retention and learning outcome across various educational settings.

Chapter 5 provides a review of social media in business synthesizing research on its advantages, challenges and effective marketing practices by companies to achieve organizational success.

In Chapter 6, AI-enhanced augmented reality in language translation is discussed, and it is revealed that emerging technologies can create an inclusive and multicultural learning environment.

Although these technologies have a transformative potential, their application cannot be successful unless several critical considerations are taken into account. Ethical issues, such as privacy of data, bias in algorithms and the necessity to design something that humans can understand and apply, should become part of the technology development and deployment strategies. Also, the digital divide, or disparities in access to technology and digital literacy, threaten to expand the existing inequalities unless intentionally tackled via inclusive policies and investments.

The proposed evidence-based compilation includes the viewpoints of researchers, educators, and practitioners to sum up the existing knowledge on AI and new digital technologies. The chapters are a blend of systematic literature reviews and empirical evidence that give the reader a nuanced understanding of the transformative potential of technology as well as the real-world challenges of technology adoption in education, business and society. Through our evidence-based research, we hope to inform decision-making among educators, business leaders, policymakers, and technology practitioners maneuvering through this fast changing digital environment.

The following chapters show that the process of integrating technology into the learning process requires not only the use of the latest tools, but also a careful balance between technological innovation and pedagogical excellence, ethical guidelines and human

values. It is only with such deliberate, evidence-based measures that we can be sure that the fruits of AI and new digital technologies are distributed fairly, and they actually contribute to the quality of education, business success, and the well-being of society.

Hyper-Personalization in the Age of AI: A Literature Review on Security, Transparency, and Compliance Challenges

Abstract

AI-driven hyper-personalization revolutionizes the user experience by providing personalized experiences on digital media platforms. This literature review aims to systematically evaluate the impact of AI-driven hyper-personalization on data security, algorithmic transparency, and compliance, and to discuss its causative mechanisms, involved risks, and ethical implications. The research used a systematic review of 44 peer-reviewed articles (2018-2025) on academic databases, confirmed through hyper-personalization, AI, data security, transparency, and compliance keywords. The results show that although hyper-personalization greatly enhances the user experience and business performance using real-time data analysis and adaptive algorithms, it is also accompanied by the risks of data infringement, loss of privacy, and algorithmic bias. It is still a big hurdle to overcome true algorithmic transparency and be completely compliant without modifying existing legislations like GDPR and CCPA, which might risk and undermine users' trust. The study demands a striking balance between personalization value and robust data protection, particularly in making out the privacy-by-design principles, multi-layered protection, and explainable AI (XAI). Further studies should be conducted to develop integral frameworks and adaptive regulations to help secure ethical, secure, and trustworthy AI-driven hyper-personalization.

Keywords: hyper-personalization, artificial intelligence, trust, compliance, transparency

INTRODUCTION

In the digital age, artificial intelligence (AI) has transformed how companies engage with users, offering a hyper-personalized experience around individual taste (Sharma, 2022). Hyper-personalization has already penetrated various platforms, be it giving product suggestions on e-commerce or AI-powered content organization on social media, and it has improved engagement and business performance much more. Such a revolution was based on sophisticated algorithms considering real-time behavior data, past interactions, and contextual data to create personalized content, recommendations, and services (Rane et al., 2023).

AI personalization increased in all industries, from banking and social media to streaming and retail. Online shopping sites use machine learning algorithms to suggest products based on browsing history, and media streaming sites like Netflix and Spotify

employ predictive analytics to enhance content recommendations to retain the user. The success of the aforementioned hyper-personalized interactions is apparent, as statistics indicate that 80% of customer interaction on streaming platforms is AI-based recommendations, enabling companies to retain customers and build experience to avoid losing users (Sharma, 2024). On internet shopping websites, hyper-personalized product recommendations have caused up to a 150% increase in conversion rate, bearing witness to the groundbreaking effect of hyper-personalization on buying behavior (Sharma, 2024).

Hyper-personalization is now a non-negotiable tactic rather than an extra strategy. However, Sharma (2024) underscores that 89% of online businesses continually invest in personalization technologies to underpin the rampant use of AI-based tactics. Additionally, 80% of customers shop from companies that provide customized experiences, symbolizing increasing aspirations among online consumers for higher value and interest-related interactions.

Despite the revolutionary capabilities of AI-facilitated hyper-personalization, research is still to be conducted on certain critical aspects to make it an ethical and sustainable system to adopt. Though research has estimated the effect of AI personalization on privacy, it overlooks its long-term effect on consumer trust and behavior patterns (Amil, 2024). Amil's study highlights that while AI-driven personalization enhances user experience and engagement, it raises concerns about data security, transparency, and ethical AI governance. Consumers will appreciate personalized recommendations initially, but over time, residual privacy concerns will erode trust, and consumers will wonder how their data is being leveraged. The study further reports that high threat levels, such as data loss and unclear consent procedures, significantly influence consumer trust in AI technologies. Without open protection and communication, AI-based

personalization will be suspicious to customers, damaging long-term take-up. Solutions for these problem types include strong encryption frameworks, better algorithmic transparency, and proactive regulation to maintain AI personalization as effective and fair. Likewise, algorithm transparency has been testified to be one of the key factors behind user uptake, but there are limited robust solutions to heighten explainability (Saura, 2024). Ethical issues of AI decision-bias and user consent complexity must be analyzed exhaustively to create no unintended results (Thangavel, 2025). Also, arguments over compliance with the regulation are predominantly aimed at prevailing policies, but insufficiently inquire how organizations can positively embrace changes in changing legal environments (Seppälä et al., 2023).

This paper aims to expand the existing knowledge on hyper-personalization by AI using its basic processes, risks entailed, and ethics involved. This work is carried out through a critique of various literature in different academic databases, presenting a fair discourse on the advantages and implications of hyper-personalization. Hence, this paper delves into the effects of AI-based hyper-personalization on data protection, transparency of algorithms, and compliance with the law to offer insights and recommendations for future studies that will make hyper-personalization more effective without undermining legal frameworks and user rights.

METHODOLOGY

Research Design

The research employed a systematic literature review (SLR) design, grounded in the methodological guidance of Paul and Rialp-Criado (2020), to ensure a rigorous, transparent, and replicable evaluation of existing literature. The review followed a six-step process to

enable a comprehensive and integrated synthesis of scholarly work: (1) Defined the scope and objectives and the specific aims of the review; (2) Selected relevant literature using a structured search strategy to identify high-quality sources from reputable academic databases; (3) Classified and organizing literature by categorizing studies according to key themes; (4) Synthesizing key findings through comparative analysis to uncover patterns, relevant to the research objectives; (5) Synthesized the findings and provided discussions; and (6) Identifying future research directions by outlining unresolved issues and proposing areas for further scholarly investigation.

Research Objectives

This review explored the role of AI-driven hyper-personalization by examining its influence on data usage and management, understanding how the underlying algorithms operate, and investigating the extent to which transparency in these systems affects user trust. It also evaluated how current personalization practices align with regulatory frameworks and identified practical measures for enhancing data security and transparency within AI-driven personalization models.

Retrieving and Selecting Pertinent Literature

This review systematically gathered relevant literature from various reputable online databases to ensure the inclusion of high-quality, peer-reviewed research. The review utilised journals that are accessible to Google Scholar and IEEE. A keyword-based search consisting of "hyper-personalization", "machine learning", "artificial intelligence", "trust", and "transparency" was used to search for papers in the abovementioned databases. The early stage of the selection process involved articles aiming at artificial intelligence and hyper-

personalization. A series of criteria was also assigned to ensure the included literatures meet the research requirements (Table 1). This was followed by carefully inspecting each abstract and reviewing the entire text for narratives hyper-personalization driven by AI.

Table 1. Inclusion and Exclusion Criteria

No.	Inclusion Criteria	Exclusion Criteria
1	Research articles authored by scholars from various countries worldwide	Conference proceedings, dissertations, or unpublished research
2	Studies across different regions with diverse and global perspectives	Studies limited to a regional focus that do not contribute to a broader global perspective
3	Published in a reputable international journal indexed in databases such as IEEE and Google Scholar, or other recognized academic sources	Articles published in non-reputable journals that do not meet scholarly standards
4	Articles written in English	Articles written in other languages
5	Year of publication between 2018 and 2025	Published before 2018

Synthesizing the Literature

The pertinent literature selected for this study was published between 2018 and 2025, which ensures a broad yet highly relevant to AI-driven hyper-personalization. A total of 45 articles met the inclusion criteria, having been carefully evaluated for their relevance to the research objectives. Data were systematically extracted from each study, and then the results and insights derived from these studies were organized and presented in Tables 2-6, which provide an overview of the significant areas this study covers.

Table 2. Table synthesis about the Impacts of AI-driven Hyper-personalization on data security.

Author	Impacts of AI-driven Hyper-personalization on Data Security
Aggarwal, A. (2024)	Challenged organizations face AI-driven personalization, focusing on privacy preservation, algorithmic bias mitigation, contextual dynamics, and user autonomy. It emphasized the need for privacy-first architectures and adaptive system designs to

balance effective personalization with robust data security measures.

Amil, Y. (2024) The study discussd how AI-driven hyper-personalization collects large amounts of user data to provide personalized experiences. It was found that even though AI-driven improves users' experiences, it also has a high risk of data leak, misuse, and trust issues. That is why strong security measures are needed to protect data.

Hanson, J., Wei, M., Veys, S., Kugler, M., Strahilevitz, L., & Ur, B. (2020) The study discussd how AI-driven hyper-personalization can impact data security by demonstrating users' reactions to perceived data misuse. It provided empirical evidence on privacy concerns, behavioral responses, and the ethical implications of data collection aligned with analyzing the risks associated with AI-driven personalization.

Islam, M. A., Fakir, S. I., Masud, S. B., Hossen, M. D., Islam, M. T., & Siddiky, M. R. (2024) They found that hyper-personalization with AI improves marketing by personalizing content to match users' preferences. Also stated that companies gather vast amounts of user personal information, including browsing and buying history, which increases the risk of privacy breaches and cyber-attacks.

Parker, O. (2023) The study investigated the crucial issue of data security, looking at risks like breaches and privacy threats while using cloud computing and AI in different fields. It also explained how these technologies shaped a new form of education through personalized learning.

Rane, N., Choudhary, S., & Rane, J. (2023) They found how AI-driven hyper-personalization upgrades customer engagement while raising crucial concerns about data security. Hence, strong encryption, consent management, and regulatory GDPR and CCPA are essential for protecting user data. The balance between hyper-personalization and privacy is key to maintaining customer trust.

Seppala, T., Mucha, T., & Matilla. J. (2023) The study examined how AI-driven hyper-personalization improves user engagement while raising concerns about data security. The study stated that it requires a considerable amount of data, which increases privacy concerns, vulnerability to cyber threats, and regulatory challenges.

Soni, V. (2024) The paper explored the tension between personalized marketing and consumer privacy using surveys and expert interviews. Found that while users value personalization, they fear data misuse. Emphasized the need for transparent data practices and regulatory compliance to build trust and improve security.

Thangavel, V. (2025) AI is now reshaping the fast-moving consumer goods (FMCG) sector by enhancing marketing, real-time data analytics, and customer engagement. While it strengthens the industry, challenges like data privacy, ethics, and security require businesses to balance the potential of AI with ethical data usage to keep consumers' trust.

Table 3. Table synthesis about the Hyper-personalization algorithm.

Author	Hyper-personalization Algorithm
Amil, Y. (2024)	A hyper-personalization Algorithm applies AI and machine learning to understand users' behavior and preferences. Techniques like this improve shopping experiences and boost engagement and sales.

Bozkurt, S., Meral, S., Ugursoy, A., (2024) Hyper-personalization algorithms use AI and machine learning to analyze data and predict users' wants. Then the system uses an automated recommendation engine to deliver product suggestions, ads, and tailored videos through social media platforms and websites.

Khurana, R. (2023) How Hyper-personalization algorithms use AI and machine learning to examine real-time user data, such as browsing behavior, transaction history, and demographics. They follow microservices and containerization using cloud-native frameworks, which scale dynamically to accommodate personalized recommendations. When embedded with collaborative filtering, deep learning, and predictive analytics, such systems lead to higher user engagement and conversion.

Mendia, J. M. V., & Flores-Cuautle, J. J. A. (2022). Hyper-personalization works as real-time data processing, like Master Data Management (near real-time), and Customer Data (real-time) Platforms for creating advanced profiles that enhance the effectiveness of personalization, ensuring consistent customer satisfaction.

Rane, N., Choudhary, S., & Rane, J. (2023) The key components of hyper-personalization algorithms that the study focuses on include recommendation engines in real-time personalization and customer segmentation tools that tailor content and interactions.

Saksena N. (2024) How advanced technologies, including artificial intelligence, machine learning, and real-time data streaming, enable retailers to deliver highly individualized customer experiences. The study highlights implementation strategies, benefits, and impacts, demonstrating how retailers leverage sophisticated data science frameworks to enhance customer engagement and drive business growth.

Srinivisan, R., Pandey, R., Pasha, N., Borah, A., Garg, A. (2025) Hyper-personalization algorithm machine learning, such as XGBoost and Random Forest, predicts users' behavior based on their transaction history and account activity. Then the systems will deliver a tailored recommendation at a time.

Table 4. Table synthesis about the effects of algorithmic transparency on users' trust.

Author	Effects of Algorithmic Transparency on Users' Trust
Guendouz, T. (2024)	Highlights the concerns about fairness and potential bias in algorithmic pricing. If pricing is unclear and unfair, users may feel exploited, losing trust in AI systems.
Liu, B. (2021)	Machine-learning AI systems are governed by system-generated rules based on their analysis of large databases. These rules are not predetermined by humans. Furthermore, they can sometimes be difficult for humans to interpret. In this research, I ask whether users trust the judgments of such systems driven by machine-made rules.
Nwanna M, Offiong E, Ogidan T, et al (2025)	It discussed the role of Explainable AI (XAI) in fostering user trust, ensuring compliance with regulations, and addressing ethical concerns like algorithmic fairness and data privacy.
Para, R. K. (2024)	Explains that although personalized suggestions enhance user experience using machine learning algorithms, they are at risk of maintaining biases and reducing the publicity of other content. This is where explainable AI (XAI) comes in, as it plays a crucial role in improving the transparency and accountability of these systems.

Thomaz, F., Salge, C., Karannaha, E, Hulland, J. (2019) Discussed how the trust of users was affected by transparency. When businesses focus on transparency in how their algorithms work, users will trust them more. Transparency will reveal how choices were made, reducing uncertainty, and confidence in the system will increase.

Vemuganti, R. (2022) The study examined how unknown knowledge about personalization technology affects user choice and trust in AI-driven systems.

Wanner, J., Herm, L., Heinrich, K., & Janiesch, C. (2022) Highlighted that algorithmic transparency plays a crucial role in building user trust and supporting the acceptance of intelligent systems. This study also extends that the Unified Theory of Acceptance and Use of Technology (UTAUT) key factor highlights the transparency in minimizing information contortion and strengthening user confidence in artificial intelligence decision making.

Yu, L., & Li, Y. (2022) It investigated how AI decision-making transparency influences employees' trust in AI systems within collaborative work environments. Utilizing the Stimulus-Organism-Response (SOR) model, the research identifies cognitive and emotional mediators—specifically, perceived effectiveness and discomfort—that affect trust.

Zerilli, J., Bhatt, U., & Weller, A. (2022) Studying human-machine systems is central to various behavioral and engineering disciplines, including management science, human factors, robotics, and human-computer interaction. Recent advances in artificial intelligence (AI) and machine learning have brought the study of human-AI teams into sharper focus. An important set of questions for those designing human-AI interfaces concerns trust, transparency, and error tolerance.

Table 5. Table synthesis about AI-driven Hyper-personalization’s alignment with regulations.

Author	AI-driven Hyper-personalization’s Alignment with Regulations
Adhikari, P., & Hamal, P. (2025)	Investigated concerns about ethics, data privacy, and struggles with regulation compliance connected to AI-driven Hyper-personalization. Stated that frameworks like GDPR and CCPA highlights businesses' hardships when aligning personalization with regulatory compliance which provides a foundation to understand how effectively organizations follow those regulations.
Bell, C., Olukemi, A., & Broklyn, P. (2024)	Their research considered the impact of AI-driven hyper-personalisation under the prism of compliance with data privacy, informed consent and algorithmic transparency. It also emphasized that being compliant with GDPR and CCPA will serve to offer assurances no abuse of data will happen, and the danger of bias or unfair manipulation can be kept at bay by clear-willed ethical guidelines.
Higgins, B. W., & Dodd, A. (2021)	Addressed the insidiously corrosive effect of AI complexity and indecision on customer trust. The report calls for more transparency and interpretability in AI systems and recommends that “clear data use and decision-making policies” may help to push back against mistrust and increase the likelihood of compliance with data protection legislation.

Khurana, R. (2023)	Declared that for AI-driven hyper-personalization to comply with regulations such as GDPR and CCPA, businesses should focus on data privacy and security. Balancing personalized AI experience with evolving data privacy rules poses significant challenges. Ethical issues, like bias in algorithms and transparency, require continuous monitoring as legal standards continuously evolve.
Prosper, J. (2023)	Explained the influence of deep learning on marketing forecasts, noting its ability to examine complicated data sets and accurately predict consumer behavior. However, despite its strengths, companies face challenges like poor data quality, expensive computational costs, non-interpretability, integration problems, and ethical issues.
Raji, N. M. A., Olodo, N. H. B., Oke, N. T. T., Addy, N. W. A., Ofodile, N. O. C., & Oyewole, N. A. T. (2024)	Explored boosting data security as an addition to the transparency in the field of AI personalization by using explainable AI. User-controlled privacy settings require stronger encryption, compliance with regulations like GDPR, and explicit data-use policies.
Rane, N., Choudhary, S., & Rane, J. (2023)	The study discussed the ethical and regulatory considerations of AI-driven hyper-personalization in CRM systems. It highlights how important data privacy, transparency, and compliance are with legal frameworks such as GDPR and CCPA. They emphasize the need for businesses to balance personalization and consumer trust by adapting consent management platforms and stronger security measures to keep on track with regulatory requirements.
Reviglio, U. (2020)	The study highlighted the connection between AI-driven hyper-personalization and regulatory frameworks, specifically under the General Data Protection Regulation (GDPR).
Shah, H. (2023)	Study how to enhance data privacy and transparency of AI personalization, encryption, multi-factor authentication (MFA), and how to utilize access controls for secured confidential data. Transparency is necessary by providing explainable AI, keeping audit trails, and providing controls for the end user to manage their data. To ensure fairness, regular audits for AI systems should be conducted to stay compliant with security frameworks such as GDPR.
Soni, V. (2024)	The study observed the dilemma of not compromising consumer data security by using AI to make marketing more individualized. The goal is to uncover the proper equilibrium between developing personalized marketing experiences and ensuring privacy protection remains strong.

Table 6. Table synthesis about the ways to improve data security and transparency in AI Hyper-personalization.

Author	Ways to Improve Data Security and Transparency in AI Hyper-Personalization
Abbas, E., Qazi, A. A. (2024)	The study is about AI-driven privacy and security settings. It highlights the ability of AI to use user behavior to adapt and implement security settings, addressing these concerns regarding threats, privacy, and balanced security and user experience, which are the key aspects to enhance transparency and protection in AI-driven systems.
Felzmann, H., Fosch-Villaronga, E., Lutz, C., & Tamò-Larriex, A. (2020)	Discussed the concept of “transparency by design” in AI development. The study explores how implementing transparency from the start of AI development can improve accountability and user trust. The authors propose guidelines for making AI

systems more explainable and ethically responsible.

- Hosain, M. T., Zaman, A., Sajid, M. S., Khan, S. S., & Akter, S. (2023) The study explained how APPLE+HE is the best way to protect privacy while personalizing the experience. It perfectly balances maintaining information privacy, accuracy, and personalization. This enables organizations to offer highly personalized AI services without compromising user privacy and adherence to the law.
- James, C. (2024) Security and transparency issues are essential if consumer trust is maintained and generative AI technologies are to be accepted sustainably. Retailers promoting responsible AI practices in delivering hyper-personalized experiences will be advantageous in the fast-changing digital market.
- Khan, S. N., & Sajjad, H. (2024) The study suggests using data anonymization, federated learning, and transparent data practices to improve data security and transparency.
- Mylrea, M., & Robinson, N. (2023) Enhancing data security and transparency in AI personalization requires encryption, anonymization, and user consent. Implementing XAI boosts trust and accountability. Ethical practices like bias detection, privacy safeguards, and transparent data use support compliance and user confidence.
- Shah, H. (2023) Explored how to enhance data privacy and transparency of AI personalization, encryption, multi-factor authentication (MFA), and how access controls must be applied to secure sensitive data.
- Xu, R., Baracaldo, N., & Joshi, J. (2021) It explained the use of complex encryption methods and access control systems to increase data security in AI-based personalization to ensure unauthorized persons do not access users' data.
-

DISCUSSION

A. Impact of AI-Driven Hyper-Personalization on Data Security

As synthesized in Table 2, the emergence of AI-driven hyper-personalization has reshaped the digital world and how humans interact, enabling specific platforms to tailor customized experiences in real time. Despite this, the accuracy and clarity of personalization rely on the collection, analysis, and storage of massive amounts of user data, which poses serious challenges regarding data security and privacy. It is the same medium that allowed personalization, profiling, predictive analytics, etc., to be possible, but it also exposes users and systems to various cybersecurity risks. This discussion explores the risks associated with hyper-personalization, comparing mitigation strategies, and assessing existing frameworks that attempt to safeguard against personal data leaks in the AI ecosystem.

One of the most recurring themes in this literature is that hyper-personalization systems portray expanded attacks during data breaches. Abbas and Qazi (2024) highlighted that hyper-personalized social media platforms are particularly vulnerable to such attacks because of the sensitive nature of user interactions and profile-based targeting. Their study shows the lack of formally standardized, user-tailored security protocols across platforms, duly recognizing that AI engines often prioritize the accuracy of personalization, at the cost of data minimization and secure storage.

Khurana (2023) handled a similar case, where they discussed that using generative AI in payment systems made them much more vulnerable. They noted that while this makes real-time recommendations easier and fraud detection much more reliable, the system needs constant access to sensitive information like transactional histories, credit card data, and the location of customers. Because of this, loopholes might make it easier for cyber criminals to hijack and force their way to this sensitive information. Khurana (2023) warns that refusing to strengthen encryption and anomaly detection would make hyper-personalization put customers at constant risk, perhaps even more so than it enhances their experience.

Islam et al. (2024), stated that the automation systems used in digital marketing, where AI tools harvested a huge amount of personal information, even emotional and behavioral cues, to refine campaigns. They said that developing marketing platforms rarely prioritizes data security, and most of the time, the unencrypted data is only stored in centralized systems, which makes it easier to hack in, leak, and even conduct illegal data sharing.

A particular argument in this literature is that hyper-personalization, more often than not, sacrifices security for better relevance and convenience of the consumers. Parker (2023) mentioned that while cloud learning platforms would tweak the resulting content to improve

performance, their integration and overall platform usage threaten data privacy and security. His article stated the vulnerability of exposed data, particularly to the student population, due to a lack of access controls and weak encryption practices. To tone down these risks, he implored the need for universities and schools to implement robust systems and controls like role-based access and proper data stream encryption.

Shah (2023) followed through with this and contended that continuously using AI to personalize the workspace and learning environment often ignores the basic principles of data compartmentalization. The researcher hinges on the fact that since user data streams freely across consolidated systems with no isolation or encryption mechanisms, various threats arise, such as data breaches, leakage, etc. Moving on, they also mentioned that sacrificing safety and security for better system responsiveness and overall user experience is not the best tradeoff, and that observing proper technical boundaries would be much better.

Because of the way the majority of AI systems prioritise personalizing content rather than considering the security of customers, Mylrea and Robinson (2023) discussed how the "AI Trust Framework" functioned through their use of entropy modeling, ethical assessment, and privacy scoring as part of their comprehensive evaluation methods. The research proved that AI engines are not usually created with existing internal security audits for security maturity, which makes the system a lot more vulnerable, despite being exceptionally proficient in user-experience personalization. This solidified their conclusion that multi-layered security is crucial in preventing hyper-personalization from tampering with the trust of their customers and the overall integrity of the platform, provided each level of data processing and algorithm development is laid out within a multi-layer security channel.

Soni (2024) surveyed and interviewed individuals from the industry to examine the privacy-personalization paradox and found that most consumers who do find convenience in

personalization remain vigilant about how their personal information is being handled. This shows that customer trust is supposed to be maintained by pairing personalization with ethical, transparent objectives and usage practices. Soni (2024) noted that the industry marketers value privacy, but many lack the tools or strategies to properly implement secure personalization without diminishing the overall effectiveness. The study strengthens the increasing demand for transparency and regulatory guidance, seeking a balance between the two.

A new layer of complexity emerges from the infrastructure choices supporting personalization. Higgins and Dodd (2021) dwelled upon the implications of data localization laws, which required companies to store data within national boundaries. Even though this was intended to protect user information from international misuse, these laws can hinder the architecture of personalization systems on a global scale. The researchers pointed out that localization sometimes forces business organizations to clone their databases, adding to unnecessary redundancy and the risk of being breached—if such maneuvers are not tended to properly.

On the flip side, decentralization is one of the proposed solutions to this problem. Khurana (2023) and Shah (2023) mentioned decentralized data storage solutions, including blockchain-backed user identities and AI governance protocols. Despite being in the early stages, these methods show a promising future towards minimizing the existing single-point vulnerabilities of centralized systems. However, implementation costs and the lack of proper standardization remain significant hurdles.

To provide more context, Seppälä et al. (2023) proposed that developing security protocols must keep up with the ever-changing AI platforms. They also pointed out that implementing cybersecurity frameworks around the system (authentication, validation, etc.)

ensures that personalization remains accurate throughout the different platforms on which they are deployed. These insights align closely with broader regulatory expectations under frameworks such as GDPR and CCPA, which increasingly demand that organizations demonstrate not only technical security competence but also procedural accountability across the entire data lifecycle. Without continuously updated security protocols that mirror the pace of AI development, organizations risk falling into a compliance gap, one where their systems operate in ways that regulators and users alike can no longer meaningfully oversee.

Much to the interest of the proposed technical solutions, the paper clearly portrays that policy frameworks are still prone to abuse and exploitation, especially in hyper-personalization systems. As critiqued by Reviglio (2020), the lack of clarity of GDPR's statement about real-time personalization, saying that the policies regarding consent mechanisms do not fully encompass all fields, which is made more apparent when looking into how much data profiling the system does. This results in what is known as "passive consent"--something that makes users consume these services without fully understanding the implicated risks of excessive data collection.

Further arguments regarding this topic were made by Raji et al. (2024), saying that the enforcement of regulations and policies is observably imbalanced. In particular, e-commerce and marketing platforms have fairly non-strict models compared to healthcare and finance sectors. This contrasted with Prosper's (2023) paper, which called for an industry-specific approach towards AI security standards, arguing that a one-size-fits-all approach completely disregards security risks and consumer expectations.

On the other hand, Bell et al. (2024) showed how unquestioningly enforcing regulations regarding personalization could be exploited under the guise of "relevance". This also highlighted the need for auditing and records to be managed by third parties for

personalizing systems and security benchmarking. Adhikari and Hamal (2025) offered a similar approach by using management information systems (MIS) and integrating them into databases equipped with refined data protection and encryption, as well as enforcing strict policies about efficiency and assuring compliance with the personalization preferences of customers.

B. How Hyper-personalization Algorithms Work

As synthesized in Table 3, the next generation of AI-based hyper-personalization is Artificial Intelligence, Machine Learning, and Real-Time data, which unifies to develop highly personalized user experiences, instead of providing generalized suggestions, such as systems constantly observing behavioral signs and environmental context to adjust content, services, or product recommendations. According to the review literature of research, the internal operations of hyper-personalization have five related components: Real-Time Behavioral Tracking as the Operational Bedrock, Intelligent Learning Models for Dynamic Adaptation, Data Integration Platforms as the Personalization Backbone, Automated Recommendation Engines as the Decision Core.

Real-Time Behavioral Tracking as the Operational Bedrock Real-time behavioral monitoring is the foundation of hyper-personalization. This involves continuous user behavior capture—browsing habits, clicks, transaction history, and engagement. Data streaming is used to make marketing offers and product recommendations change by the moment, based on the user's behavior. Collectively, these studies reaffirm real-time behavioral tracking as the pivotal operational layer that makes responsiveness and personalization precision possible. Amil (2024) stated that personalization platforms depend on continuous behavioral tracking to guide and optimize AI responses. If there are changes in

users' preferences, the algorithm will adapt to keep recommendations contextually relevant and updated.

This fundamental perspective was supported by Rane et al. (2023), highlighted that real-time user feed data allows suggestion engines to adjust content and/or products to be suggested. They examined how companies used AI-driven models to monitor user decision behavior, specifically in customer-facing use cases such as e-commerce and customer management systems. Saksena (2024) also supports this operation strategy by emphasizing how retailers engage with real-time behavioral data streams to adapt marketing offers and product recommendations second by second dynamically, depending on the user's actions.

Additionally, Srinivasan et al. (2025) emphasized how financial technology applications like Revolut and PayPal utilize real-time transaction monitoring in delivering personalized financial advice, budgeting strategies, and investment recommendations. Services like these respond to users' current actions and behaviors, establishing an almost instant feedback loop between user activity and tailored responses. The study shows that financial services that use hyper-personalization significantly depend on real-time user behavior monitoring to enhance engagement and conversion rates.

Systems with hyper-personalization go beyond capturing behavior by relying on intelligent learning algorithms in processing and responding to data. Few of them are supervised and unsupervised machine learning, which allows them to backtrack past trends and predict future user demands. Khurana (2023) stated the fundamental tools for analyzing behavioral data and how collaborative filtering and deep learning are part of it. These methods play an essential role in providing systems with the ability to recognize user preferences, identify user similarities, and recommend items based on foreseen interest. Amil (2024) bridges this by detailing how the learning models adapt and improve as they

continually interact with the user, forming a feedback loop that improves with time. The algorithm adjusts future output with every action taken and processed to improve its prediction accuracy.

Rane et al. (2023) also identified predictive personalization as being enhanced when machine learning algorithms are trained on fine-grained, real-time behavior so that AI can evolve alongside real-time changes in user intent. Also, Bozkurt et al. (2025) discuss how the potential for AI and machine learning to map data into custom action is enabled. Their study describes how predictive analytics and deep learning algorithms would allow systems to cut through demographic profiles to deliver contextually relevant and emotionally relevant experiences. Moreover, the models can improve over time by learning from user behavior across platforms and devices to make subsequent interactions more effective. Examples include Netflix's genre prediction and Spotify's playlist that one can edit based on listening or viewing behavior—a dramatic example of smart learning systems applied to personalization.

Where behavior data is gathered, analyzed, and combined, the suggestions engine is the operational hub that decides what tailored output will be provided. Rane et al. (2023) described how these engines operate in real-time operations, using rule-based reasoning in combination with learned behavior to facilitate content or product recommendations. It further includes the ability of the system to tailor recommendations according to the fresh action undertaken by the user, which makes hyper-personalization unique compared to traditional practices.

Saksena (2024) also explained that by describing how AI-driven engines in retail use cases react to user navigation and decision flows, giving dynamic pricing or recommendations based on the present shopping goal. Khurana (2023) supports this by stating that these engines are implemented within a scalable, cloud-native infrastructure that

improves microservices architecture and enables fast deployment and reconfiguration of personalization logic across distributed systems. AI-powered models and flexible systems deliver fast, personalized suggestions that scale effortlessly.

Furthermore, Srinivasan et al. (2025) described how Fintech recommendation systems use machine learning algorithms, like XGBoost, to make decision-making tasks such as dynamic pricing and tailored financial advice more efficient. They highlighted that the timing of the suggestion plays an important role as recommendations greatly affect response rate, emphasizing the need for successful automation that syncs with user behavior.

Bozkurt et al. (2025) stated examples of automated recommendation systems that are in action. They emphasize different platforms such as Amazon, Trendyol, and Hepsiburada that use AI-driven technology to deliver real-time product suggestions, customized pricing, and specific marketing tools. These systems are implemented into e-commerce websites and marketing tools like chatbots and SMS/email communications, allowing instant, tailored offers while reducing the need for more human interaction. The study also shows the feasibility of enhancing user engagement and perceived value by creating personalized video content on demand.

C. Algorithmic Transparency and user trust

As synthesized in Table 4, the transparency of algorithms has been an international concern in designing and deploying AI-based systems since users interact with intelligent technologies and make independent decisions. While transparency can significantly improve users' comprehension and satisfaction, it poses crucial concerns about bias, fairness, information overload, and ethical responsibility. Thomaz et al. (2019), Guendouz (2024), Nwanna et al. (2025), Para (2024), Liu (2021), Yu and Li (2022), Vemuganti (2022), Wanner

et al. (2022), and Zerilli et al. (2022) all mention these factors, noting how algorithm transparency influence positively the trust issue of the user side and balance to be accomplished between explainability, simplicity, and complexity. These studies highlight the importance of making AI systems transparent and the need for transparency to be meaningful, understandable, and in line with user expectations and regulatory requirements.

One of the main issues mentioned by the studies worldwide is the transparency-trust trade-off. Even though transparency is typically believed to increase user trust, research shows that excessive and poor communication on a system's process can have the opposite effect. Thomaz et al. (2019) emphasize that trust can be built up by having moderate transparency, which can reduce uncertainty. However, high or lower levels of technical disclosure can create confusion or even reveal biases, which can lower their confidence. Para (2024) and Yu and Li (2022) also establish that while transparency advocates fairness and user awareness, it leads to doubts about algorithmic decisions, specifically if they are perceived as biased or limiting. This reveals the ongoing challenge of finding a balance between simplicity, legibility, and depth in transparency design so that it will not confuse or puzzle users.

Another approach explores the role of Explainable AI (XAI) in building user trust. Nwanna et al. (2025) and Para (2024) explain that XAI makes it easier to comprehend and justify algorithmic decisions, which is greatly important in personalized systems where users are often unaware of how content or recommendations are generated. Guendouz (2024) further contributed that transparency signaling in AI-mediated communication reinforces the organization-public relationship, proposing that perceived transparency can elevate trust even though technical transparency was restricted. Liu (2021) further indicates that users may struggle with trusting machine-made choices where algorithms create rules rather than human

judgment. Such findings further claim that transparency must be both functional and relational—implemented to inform and evoke ethical and emotional alignment with users.

Several specific algorithms remains to be ever so challenging for users to fully understand, which is why it is inherently difficult for humans to completely rely on AI, as Vemuganti (2022) highlighted that because users are not fully aware of how their data is being processed, together with their recommendations and suggested contents are being tabulated, their trust on the said technology remains in the blur. This was followed by Guendouz (2024), stated that systems seemingly looking manipulative and disproportionate stem from their lack of transparency. Yu and Li (2022) then noted that the cognitive and affective pathways are susceptible to being influenced by user trust, and that even a slight mishap can cause issues regarding trust, despite the clear transparency and efficiency. The human-AI joint workforce must also consider error tolerance, relations, trust, and explainability of the situation, as noticed by Zerilli et al. (2022). These studies show the struggles of maintaining transparency, keeping user trust at all times high, and not compromising it.

Personalization based on algorithms is a significant cause of users' lack of trust, which remains a concern. Para (2024) found that while personalization can enhance user experience and engagement, it may reduce diversity and strengthen existing biases. Nwanna et al. (2025) explain that unfairness brought by AI systems is morally inappropriate, specifically where the outcome of algorithms displays discrimination against particular sets of users. Guendouz (2024) recognizes that ambiguous price algorithms can be the reason for unfairness and manipulation. Yu and Li (2022) find that unease caused by a lack of transparency can complicate perceptions of bias or unfairness. Zerilli et al. (2022) proposed that trusting human-AI collaboration relies on achieving the balance between transparency,

fairness, and fault tolerance. These studies demonstrate that fairness needs to be addressed for transparency to lead to long-term user trust in AI personalization.

Aside from technical transparency, what organizations communicate about their use of algorithms is also key to influencing user trust. Wanner et al. (2022) mentioned that transparency signaling, i.e., clear explanations of how AI systems are designed, can improve organization-public relationships and trigger a sense of openness. Guendouz (2024) emphasized that consonant or false communication will likely reduce perceived transparency and wipe out trust, particularly in price and recommendation systems. Yu and Li (2022) noted that transparency must address both the cognitive and affective requirements of users, and how perceived effectiveness and discomfort become intertwined in the construction of trust. Zerilli et al. (2022) focused on clarity in human-AI interfaces so as not to confuse or overwhelm users. These findings imply that transparency is a characteristic of design for systems and strategic communication as well organizations need to issue discrete, consistent, and user-focused messages on AI if they wish to be trusted.

As beneficial as AI personalization is, it provokes issues of longer duration about transparency, justice, and moral accountability. Although processes and industry guidelines are gradually changing to meet these concerns, there are still wide gaps in organizational deployments of transparency and users' understanding and engagement with these systems. To become credible, organizations need to make AI transparent, be fair while making decisions, and enable users to be the masters of their digital information. Cooperative collaboration among users, regulators, and industry must occur to enhance the security, transparency, and clarity of AI-driven personalization and decision-making, and that will serve to promote and maintain user trust in an accelerating technology environment.

D. Compliance with data regulations

As synthesized in Table 5, AI hyper-personalization has transformed online engagement by providing hyper-personalized recommendations, content filtering, and future-predicted suggestions. Although this feature increases the user experience and engagement, it raises immediate concerns about data security, algorithm transparency, and regulatory matters. Soni (2024), Shah (2023), Reviglio (2020), Raji et al. (2024), Prosper (2023), Khurana (2023), Higgins and Dodd (2021), Rane et al. (2023), Adhikari et al. (2025), and Bell et al. (2024) explored these dimensions, shedding light on the paradoxes and problematics of AI-enabled personalization and its alignment with international regulatory frameworks like the General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA).

One of the most significant issues for most research is personalization vs. privacy. This is a scenario in which consumers desire a personalized experience but are concerned their data can be managed incorrectly or hacked. Soni (2024) and Shah (2023) formulated this paradox in terms of how customers define trust through an elaboration of how consumers formulate trust. In their studies, customers love AI-based personalization but are very scared of unauthorized data profiling, manipulation, and collection in the guise of getting them on board.

Regimes like GDPR and CCPA attempt to address these concerns by imposing consumer supremacy through open-ended consent requirements and data minimization methods. However, as Reviglio (2020) and Raji et al. (2024) contend, compliance is complex. AI personalization applications depend on intensive real-time data processing, which typically operates within the jurisdiction of uncertainty of law under which consumers unknowingly consent to data use terms that cannot be penetrated. It is an ethical concern of

user agency and informed preference because consumers tend not to know how AI algorithms shape their preferences, shopping behavior, and web existence.

Transparency is required in AI personalization, but it typically raises controversy in most studies. Where AI algorithms are not transparent, that is, black-box personalization, regulation becomes hard to implement and erodes customers' trust in the system. Shah (2023), Soni (2024), and Raji et al. (2024) concurred that most personalization models are opaque and difficult to interpret. This also complicates the explanation to regulators and users about the decisions being made.

Reviglio (2020) critiqued the application of GDPR, pointed out that while transparency regulations exist, AI personalization runs without adequate, clear explanations. Higgins and Dodd (2021) expand this concern further by discussing data localization trends, contending that strict transparency regulations could hinder AI innovation. At the same time, Bell et al. (2024) cautioned that AI-based marketing personalization will reinforce biases and bring about manipulative profiling behaviors that influence consumer decisions without free awareness.

Rane et al. (2023) and Adhikari et al. (2025) noted that AI banking and e-commerce personalization are still poorly regulated, and algorithms are not adequately controlled. When the personalization models are refreshed from user data, it is difficult to ascertain whether they are GDPR's Article 22 compliant, giving the consumer the right to object to automated decisions. This implies personalization processes are out of control, and regulatory and ethical questions arise.

The research presented here provides varying opinions on whether AI-based hyper-personalization complies with the laws. Soni (2024) and Shah (2023) argue that although legislation such as GDPR and CCPA provides compliance needs, it is difficult to attain them

in their entirety, given the adaptive personalization strategies of AI. Reviglio (2020) also stated that GDPR does not work. He goes on to say that its rules do not tackle AI personalization. Raji et al. (2024) also agreed that companies would rather follow unclear compliance rules. They also add that it is hard to blame AI personalization for breaking privacy laws.

Prosper (2023) and Khurana (2023) referenced the problem of AI personalization security within marketing and e-commerce. They argue that while personalization boosts the value of customer experience, it also elevates the value of data hacking, identity theft, and profiling abuse. Bell et al. (2024) also explain that AI personalization will cause unwanted behavior targeting without regulation, and it will be challenging to manage.

The argument against regulations for AI is reinforced by the research of Higgins and Dodd (2021) on data localization trends. They observe that stringent data rules render it difficult for AI to offer personal experiences since companies struggle to meet intricate local regulations while attempting to provide personalization. Without evident rules for AI, enforcing the rules is illogical, and deciphering compliance is complicated.

Bias in personal AI is also another area studied in different studies. Prosper (2023) and Bell et al. (2024) showed that algorithms for personalization trained on biased datasets can unknowingly become discriminative in recommendations, leading to discriminatory marketing plans. Adhikari et al. (2025) argued that AI-powered personalization in finance and banking will harm certain groups due to biased credit scoring systems and personalization strategies toward financial services. Similarly, Raji et al. (2024) suggested price disparity via e-commerce personalization, such that AI-powered price optimization can differentially affect purchasers based on behavioral data. Higgins and Dodd (2021) discussed ethical concerns regarding algorithmic bias in AI personalization and state that data

localization boundaries could contribute even more to bias issues by inhibiting access to rich datasets. While GDPR and CCPA attempt to address fairness challenges, enforcement actions are not standardized, and biased personalization models may still exist with inadequate intervention.

While most studies agreed on the privacy, transparency, and compliance challenges associated with AI personalization, their outlook on the future of AI governance differs. Soni (2024) and Shah (2023) argued that stricter enforcement may improve compliance, whereas Reviglio (2020) and Bell et al. (2024) highlighted deeper ethical concerns that persist beyond regulatory gaps. Khurana (2023) and Higgins & Dodd (2021) suggest that AI personalization may coexist with compliance frameworks if businesses improve transparency and adopt interpretability measures. However, Raji et al. (2024) and Adhikari et al. (2025) stated that personalization models evolve quickly than the regulations can catch up, resulting in an ever-sustained cycle of regulatory uncertainty. Ultimately, AI-based hyper-personalization offers great value but remains a thorny issue around privacy, transparency, and regulatory compliance. Though the existing law is working to contain AI personalization, the mentioned study pinpoints sectors of sustained areas of enforcement challenge, ethical regulation, and compliance harmonization. As AI personalization advances, regulators and firms must capture the harmony between good governance and innovation in addressing these tensions regarding how they must deal with them.

E. Improving Data security and transparency in AI personalization

As synthesized in Table 6, the application of artificial intelligence (AI) in personalization systems has transformed how organizations offer personalized experiences

across different fields. However, this new technology has simultaneously heightened data security, privacy, and transparency concerns.

The key to enhancing AI personalization begins with what Soni (2024) calls the "personalization-privacy paradox." This conflict is between what consumers want from personalized experiences and their fears about protecting personal information. Soni's results suggest increased transparency can alleviate privacy concerns, with a regression coefficient of $\beta = 0.45$ ($p < 0.01$). This result shows that increasing transparency is one of the most valuable ways to build AI personalization systems. This fact suggests that organizations should strengthen their data protection by strengthening transparency programs. Methods. Khan and Sajjad (2024) also supported this method by observing that "enterprises that target data protection and transparency will be most likely to earn consumer trust, resulting in increased participation and sales." Their study testifies that adopting strong data security and transparency standards should not be understood as compliance but as an investment strategy that yields actual business benefits. Such an understanding prompts organizations to challenge security and openness improvements as competitive strengths rather than operational burdens, potentially changing how Funds are allocated to these core functions.

Literature also continues to call for implementing multi-layered, comprehensive steps for the facilitation of data security and transparency of AI personalization. According to Xu et al. (2021) PGU (Phase, Guarantee, Utility) framework is a structured approach to analyzing and improving privacy solutions in the machine learning pipeline. It allows organizations to invest strategically towards security improvement by examining three dimensions: the ML pipeline point of protection deployment, the promised privacy warranty strength, and the system utility impact. Organizations using this framework can conceptualize

more sophisticated and realistic solutions for improving data security without hampering the functionality of their personalization systems.

Hosain et al. (2023) provided a much more technical framework for this field by the establishment of federated educational systems that included differential privacy (APPLE+DP) and homomorphic encryption (APPLE+HE). These extended means of maintaining privacy enabled secure, decentralized training of personalization algorithms while retaining rigid user privacy. They concluded that integrating these approaches into hyper-personalized systems may be one of the most promising avenues of safe individualized design.

Charles (2024) stated that applying generative AI to highly personalized retail marketing has vast potential but must be carried out carefully for data security and openness. Since customers are providing their data and retailers are gathering and applying ample customer data to design personalized experiences, robust data protection protocols are required. Applying end-to-end encryption, carrying out frequent security audits, and adhering to global data protection principles can go a long way toward minimizing privacy risk.

In their research, Felzmann et al. (2020) outlined that it is essential to constructively follow the combination of transparency throughout each phase of AI development so that it becomes personalized and not confusing. They further emphasize several key drivers of the importance of transparency, such as trust creation, decision explanation, system accountability, and user control. The plan describes that it is better to embed transparency in all facets of AI development instead of considering it only as a regulatory requirement or afterthought. Applying XAI (i.e., explainable AI) methods is emerging as the most fitting solution to improve system understanding. Abbas and Qazi (2024), list a variety of security developments, among which the employment of anomaly detection systems is one, not only

identifying irregular behaviors in the system but also responding to them accordingly. At the same time, improving security systems should not lead to decreased user experience, as sound security systems should remain the main support for the user. It is of utmost importance to strike the right balance, as too strict security measures can cause more harm than they prevent regarding their technical stability, although they are highly functional.

Mylrea and Robinson (2023) proposed using regulations and standards as another escape route for beefing up the security and transparency of AI personalization. They suggest a AI Trust Framework and Maturity Model (AI-TMM) that implements a structured way of evaluating and enhancing AI implementations using an "entropy lens" based on information theory. The new vision of the framework deals with privacy keeping in mind the fact that regulatory concerns go first, that the implementation of technological measures respecting regulations and based on security requirements is a prerequisite, issuing organizations a tactical management with the completion of different factors involved in the process of reaching the apex of success and the governance of their AI systems. Adopting policy changes for a better AI that protects customers' privacy and enables, at the same time, transparency is a way of going. Thus, organizations can also improve their processes of security manageability, security audits, and compliance with policies and regulations by following the vertical progress of security enhancement and transparency issues. Using such frameworks, organizations can be free of only superficial security aid, taking into account the integrated security and transparency aspect, as well as more general governance. Shah (2023) argues for more standardized measures and policy guidelines that will inform ethical AI use rather than the usual process of implementing the same varieties of standards with significant differences in the execution phase. The proposal of such standardized guidelines, instead of reinventing the wheel with every new AI personalization system, will contribute to the

organization's objectives and make the end-users, developers, and regulators comprehend them better. Using standardized best practices can significantly improve the security and transparency of the systems and set the bar very high for organizations to adopt these rules.

Mylrea and Robinson (2023) propose using company ethics as one of the primary drivers for improving customer security and trust in AI personalization. They developed the AI-TMM that shows a systematic pathway for assessing and enhancing AI implementations using an "entropy lens" derived from information theory. The framework lays out the topics of interest, including data privacy, legal observance, and technical safeguarding measures, delivering organizations a method to extensively diagnose and improve their AI systems. Since companies now embrace these frameworks, they will quit the pattern of one-after-the-other improvements in security and transparency and start using a more straightforward yet effective way of adhering to overall governance norms.

Interdisciplinary collaboration was raised as the research highlighted a necessary step in developing AI personalization systems (Kim et al., 2024; Li et al., 2024). It was agreed that privacy is a very sensitive issue and that only individuals can give authorization to process their data. The authors note that this is a discussion where multiple areas come in to contribute with their valuable perspectives. Because necessary advancements in AI personalization systems could be obtained from a wide range of fields, such as technical disciplines, ethics, law, and psychology. Shah (2023) conducted research explicitly discussing innovative ways to improve data security in educational AI personalization. Examples of such technical solutions include state-of-the-art encryption technologies, resilient authentication systems, and blockchain technology. These methods of technical enhancement are not unexploited; instead, they serve as challenges for developing security in the outlined application domain areas, and thus, a possibility for other applications unrelated

to the topic of automation. The research gives utmost importance to the idea that there should be changes in the perception of security improvements towards the innovation process, i.e., such measures should not become constraints but be seen as the steps towards green and sustainable AI deployment, which results in both users' privacy protection as well as the delivery of the benefits of personalization.

In general, gaining data security and transparency ensures that AI personalization uses complex tactics, including the business's technical, ethical, regulatory, and communicative aspects. The study recommends that companies use integrated frameworks, a security system that works on a multi-layer basis, transparency mechanisms that make the lifecycle visible, and explainable AI techniques that will help improve the personalization of their systems. Organizations are supposed to develop their improvement strategies to adapt to the rapidly changing regulatory environment and maturing technologies that are likely to impact the world of AI while maintaining their users' trust. Suppose AI as a tool for personalization is to progress in the future. In that case, it will result from not trading off personalization's effectiveness with security and transparency but rather the building of integrated systems that lead to attaining all three goals by considering the details, expressing the procedure coherently, and continually responding to new difficulties and opportunities.

CONCLUSION

Hyper-personalization runs on real-time behavioral monitoring, intelligent learning algorithms, and rapid data fusion systems. All these combine to establish adaptive and personalized user experiences. AI and machine learning continuously optimize repeatedly based on real-time interactions and convert digital interactions into contextual and customized experiences.

AI hyper-personalization has brought user experiences to the stage of providing personalized suggestions and foresight recommendations. Attempts are being made to limit its ethical impact through legislation such as GDPR and CCPA, but compliance remains challenging. Transparency and fairness issues related to algorithmic bias persist, as personalization progresses faster than regulation can keep up. Though it enhances the users' engagement, a more proactive investigation about personalization's ethical and regulatory implications is necessary as AI technology evolves consistently.

Algorithmic transparency is one of the pillars of user trust in AI technologies. As much as it brings awareness and fairness, it creates issues of complexity and bias. Explainable AI (XAI) has an important role in solving trust issues and explaining algorithmic decisions, especially in personalized systems. There needs to be collaborative work from the industry, regulators, and users to develop trustworthy AI. Transparency must be relational and functional and strike a balance between communication, justice, and empowering users to build long-term trust.

AI-powered hyper-personalization is convenient but risks privacy and data security. Real-time data collection and profiling increase the risk of violations. Transparency and control on the user's part are helpful, but a better solution involves privacy by design, robust encryption, and sector regulation. For hyper-personalization to be possible, systems must be designed to be secure, and organizations and developers must build in data protection at every step of the process, from gathering to deployment.

Data protection and transparency in AI hyper-personalization must be enhanced through harmonizing technical solutions with ethical standards. Organizations have to implement multi-layered security controls, employ explainable AI techniques, and maintain end-to-end visibility controls throughout the AI development life cycle. Personalization and

privacy protection must be achieved harmoniously through integrated frameworks, trans-disciplinary solutions, and standardized regulatory requirements, ultimately building user trust through personalized experiences.

REFERENCES

- Abbas, E., & Qazi, A. A. (2024). Customized AI-powered security and privacy configurations for social media websites. *BULLET: Jurnal Multidisiplin Ilmu*, 3(1), 108–117.
- Adhikari, P., & Hamal, P. (2025). The role of big data analytics and management information systems in consumer personalization in U.S. retail, banking, and finance. *International Journal of Scientific Research and Applications*, 14(2). <https://doi.org/10.30574/ijrsra.2025.14.2.0388>
- Aggarwal, A. (2024). Navigating the complex landscape of AI-driven personalization: Challenges and considerations in the generative AI era. *International Journal of Scientific Research in Computer Science Engineering and Information Technology*, 10(6), 2284-2295.
- Amil, Y. (2024, September 1). *The impact of AI-Driven personalization tools on privacy concerns and consumer trust in e-commerce*. MatheO - Master Thesis Online. <https://matheo.uliege.be/handle/2268.2/21371>
- Bell, C., Olukemi, A., & Broklyn, P. (2024). AI-driven personalization in digital marketing: Effectiveness and ethical considerations. *Preprints*. <https://doi.org/10.20944/preprints202408.0023.v1>
- Bozkurt, S., Uğursoy, A. S., & Meral, S. P. (2025). The impact of personalized messages and designs on consumer experiences and marketing communications in technology: Hyper-personalization. In *impact of contemporary technology on art and design* (pp. 135–164). IGI Global. <https://doi.org/10.4018/979-8-3693-4318-0.ch007>
- Felzmann, H., Fosch-Villaronga, E., Lutz, C., & Tamò-Larrieux, A. (2020). Towards transparency by design for artificial intelligence. *Science and Engineering Ethics*, 26(6), 3333–3361. <https://doi.org/10.1007/s11948-020-00276-4>
- Guendouz, T. (2024, July 8). The emergence of algorithmic pricing enhanced by hyper-personalization in the era of artificial intelligence. *North American Journal of Social and Political Philosophy (NAJSP)*, 3(1), <https://doi.org/10.5281/zenodo.10800865>
- Hanson, J., Wei, M., Veys, S., Kugler, M., Strahilevitz, L., & Ur, B. (2020). Taking data out of context to hyper-personalize ads. *Association for Computing Machinery*, 1–13. <https://doi.org/10.1145/3313831.3376415>

- Higgins, B. W., & Dodd, A. (2021). Artificial intelligence and trust: Improving transparency and explainability policies to reverse data hyper-localization trends. *The Journal of Science and Law*, 8(1), 1-11. doi:10.35005/q8t1-ek30
- Hosain, M. T., Zaman, A., Sajid, M. S., Khan, S. S., & Akter, S. (2023). Privacy preserving machine learning model personalization through federated personalized learning. *In 2023 4th International Conference on Data Analytics for Business and Industry (ICDABI)* (pp. 536–545). IEEE. <https://doi.org/10.1109/ICDABI60145.2023.10629638>
- Islam, M. A., Fakir, S. I., Masud, S. B., Hossen, M. D., Islam, M. T., & Siddiky, M. R. (2024). Artificial intelligence in digital marketing automation: Enhancing personalization, predictive analytics, and ethical integration. *Edelweiss Applied Science and Technology*, 8(6), 6498–6516. <https://doi.org/10.55214/25768484.v8i6.3404>
- James, C. (2024, October 22). *Generative AI in retail marketing: Hyper-personalized campaign messaging*. Available from: <https://shorturl.at/Nlwrr>
- Joshi, R., Patel, N., Iyer, M., & Iyer, S. (2021). Leveraging reinforcement learning and natural language processing for AI-driven hyper-personalized marketing strategies. *International Journal of AI & ML Innovations*, 10(1).
- Khan, S. N., & Sajjad, H. (2024, September 24). Personalization in e-commerce: Balancing consumer privacy and marketing effectiveness. *Research Corridor Journal of Engineering Science*, 1(2), 108–117. <https://doi.org/10.5281/zenodo.15068260>
- Khurana, R. (2023, October). Architecting the future of e-commerce payments with generative AI: Driving next-generation fraud intelligence, hyper-personalization, and autonomous transactional ecosystems for global market leadership. *International Journal of Innovative Research in Technology*, 10(5), 451-456.
- Khurana, R. (2023). Hyper-scalable cloud-native AI frameworks for predictive hyper-personalization in high-traffic e-commerce ecosystems. *International Journal of Computer Engineering and Technology*, 14(3), 196–206.
- Kim, Y., Lee, J., Kim, S., Park, J., & Kim, J. (2024). Understanding users' dissatisfaction with ChatGPT responses: Types, resolving tactics, and the effect of knowledge level. *In Proceedings of the 29th International Conference on Intelligent User Interfaces (IUI '24)* (pp. 1–20). Association for Computing Machinery. <https://doi.org/10.1145/3640543.3645148>
- Liu, B. (2021). In AI we trust? Effects of agency locus and transparency on uncertainty reduction in human–AI interaction. *Journal of Computer-Mediated Communication*, 26(6), 384–402.
- Li, L., Huang, W., & Liu, B. (2024). A research-oriented model for artificial intelligence education: Integrating multidisciplinary approaches to foster innovation and holistic

learning. In *Proceedings of the 2024 7th International Conference on Educational Technology Management (ICETM '24)* (pp. 480–485). Association for Computing Machinery. <https://doi.org/10.1145/3711403.3711481>

Mendia, J. M. V., & Flores-Cuautle, J. J. A. (2022). Toward customer hyper-personalization experience — A data-driven approach. *Cogent Business & Management*, 9(1). <https://doi.org/10.1080/23311975.2022.2041384>

Mylrea, M., & Robinson, N. (2023). Artificial Intelligence (AI) Trust framework and maturity model: Applying an entropy lens to improve security, privacy, and ethical AI. *Entropy*, 25(10), 1429. <https://doi.org/10.3390/e25101429>

Nwanna, M., Offiong, E., Ogidan, T., & others. (2025). AI-driven personalisation: Transforming user experience across mobile applications. *Journal of Artificial Intelligence, Machine Learning & Data Science*, 3(1), 1920–1929. <https://doi.org/10.51219/JAIMLD/maxwell-nwanna/425>

Para, R. K. (2024). The Role of Explainable AI in Bias Mitigation for Hyper-personalization. *Journal of Artificial Intelligence General science (JAIGS)*, 6(1), 625–635. <https://newjaigs.com/index.php/JAIGS/article/view/289>

Parker, O. (2023). *Cloud Computing and AI in Education: Revolutionizing Personalized Learning While Ensuring Data Security*. Retrieve from <https://11nq.com/pqubaiq>

Paul, J., & Rialp-Criado, A. (2020). The art of writing literature review: What do we know and what do we need to know? *International Business Review*, 29(4), 101717. <https://doi.org/10.1016/j.ibusrev.2020.101717>

Prosper, J. (2023). *Challenges and Best Practices in Implementing Deep Learning for Marketing Predictions*. Retrieve from <https://11nq.com/uf1huls>

Raji, N. M. A., Olodo, N. H. B., Oke, N. T. T., Addy, N. W. A., Ofodile, N. O. C., & Oyewole, N. a. T. (2024). E-commerce and consumer behavior: A review of AI-powered personalization and market trends. *GSC Advanced Research and Reviews*, 18(3), 066–077. <https://doi.org/10.30574/gscarr.2024.18.3.0090>

Rane, N., Choudhary, S., & Rane, J. (2023). Hyper-personalization for enhancing customer loyalty and satisfaction in Customer Relationship Management (CRM) systems. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4641044>

Reviglio, U. (2020). Towards a Right not to Be Deceived? An Interdisciplinary Analysis of Media Personalization in the Light of the GDPR. In *IFIP advances in information and communication technology* (pp. 47–59). https://doi.org/10.1007/978-3-030-39634-3_5

Saksena, N. (2024). Hyper-Personalization in Retail: Leveraging Data Science and Real-Time Streaming. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 10(6), 1382-1392.

- Sarioguz, O., & Miser, E. (2024). Assessing the role of artificial intelligence in enhancing customer personalization: A study of ethical and privacy implications in digital marketing. *International Journal of Science and Research Archive*, 13(2), 812–825. <https://doi.org/10.30574/ijjsra.2024.13.2.2207>
- Saura, J. R. (2024). Algorithms in digital marketing: Does smart personalization promote a privacy paradox? *Journal of Strategic Marketing*, 13(5). <https://doi.org/10.1177/23197145241276898>
- Seppala, T., Mucha, T., & Mattila, J. (2023). Beyond AI, blockchain systems, and digital platforms: digitalization unlocks mass Hyper-Personalization and mass servitization. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4433149>
- Shah, H. (2023). *AI and cloud computing in education: Enhancing personalized learning with robust data security measures*. Retrieved from <https://11nq.com/2rvt9vq>
- Sharma, R. (2024, October). Data-driven personalization: Revolutionizing user experience. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 10(5), 868–877. <https://doi.org/10.32628/CSEIT241051075>
- Soni, V. (2024). AI and the Personalization-Privacy Paradox: Balancing Customized Marketing with Consumer Data Protection. *International Journal of Computer Trends and Technology*, 72(9), 24-31.
- Srinivasan, R., Pandey, R., Pasha, N., Borah, A. J., Ray, A. P., & Garg, A. (2025). *Hyper-personalization in digital marketing: The role of FinTech and predictive analytics*. *Advances in Consumer Research*, 2(3), 127.
- Thangavel, V. (2025). Revolution of AI in hyper-personalization marketing of FMCG. *St. Francis Institute of Management and Research Mumbai*. <https://doi.org/10.2139/ssrn.5038511>
- Thomaz, F., Salge, C., Karahanna, E., & Hulland, J. (2024). Learning from the dark web: Leveraging conversational agents in the era of hyper-privacy to enhance marketing. *Journal of the Academy of Marketing Science*, 48(1), 43–63. <https://doi.org/10.1007/s11747-019-00704-3>
- Vemuganti, R. (2022b). Privacy, hyper-personalization, and autonomy harms. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4072059>
- Wanner, J., Herm, L., Heinrich, K., & Janiesch, C. (2022). The effect of transparency and trust on intelligent system acceptance: Evidence from a user-based study. *Electronic Markets*, 32(4), 2079–2102. <https://doi.org/10.1007/s12525-022-00593-5>
- Xu, R., Baracaldo, N., & Joshi, J. (2021, August 10). Privacy-Preserving Machine Learning: Methods, challenges and directions. *arXiv*. <https://arxiv.org/abs/2108.04417>

Yu, L., & Li, Y. (2022). Artificial intelligence decision-making transparency and employees' trust: The parallel multiple mediating effect of effectiveness and discomfort. *Behavioral Sciences*, 12(5), 127.

Zerilli, J., Bhatt, U., & Weller, A. (2022). How transparency modulates trust in artificial intelligence. *Patterns*, 3(4), Article 100455.
<https://doi.org/10.1016/j.patter.2022.100455>

Gamification in Computing and Information Technology Education at the Tertiary Level: A Literature Review

Abstract

This review looks at how using games in education helps college students learn better in Computer Science and IT classes. The researchers used a step-by-step method to study existing research. The review utilized information and computer science literature gathered from reputable and credible online databases that have published relevant literature. To guarantee the most recent studies were included, all searches were restricted to the time period from 2020 to the present. The papers were screened according to the inclusion and exclusion criteria, yielding 37 articles. After that, each article was thoroughly read and analyzed, producing 20 finalized articles for inclusion based on their alignment with the study's objectives. The results show that gamification is not a universal solution but rather a contextual tool that requires careful customization. It is also revealed that increased engagement doesn't automatically translate to improved learning outcomes, suggesting fundamental flaws in how gamification is currently conceptualized and implemented. Still, gamification increases students' interest, confidence, and intrinsic motivation in learning. In this type of environment, greater value is given to student learning and interest, while also promoting their satisfaction in engaging with school activities related to computer science and programming. Based on the evidences, the researchers strongly suggests that institutions should treat gamification as a validated educational strategy with proven benefits. In order to do this, they must first codify policies, next is to encourage collaboration among schools to share best practices, improve gamification analytics, and implement regular feedback systems for continuous improvement.

Keywords: students, gamification, computer science, information technology, programming education

INTRODUCTION

In today's era dominated by technology, many tools are expected to emerge in support of learning, and gamification is one such method that helps make students more active in demonstrating their various skills in a more dynamic way, allowing them to maintain knowledge, interest, determination, and concentration throughout their studies (Özdamli & Yazdeen, 2021). Gamification also shapes each individual's learning process, especially in fields that require focus for knowledge to flow more effectively through play. Portela (2020) stated that making each part of the learning activity more engaging and prioritizing these strategies to ensure that computer science and programming students don't experience gaps in knowledge or feel excluded from any part of their educational journey. Gamification is a

game-based approach that continues to gain strength in education in order to make each element more beneficial in teaching and learning, especially in subjects under the programming course (Cao et al., 2022). It cannot be denied that many students continue to struggle with learning various subjects, which often leads them to quickly give up, particularly those in programming or computer science. Because of this, gamification becomes a tool to deepen the knowledge of each student experiencing difficulties in learning. Gamification brings color, value, and fun, enhances motivation and engagement to the learning process (Swacha & Szydłowska, 2023). In the realm of gamification, the active participation of each individual student in the computer science course is clearly visible. One of the methods used to help students easily adapt to learning is through game choices, where each student is given time to answer quizzes enhanced with sound and design. This includes features like leaderboards, badges, and points awarded after completing a quiz assessment (Zainuddin et al., 2020). As a result, knowledge expands, decision-making improves, and various skills are developed, especially critical thinking, where one can observe the continuous sharpening of memory and the ability to recall what they have answered.

When it comes to teaching, many students experience anxiety because their interests vary, which often leads to important lessons not being fully absorbed during daily classes. It is evident that not everyone can quickly understand or keep up with the pace of learning being taught (Tomić et al., 2025). However, with the rise of gamification, more students can now relate, especially with the growth of technology, which students tend to appreciate, particularly when it involves tech-related activities. For many learners, boredom during classes becomes a barrier to absorbing information, which leads some of them to create their own self-study methods in order to better understand and keep up with the lessons. But when this happens, the overall quality of interaction and guidance in the classroom is reduced,

especially in Computer Science, where peer and instructor-led learning is essential. That is why gamification. as it continues to grow, is expected to help ensure that no student is left behind in any level of education (Alsadoon et al., 2022). It plays a crucial role in helping each individual develop a mindset that aligns with the standards of effective learning.

The implementation of gamification in education has become popular, especially in this era where technology is emerging (Zhan et al., 2020; Videnovik et al., 2023). Computer science and information technology programs are the ones that contribute to the enhancement of technology. Implementation of gamification in these programs is beneficial to improve their engagement and motivation (Ahmad et al., 2020; Zahedi et al., 2021). Gamification includes applying game elements to teaching, such as giving points and badges for every participation and game-driven challenges (Figueiredo et al., 2020; Hastings et al., 2022). And also developing educational games that are built using a gamification framework (Winanti et al., 2021; Lampropoulos et al., 2023). These modern learning materials are very useful for teaching computer science and information technology students and have the potential to help them enhance their critical thinking and problem-solving skills (Velázquez-García et al., 2023; Cuervo-Cely et al., 2022). Even though there are positive impacts of gamification on education, and even most of the articles prove that gamification in education is helpful to student retention and motivation Rodrigues et al., (2021) and Chong et al., (2024), there are still challenges that it faces, such as some of the gamification implemented only providing short-term benefits and a lack of proof for consistent effectiveness (Zhan et al., 2020; Videnovik et al., 2023). According to respondents, they are worried since the coverage of the lesson on games is limited, so there are no particular studies that prove the effectiveness of gamification on education (Tasadduq et al., 2021; Alomair & Hammami, 2020). According to the researcher's literature review, most of the studies the researchers gathered are focused on

the effect of gamified education on students, which is relevant to the study they are conducting (Call et al., 2021; Chong et al., 2024). There are still gaps that need answers, such as which game elements affect the students' learning performance, and also what strategies for gamified frameworks the instructors used to be able to deliver the programming lessons (Pinto & Terroso, 2022; Lampropoulos et al., 2023). There are limitations that are observed, such as the difference in the duration of implementing gamification in computer science and information technology education; different types of frameworks are used, which leads to different results; and the size of the sample also influences the results, as a small sample size cannot conclude the effectiveness of gamification in education (Jawad & Tout, 2021; López-Fernández et al., 2023). Finally, there are no consistent standards for adopting gamification in education. Furthermore, demographic differences influence how students and teachers adapt to gamification, as availability, resources, and culture vary among countries (García-Iruela et al., 2020; Alomair & Hammami, 2020).

Gamification has been demonstrated as a potential strategy for engagement and outcomes in CS and IT education. The mechanism of action differs, contextual challenges and motivation by students differ leading to an uneven effect. Although studies like Zhan et al. (2022) and Ahmad et al. (2020) emphasise its possibility to increase problem solving, cooperation and academic results; however, despite that paper, the effectiveness of gamification is still inconsistent, depending on used approaches, context limitations and variations about student motivations. For example, García-Iruela et al. (2020) discovered that higher student activity in the gamified environment is not directly associated with tangible learning improvements, while Zahedi et al. (2021) found that, in the short-term, gamification worked to improve academic achievement in the short-term, but there was no major effect on retention and identity development in CS in the long-term. Similarly,

Tasadduq et al. (2021) unveiled cultural and pedagogic obstacles in transferring gamification to rote-learning environments, while Lampropoulos et al. (2023), noted technical challenges on combining augmented reality and gamified solutions. These gaps and discrepancies point to a fundamental disjunction: the fact that, despite its benefits (such as its supportive role in participation, creativity and peer learning (Videnovik et al., 2023; Velázquez-García et al., 2023), gamification's full potential has yet to be realised, due to such remaining challenges as student anxiety resulting from competition (Figueiredo et al., 2020), the sustainability of engagement (Rodrigues et al., 2021) and the required teacher expertise (López-Fernández et al., 2023).

The purpose of the study is to examine the effectiveness of gamification methods and techniques in influencing the academic performance and skill development of students', especially in the tertiary level with Computer Science and Information Technology courses. Zahedi et al. (2021) observed in their study that the inclusion of video game elements, especially virtual points enhanced the academic performance of both male and female students. This study aims to determine the important factors that influence the effectiveness of gamification, the challenges faced in the process of implementation of gamification like the inability to support various kinds of learners with individuals having different expectation and reaction to it (Alomair & Hammami, 2020), and assess the influence of gamification on the retention and academic outcomes of students. In their study, Chong et al (2021), showed that gamification improves students' motivation and performance, which are highly associated with retention.

Therefore, this research is focusing on the impact of gamification towards students learning by looking into what are the key factors making gamification successful, the challenges of implementing it, and how it improves students' retention and performance,

Specifically, the study will attempt to synthesize (1) the factors that make it a success, (2) implementation challenges, and (3) its effects on retention and performance.

THE REVIEW

The Design

This literature review will follow a systematic review approach. The design will utilize the six-step guidelines to suit the needs and limitations of this literature review (Durach et al., 2017). First, we define the review's purpose and research questions. Second, we develop a clear review protocol, including inclusion and exclusion criteria. Third, we conduct a comprehensive literature search. Fourth, we screen and select relevant studies. Fifth, we extract and analyze data from the selected literature. Finally, we report and synthesize the findings to draw conclusions and identify research gaps.

Research Objectives

This literature review aims to answer the research question: How effective are learning through gamification methods in influencing students' academic performance and skill development? Moreover, it seeks to accomplish the following objectives: (1) To identify the key factors that influence the effectiveness of gamification in Computer Science and Information Technology Courses; (2) To identify the challenges in implementing gamification; and (3) To evaluate the effectiveness of gamification in optimizing student retention and academic performance.

Retrieving and Selecting Pertinent Literature

The purpose of the review was to identify and choose high-quality and relevant literature on the application of gamification in computer science education. The review

utilized information and computer science literature gathered from reputable and credible online databases that have published relevant literature. Search string keywords used for the online databases are "Natural language, development, Machine Learning," and related terms. Seventeen thousand nine hundred (17,900) articles were identified from the database search. Thirty-two thousand eight hundred eleven (32,811) results were identified from ScienceDirect, and 12 articles from IEEE. Additionally, Google Scholar was used to look up most articles from websites published by other journals. About a thousand articles were found, including those from reputable publishing websites like IEEE, ScienceDirect, etc. To guarantee the most recent studies were included, all searches were restricted to the time period from 2020 to the present, and queries were also targeted at particular subject areas. These topic-specific searches yielded the following results: 56,900 articles on gamification in computer science, 386,000 on anxiety in learning computer science courses, 32,600 on gamification motivating computer science students, and 21,700 on gamified e-quizzes in computer science courses. Subsequently, the papers were screened according to the inclusion and exclusion criteria, yielding 37 articles. After that, each article was thoroughly read and analyzed, producing 20 finalized articles for inclusion based on their alignment with the study's objectives. To ensure the quality of the literature that the researchers will utilize, an inclusion and exclusion criterion is applied. The inclusion criteria focused on peer-reviewed articles written in English and published from 2020 up to the present. Articles must discuss or be related to implementing gamification in education, and the respondents must be computer science and information technology students. Also included are gamification's effects on student academic performance or related aspects, on the other hand. The exclusion criteria exclude articles that are published in unreliable databases, outdated articles, non-English materials, and articles unrelated to

the topics. These criteria are established in order to gather only credible, high-quality, and relevant studies that will be included in the final analysis or the results, and discussion.

Synthesizing the Literature

The selected pertinent literature was published from the year 2020-2024. The total articles is 20, which met the criteria for the review and were selected from the studies, extracting data from each article and examining the main study findings combined in Tables 1-3.

Table 1. Table synthesis of the factors that influence the effectiveness of gamification.

Author	Factors That Influence The Effectiveness Of Gamification
Ahmad, A., Zeshan, F., Khan, M. S., Marriam, R., Ali, A., & Samreen, A. (2020).	This study primarily explores the use of gamification techniques in teaching computer science subjects. It also examines how group size affects student satisfaction and learning outcomes.
Alomair, Y., & Hammami, S. (2020).	This study underlines the need to incorporate game dynamics and adaptive approaches into the learning environment. It offers a motivated learning strategy that stimulates many types of learners. They do, however, recommend that additional research is needed to boost learners' motivation ratios.
Call, M. W., Fox, E., & Sprint, G. (2021).	In this research, the gamification system (Leaderboard) gives rewards to the students on passing the unit test in advance, creating a positive reinforcement cycle. The reason this gamification is effective, based on this study, is that the Integration with industry-specific tools such as GitHub Classroom, build servers, and Moodle assists the learning of real-world skills in an environment that is gamified. Finally, Students who used the Leaderboard spent a greater amount of time committing code and passed a greater number of unit tests, implying greater engagement.
Chong, M. M., Subramanian, P., Ting, M., & Ying, L. J. (2024)	The authors highlighted that learners are inclined to interactive and rewarding learning strategies because these are more motivating and provide a feeling of success. That is to say, gamification plays an important role in boosting motivation factors, which are essential to enhance learning effectiveness. And with this generation's obsession to technology, gamification strategies are particularly helpful to Gen Z learners who like interactive and technology-based learning strategies.
Cuervo-Cely, K. D., & Ramírez-Echeverry, J. J. (2022)	The study found that the effects of Gamification work best when it includes diverse elements like challenges, rewards, and feedback while aligning closely with learning objectives to maintain relevance and motivation. Student autonomy and immediate progress tracking further enhance engagement and self-efficacy.
Figueiredo, J., & García-	This study found that gamification's success hinges on game elements (e.g., leaderboards, badges) and personalized feedback, which boost motivation

- Peñalvo, F. J. (2020) and engagement, as shown by improved attendance (18.1%) and student feedback in the study. Teacher involvement and balancing competition with collaboration are also critical to sustain participation and avoid demotivating lower-ranked students.
- García-Iruela, M., Fonseca, M. J., Hijón-Neira, R., & Chambel, T. (2020) The study found that the problems posed by gamified features are not always resolved by their mere use. Students' participation in a course with these features does not necessarily indicate an improvement in learning; rather, the quality of the activity produced matters more than its quantity.
- Hastings, J., Weitzl-Harms, S., Spanier, A., Rokusek, M., & Henszey, R. (2022) The ZORQ GDGF serves as a catalyst for motivating students by enhancing student engagement and achievement in undergraduate Computer Science (CS) education, independent of student experience or background. The dynamic gamification components used in the GDGF make it a desirable learning approach for pupils.
- Jawad, H. M., & Tout, S. (2021) The study examines various elements that influence the effectiveness of gamification in education, including game design principles, student motivation, technological tools, and curriculum integration.
- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2023) This study aims to assess the impacts and benefits of integrating augmented reality paired with gamification in computer science education. The study found that a student-centered approach involving the students in the educational tool's development and integrating augmented reality paired with gamification resulted in an effective educational tool that is easy to use and learn and has positive impacts on the students' motivation, engagement, emotions, self-determination, and performance.
- López-Fernández, D., Gordillo, A., Pérez, J., & Tovar, E. (2023) The objective of this research is to determine if game-based learning is beneficial in terms of learning and motivation for computer science students, as well as whether its effectiveness varies depending on whether it is used in face-to-face or online remote learning settings. During the pandemic, teacher-authored instructional video games became effective as educational institutions transitioned from face-to-face to online or remote learning, influencing the effectiveness of gamification in computer science education.
- Pinto, M., & Terroso, T. (2022) The study reveals that students struggle to understand programming subjects such as algorithms and data structures, and based on the initial teaching where traditional teaching is used, the researchers discovered that after the students took a test, only 11 out of 30 passed. To address this, a gamified method is developed, and a gamification framework is implemented. With the evidence provided here, we can conclude that the difficulty of learning and poor motivation are key factors in the effectiveness of gamification in computer science education.
- Rodrigues, L., Toda, A. M., Oliveira, W., Palomino, P. T., Avila-Santos, A. P., & Isotani, S. (2021) The objective of this research is to find out how and to whom gamification improves programming learning. The research findings show that the factors that influence the effectiveness of gamification in education are intrinsic motivation, where gamification affects learning of students by increasing their intrinsic motivation, duration and familiarity with the lesson, wherein students tend to have changes in their intrinsic motivation over time as programming lessons become more unfamiliar to the students.
- Tasadduq, M., Khan, M. S., Nawab, R. M. A., Jamal, M. H., & Chaudhry,

- M. T. (2021) study found that immediate feedback, resubmission options, and rewards (points, badges, leaderboards) improved assignment performance, but intrinsic motivation remained unchanged. Unlike Western students, Pakistani students from rote-learning backgrounds did not experience negative effects from extrinsic rewards, suggesting cultural adaptation is crucial for successful gamification.
- Velázquez-García, L., Cedillo-Hernández, A., & Cendejas-Castro, E. A. (2023) The purpose of this study is to evaluate the impact of implementing a virtual educational escape room influenced by gamification, which is a game that is solved using VR devices and answering questions regarding math, kinematics and vectors, dynamics of particles, numerical methods, and programming in MATLAB, which requires students to group them and has a limited time only. The study shows that the key factor that is influenced by gamification is student active participation, which means that by using gamification strategies, the students become more collaborative, promoting teamwork and enhancing their learning experience.
- Videnovik, M., Vold, T., Kjøning, L., Bogdanova, A. M., & Trajkovik, V. (2023) The purpose of this study is to examine how colleges and universities are employing game-based activities to introduce computer science fundamentals. Various forms of educational and games methods were employed. The study indicates that students find programming difficult to learn, especially in object-oriented programming (OOP) languages such as C++ because it is complicated and needs to algorithmically think and strong problem-solving skills, which makes the process of learning is extended. There are three aspects which account of gamification in computer science education: student motivation, class participation, and interactive learning environment. Through gamification, students also have an opportunity to learn about such fundamental programming topics as inheritance, nested loops, and recursion in a fun and interesting way.
- Winanti, W., Abbas, B. S., Suparta, W., Heryadi, Y., & Gaol, F. L. (2021) This research aims at contributing a gamification model for computer science education where a gamification model is employed in non-game context in contrast to game based learning. Due to the students' learning difficulties in understanding the programming basis and lack of creativity, involvement and attention, the gamification framework can help teaching of computer science. Game framework and features like leaderboard and collaboration also increase the effectiveness of gamification in teaching computer science.
- Zahedi, L., Batten, J., Ross, M., Potvin, G., Damas, S., Clarke, P., & Davis, D. (2021) The present study revealed that the presence of video game mechanics including virtual points had a positive impact on academic performance in both male and female students, and gender was not associated with this effect. But the success of gamification is, in fact, contingent on how it aligns with students' inner drivers, such as motivation to compete.
- Zhan, Z., He, L., Tong, Y., Liang, X., Guo, S., & Lan, X. (2020) The design, motivation and learning environment of gamification on programming teaching has been shared in this study. Some features, like points, leaderboards and virtual simulations can boost student engagement or ratchet up pressure. An orderly environment encourages cooperation between pupils, and this results in higher levels of learning.
- Zsigmond, I., Bocicor, M. I., & Molnar, A.-J. (2020) The research established the impacts of employing badges or awards in the form of gamification in programming and engineering programs, as well as to enhance badge-based gamification in e-learning, which has been recognized as an important factor determining gamification effectiveness.

The study also found that gamification had a substantial and beneficial influence on students' learning behavior and engagement.

Table 2. Table synthesis of the challenges in implementing gamification.

Author	Challenges In Implementing Gamification
Ahmad, A., Zeshan, F., Khan, M. S., Marriam, R., Ali, A., & Samreen, A. (2020).	This study of computer science is commonly seen as a difficult subject, which can result in challenges related to student engagement and performance. This study focuses on improving student motivation, participation, and overall satisfaction in this rigorous field.
Alomair, Y., & Hammami, S. (2020).	According to the research review study, one of the issues with gamification is that it cannot accommodate diverse types of learners. Individuals have differing expectations and emotional reactions to game mechanisms.
Call, M. W., Fox, E., & Sprint, G. (2021).	In this research, the gamification system (Leaderboard) gives rewards to the students on passing the unit test in advance, creating a positive reinforcement cycle. The reason this gamification is effective based on this study is that the Integration with industry-specific tools such as GitHub Classroom, build servers, and Moodle assists the learning of real-world skills in an environment that is gamified. Finally, Students who used the Leaderboard spent a greater amount of time committing code and passed a greater number of unit tests, implying greater engagement.
Chong, M. M., Subramanian, P., Ting, M., & Ying, L. J. (2024)	The researchers clearly indicate that there is scope to fine-tune gamification strategies, suggesting that implementations might not be completely optimized. Furthermore, since the students are diverse in origin, creating an all-around effective gamification approach might prove to be challenging.
Cuervo-Cely, K. D., & Ramírez-Echeverry, J. J. (2022)	Design complexity and balancing competition (e.g., leaderboards causing stress) pose challenges, along with integrating gamified tools into existing curricula without overwhelming students. Sustaining long-term engagement remains uncertain without longitudinal studies.
Figueiredo, J., & García-Peñalvo, F. J. (2020)	According to the study, these are the challenges found in implementing gamification. Leaderboards risk demotivating struggling students, while overemphasis on competition may undermine collaboration, per student comments. Additionally, gamification's perceived "playfulness" could reduce academic seriousness, and its design requires significant effort to maintain long-term engagement.
García-Iruela, M., Fonseca, M. J., Hijón-Neira, R., & Chambel, T. (2020)	A student's level of activity may vary in order to achieve high grades, but increased activity does not always translate into a discernible change in learning.
Hastings, J., Weitzl-Harms, S., Spanier, A., Rokusek, M., & Henszey, R. (2022)	“Gamification is a very young branch in the digital age,” the researchers said. Research has shown that meaningful gamification in education is limited, although engagement plays a significant role to measure the effectiveness of gamification. This task motivates scholars to ascertain the most suitable gamification type in various education fields and to provide more knowledge about the typology and framework of gamification.
Jawad, H. M., & Tout, S. (2021)	Its objective is to investigate how the application of gamification methods is beneficial to enhance the appeal of computer science to lie within the reach of the students of Generation Z, using new teaching techniques and methodologies that help to create interest on such topic.

- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2023). The experimental results indicate that the adoption of such a solution based on an AR- gamified approach for the development of educational tools, through tools like Unity and Vuforia, along with the complex skills for integrating game elements (requiring technical expertise). It also need to be developmentally foreseen and collaborated with students too We need to care about the student access wifi, the students and the balance between education and how students engage. Also, the game targets students who already know how to use mobile application, which is drawback for not familiar users to mobile technology and though students have a good opinion to integrate gamified educational tools, some of them feel bored and frustrated to some extent, so that there is still need for the improvement.
- López-Fernández, D., Gordillo, A., Pérez, J., & Tovar, E. (2023). According to the study, the games implemented by the university are teacher-authored or created by the instructor; thus, some challenges are expected, such as instructor technical expertise; not all instructors who teach computer science concepts have the ability to create game-based materials. Furthermore, the study reveals that there are student experiences between face-to-face learning and online game-based learning because, according to the result of the questionnaire, it indicates that some of the students feel less engaged in online game-based learning because there is no guidance from the instructor, unlike in face-to-face learning, where they are gathered and build teamwork and feel more engaged because everyone is present and everyone will take the game at the same time.
- Pinto, M., & Terroso, T. (2022). The study found that implementing a gamified approach in computer science courses such as algorithms and data structures has faced various problems, including the shift from traditional to gamified ways to learning, which might be a significant change for student learning. And developing this type of game may be challenging and time-consuming for instructors since it includes establishing badges for student participation and missions, as well as ensuring that the game is connected with student learning objectives and other game aspects.
- Rodrigues, L., Toda, A. M., Oliveira, W., Palomino, P. T., Avila-Santos, A. P., & Isotani, S. (2021). The study found mixed results as most of the studies they reviewed are focused on analyzing behavioral outcomes, whereas their study is focused on motivation and cognitive outcomes. The study faced challenges such as small sample size (sample size of 19 which limits generalizability), missing data (38% missing data from motivation outcomes wherein students are asked to answer optional motivation survey with no incentives), external disruptions (COVID-19 forcing a shift to online learning), and the study's design having unbalanced assessment of extrinsic vs. intrinsic motivation because of the extra points for quizzes (extrinsic) overshadowed the voluntary motivation surveys (intrinsic), skewing both participation and results.
- Tasadduq, M., Khan, M. S., Nawab, R. M. A., Jamal, M. H., & Chaudhry, M. T. (2021). According to the study, the challenges include overcoming passive learning habits in rote-learning systems, low engagement with collaborative features (e.g., discussion forums), and ensuring sustained motivation over time. Technical hurdles in designing tailored gamification tools and student resistance to new methods (e.g., preferring traditional submissions) also pose difficulties. Additionally, gamification improved assignment scores but not exam performance, indicating a gap in promoting deeper learning.

Velázquez-García, L., Cedillo-Hernández, A., & Cendejas-Castro, E. A. (2023) The study shows that there are challenges facing the implementation of gamification since this kind of gamified activity is problem-based learning, requires cooperation, and needs information, communication, and technologies, which make the integration of the game time-consuming. After participants answered a questionnaire, the researcher found out that even though students responded to the gamified activity positively, there were still students who showed doubt about the benefit of it since the activity was only short in duration and the limited number of challenges posed issues for their learning process.

Videnovik, M., Vold, T., Kionig, L., Bogdanova, A. M., & Trajkovik, V. (2023) The study reveals that there are several challenges at the university level to implement gamification on computer science courses, such as the are no standardized games that teach computer science topics, which leads to inconsistency across the computer science courses. And also not all faculty have the skills to implement gamification, which leads to hesitancy in adopting gamification in computer science education.

Winanti, W., Abbas, B. S., Suparta, W., Heryadi, Y., & Gaol, F. L. (2021) Even though there are numerous benefits that demonstrate gamification's effectiveness in computer science education, we cannot deny that there are still challenges associated with the implementation of the gamification framework, such as the complexity of the game mechanics, the additional workload for the instructors because it requires some uniqueness in the game to keep the students engaged, and student engagement. These are some of the problems highlighted in the research.

Zahedi, L., Batten, J., Ross, M., Potvin, G., Damas, S., Clarke, P., & Davis, D. (2021) The study revealed that despite the benefits of gamification in the academic performance of the students, not all students were motivated by the gamification elements and majority of the female students were uninterested or had a negative opinion on it when asked to discuss their feelings about the gamification elements. Additionally many students reported issues with glitches in the gamified tool, which could have influenced how gamification affected their motivation.

Zhan, Z., He, L., Tong, Y., Liang, X., Guo, S., & Lan, X. (2020) The study highlights challenges to gamification's full potential, including anxiety and pressure among students, perception of manipulation, and sustainability of engagement. Competition-driven gamification can reduce willingness to participate, while repetitive rewards and challenges may lose interest over time.

Zsigmond, I., Bocicor, M. I., & Molnar, A.-J. (2020) Some of the challenges that gamification faced include the fact that there are some related studies that show mixed outcomes for the implemented gamification, indicating that a further study should be conducted to develop a more customizable badge-awarding system for other programming and engineering programs.

Table 3. Table synthesis about the effectiveness of gamification in optimizing student retention and academic performance.

Author	Effectiveness Of Gamification In Optimizing Student Retention And Academic Performance
Ahmad, A., Zeshan, F., Khan, M. S., Marriam, R., Ali, A., & Samreen, A. (2020).	The study's results indicate that gamification is a valuable method for teaching complex subjects in higher education. However, it also emphasizes the need to consider group size to improve classroom dynamics and enhance the overall learning experience.

- Alomair, Y., & Hammami, S. (2020). According to the study, gamification tries to boost learners' motivation and engagement inside the adaptive environment by incorporating many game aspects (e.g., badges, leaderboards, levels). As a result, the adaptive gamified learning environment can help learners improve their motivation and performance.
- Call, M. W., Fox, E., & Sprint, G. (2021). The effectiveness, based on the results of their study, shows that students finished assignments earlier, which may contribute to reduced last-minute stress and better performance. Also, by incorporating software engineering practices through gamification, students are better prepared for real-world programming environments, which can aid in long-term retention and performance.
- Chong, M. M., Subramanian, P., Ting, M., & Ying, L. J. (2024). The research is positive in its findings, with gamification proven to enhance motivation and academic performance, both of which are highly associated with retention. Gamification enhances engagement and programming problem-solving skills, motivating the students and preventing them from falling behind academically.
- Cuervo-Cely, K. D., & Ramírez-Echeverry, J. J. (2022). The finding of the study found that Gamification significantly boosts motivation (e.g., higher task valuation and intrinsic goals) and may improve retention, but direct academic performance impacts require further research with larger, diverse samples and explicit grade/retention metrics.
- Figueiredo, J., & García-Peñalvo, F. J. (2020). From the findings shown in the study, gamification does increase class attendance and activity scores, suggesting that students have better retention and performance. While final failure rates weren't measured, the study notes higher student involvement and teacher insights into skill gaps as positive indicators.
- García-Iruela, M., Fonseca, M. J., Hijón-Neira, R., & Chambel, T. (2020). There was no discernible difference in activity levels between the gamified and non-gamified groups in this study. According to researchers, this is because users only have a brief opportunity to interact with the gamified site.
- Hastings, J., Weitz-Harms, S., Spanier, A., Rokusek, M., & Henszey, R. (2022). The findings of this study demonstrate that ZORQ GDGF's goal of increasing student involvement and success in undergraduate C S education has been accomplished. Students also had good reactions to their experience. This study demonstrates that significant gamification in undergraduate computer science teaching may be achieved by engaging students through coding.
- Jawad, H. M., & Tout, S. (2021). The study evaluates the impact of gamified learning environments on student engagement, knowledge retention, and overall academic achievement in computer science courses.
- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2023). The study results show that the integration of augmented reality paired with gamification in computer science education greatly enhanced students' immersion, engagement, and motivation, fostering positive emotions such as joy, surprise, anticipation, and trust while also supporting self-determination, improving understanding, and boosting computer science self-efficacy by triggering both intrinsic motivation. In addition, students felt a sense of belonging, cultivated social skills, demonstrated social-emotional development, and showed improvements in critical thinking and computational thinking.

- López-Fernández, D., Gordillo, A., Pérez, J., & Tovar, E. (2023) The findings of this study show that teacher-authored educational video games are extremely beneficial in terms of student knowledge acquisition and motivation in both face-to-face and online/remote learning. It also demonstrates that students enjoy playing the games, which improves their learning experience. Regardless of the environment or method, students see game-based learning positively.
- Pinto, M., & Terroso, T. (2022) Gamification demonstrated that, upon multiple observations, the researcher noticed that it improved the students' learning and academic performance. The gaming challenges, points, and badges help students become more motivated and interested in their classes. The gamification method also improves students' ability to learn programming principles. The study showed that following the initial exam, in which only 11 out of 30 students passed using the traditional method of learning, the deployment of the gamified approach results in significant positive learning outcomes.
- Rodrigues, L., Toda, A. M., Oliveira, W., Palomino, P. T., Avila-Santos, A. P., & Isotani, S. (2021) The study revealed that gamification enhances learning gains by boosting students' intrinsic motivation, but its effectiveness depends on contextual factors such as their familiarity with programming and intervention duration, whereas students with existing programming knowledge sustained better outcomes and motivation, while beginners experienced diminishing outcomes as the lessons became more unfamiliar. The study also found that gamification did not directly increase quiz completion rates, suggesting that extrinsic rewards may have driven engagement instead of intrinsic motivation. Overall, gamification can enhance learning and retention, but its effectiveness depends on students' backgrounds and implementation design.
- Tasadduq, M., Khan, M. S., Nawab, R. M. A., Jamal, M. H., & Chaudhry, M. T. (2021) According to the findings of the study, Gamification significantly boosted assignment performance due to immediate feedback and practice opportunities, but exam scores showed no improvement, suggesting limited impact on conceptual understanding. While no direct retention data was collected, increased engagement could indirectly reduce dropout rates. The study highlights that gamification works best for skill reinforcement rather than deep learning, with long-term benefits requiring further investigation.
- Velázquez-García, L., Cedillo-Hernández, A., & Cendejas-Castro, E. A. (2023) The study shows there are positive effects of gamification on students, such as it improves the students problem-solving, collaboration, motivation, and satisfaction, which leads to increased student engagement, and since escape rooms are popular with students, it leads to the students working together to solve challenges, which means it increases their communication skills and social skills.
- Videnovik, M., Vold, T., Kionig, L., Bogdanova, A. M., & Trajkovik, V. (2023) According to the study, gamification in computer science education has a significant impact on student performance. It increases computer science students' interest in learning programming, indicating that gamification is effective in teaching programming concepts. Gamification also improves students' computational skills and problem-solving abilities, and many games with multiplayer games promote teamwork and peer learning.
- Winanti, W., Abbas, B. S., Suparta, W., Heryadi, Y., & Gaol, F. L. (2021) According to the results of the gamification framework development method, which splits students into two groups, the first group will utilize conventional methods of instruction, while the second group will use the

gamification framework. According to the study, the gamification group outperformed the conventional learning group by 15 to 25 percent. This reveals that students who used the gamification framework enhanced their engagement and participation in class. As a result, the gamification framework in computer science education improves student learning and performance in school.

- Zahedi, L., Batten, J., Ross, M., Potvin, G., Damas, S., Clarke, P., & Davis, D. (2021) According to the study, gamification improved students' academic performance but had no effect on their identity development or retention in computer science. Although students performed better with gamified elements, their long-term motivation and engagement were not significantly affected, particularly among female students. The study suggested that for future gamification, game elements should be thoughtfully crafted to accommodate different learning styles and motivations in order to effectively engage students.
- Zhan, Z., He, L., Tong, Y., Liang, X., Guo, S., & Lan, X. (2020) The study suggests that gamification is effective in programming education when used strategically, enhancing student engagement, problem-solving skills, and interactive learning. However, its effectiveness depends on balanced collaborative learning, clear objectives, and structured rewards.
- Zsigmond, I., Bocicor, M. I., & Molnar, A.-J. (2020) The study concludes that the use of gamification improved learning behavior and student motivation. The introduction of digital badges, using static code analysis, has some useful potential in motivating students; hence, offering digital badges demonstrates that students are encouraged and develop their coding abilities. The data indicate that gamification that is engaging and helpful improves pupils' academic performance. However, the study indicates that the badge-based rewards system and its algorithm should be improved in order to completely assess the long-term impacts on student performance.
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DISCUSSION

Key Factors that Influence the Effectiveness of Gamification

As presented in Table 1, the Computer Science and Information Technology (CS and IT) are among the most demanding academic programs in tertiary education due to their focus on mastering programming fundamentals, logical reasoning, and difficult problem-solving. In the study of Videnovik et al. (2023), they found that students struggle to learn how to program, particularly in object-oriented languages, because of their complexity, which requires algorithmic thinking and strong problem-solving skills. Because computer science is conceptually challenging, students are losing motivation to learn computer programming and losing confidence resulting in lower performance. Several researches have also done so in

the past years on integrating gamification in education and analyzing what this has done to the motivation, involvement, and performance of students in the tertiary level specifically in the field of computer science and information technology courses. In the research points, badges, leaderboards and challenges has become the most common gamification elements and techniques to be used to make learning more effective and engaging. For instance, in the work by Figueiredo et al. (2020) they discovered that the incorporation of game elements such as leaderboard, badges, and tailored feedback received from students has successfully motivated students, proven by the data which shows an increase of 18.1% in students' attendance. Similarly, the study by Zahedi et al. (2021) found that incorporating video game factors to include points and in particular, virtual points, has been observed to enhance the academic performance of male and female students revealing its effectiveness may depend on how it aligns with the students' own motivation such as competitiveness. In a Different study of Winanti et al. (2021) gameful design framework for computer science, the incorporation of game elements such as leaderboards and collaborative tools improves the student's engagement and the teach of complex programming topics. Cueruvo-Cely et al. (2022) further highlighted that including game elements such as challenges, rewards, feedback, etc are the most effective part of the gamification. The objective of this study discussion is to identify, synthesize, and discuss the literature related to factors influencing the efficacy of gamification at a tertiary level, particularly in computer science and information technology courses. This part of the study aims to find out what effects these structures have on students' engagement, motivation and performance.

The use of game-like features such as points, leaderboards, badges and challenge is one of the most mentioned factors influencing the effectiveness of gamification for the CS and IT classroom in many research perspectives. The mentioned game elements have been

demonstrated to have a great impact on students' motivation and engagement. In the study of Figueiredo et al. (2020) it is emphasized that the success of gamification depends on game elements and it shows improvement in the attendance and motivation of students and has been shown by the 18.1% improvement in students' attendance. In another similar study by Zahadi et al. (2021) they found that the integration of video game elements helps in improving the performance of both male and female students. However, the effectiveness of gamification does not solely rely on the integration of game elements only, other factors like careful planning, design and structure of gamified tools should be considered. In the study of Garcia-iruelam et al. (2020) they point out that difficulties in learning are not solved by gamified elements and student participation in a gamified course does not mean that there will be an improvement in their learning. They emphasized that what matters is the quality of the gamified activities and not the quantity of it. In another study, Zhan et al. (2020) showed that the application of gamification in programming instruction is effective because of its design, motivation, and learning environment. They emphasized that game elements can either increase student engagement or put pressure on them, and a well-organized setting can promote teamwork and improve their learning outcomes. This means that designing and creating gamified tools requires other key factors to be considered and one key factor to be considered is student-centered approach. A study by Lampropoulos et al. (2023) shows that involving the student in the development process of educational tools helps in creating an effective tool which is easy to use and learn and improves students' motivation and performance. Another factor that should be considered is the context and relevance of the gamified tool. In the study of Cuervo-Cely et al. (2022) they found that gamification is at its best when it includes different game elements and is in line with the course objective to keep it relevant and motivating for students. In another similar study, Tasadduq et al. (2021)

emphasize that the success of gamification is dependent on cultural context, educational background, and specific game elements used. An example of the Pakistani from rote-learning background hasn't experienced negative impacts on extrinsic rewards compared to Western students, in which this suggests that cultural adaptation affects the success of gamification.

Besides cultural context, another question that is critical yet not sufficiently explored based on Table 1 is whether gamification continues to be effective after the initial novelty has been exhausted. Some of the studies that were synthesized in Table 1 propose that the excitement levels students will show towards gamified aspects may not be maintained in the long term. An example is Rodrigues et al. (2021), who found that although gamification resulted in an increase in intrinsic motivation during the initial stages, the level of motivation among students generally decreased as the lessons on programming became more and more new and challenging. This trend can be attributed to a so-called novelty effect, where the excitement of a new learning format makes it initially engaging, but later becomes less so as the novelty effect subsides. In a similar fashion, as expressed in Table 1, Zhan et al. (2020) warn that the elements of a game, including points and leaderboards, may either enhance engagement or cause pressure, and that the balance between the two is especially vulnerable when exposure to the game is extensive. Once rewards are repetitive and predictable, they cease to motivate, which is sometimes called in the literature as gamification fatigue.

There are implications on long-term effectiveness. Chong et al. (2024), also included in Table 1, emphasize that gamification can be particularly effective with Gen Z learners who are attracted to interactive and technology-based experiences - however even this generation that is technologically savvy may lose interest in the game once the novelty wears off unless the underlying challenge and variety is satisfactory. Cuervo-Cely and Ramírez-Echevarry

(2022) provide a partial answer to this issue, discovering that gamification remains effective when it constantly conforms to learning objectives and involves student autonomy and real-time tracking of progress. This implies that the most susceptible designs of gamification are those that deploy a fixed set of badges or a single leaderboard which is not changed over time, whereas those designs which introduce new challenges, rotate reward structures, and adapt to student progress are better placed to maintain engagement over time.

To resolve the novelty issue in practice, teachers are advised to make use of a rotating gamification model periodically introducing new elements of the game, different forms of challenges, or new reward structures across a semester instead of relying on the same mechanics all the time. As an example, the use of a leaderboard during the first four weeks could be substituted with a team-based collaborative badge system during the remaining weeks, and a mastery-based certification challenge during the end of the course. The sense of novelty is maintained by this rotation, which is progressively becoming more academically challenging. The long-term effectiveness of gamification, as Table 1 as a whole tends to suggest, is less of a question of which elements to employ to achieve the desired effect and more of a question of how those elements change according to the current position of students in their learning process.

Challenges in Implementing Gamification

As presented in Table 2, the computer science and information technology program is one of the hardest programs offered at many universities around the world due to its nature, which requires complex logic and a deep understanding of programming. Teaching and learning subjects under these programs are very challenging for both students and instructors. As technology continuously emerges, universities around the world have begun to implement gamification as part of their curriculum in order to address the following issues. The basic

aim of integrating gamification in CS/IT education is to increase the effectiveness and efficiency of the overall academic performance of the students, using different types of gamification frameworks and styles. One of the greatest advantages of gamification is the ability to increase student engagement, participation, and achievements. Several research has shown that the addition of points, badges, leaderboards, and interactive tasks could make learning more enjoyable and effective. For instance, one evidence for this is done by Pinto et al. (2022) which discovered that bringing to life game inspired challenges and award students with points and badges when participating in class has a positive effect on engaging the students in the class. The same is true for Figueiredo et al. (2020) which found that when gamification was implemented, it increased attendance rates for students and the general activity scores, signifying that students were performing better at retaining classes and becoming more actively involved. Lampropoulos et al. (2023) also pointed out that gamification contributes to students feeling positive, enhance understanding as well as improve their critical thinking skills and computational skills. Supporting this point of view, another study by Velázquez-García et al. (2023) found that the escape room game mechanics became successful for students to acquire better communication and social skills and also improved problem-solving skills and collaboration between students. Finally, López-Fernández et al. (2023) has also stated that Expressing thanks to the instructor teachers' produced games that the students really like, and derive pleasure from the learning process either the learning is done face-to-face or online. Similarly, also Videnovik et al. (2023), the research shows that learners from computer science are able to assimilate programming concepts comfortably, which fosters cooperation and peer learning. In general, the review highlights that gamification is effective in computer science and IT education when suitably applied, to promote a more interactive and interesting learning environment.

One of the main barriers to the successful implementation of gamification is the technical challenge of developing and integrating game mechanics into the context of educational platforms. Advanced skills and tools are commonly necessary in gamified systems to create items such as leaderboards, badges, or AR-simulations. For example, Lampropoulos et al. (2023) noted that there were limitations to designing AR-based gamified tools since designing such tools would require software expertise of programs such as Unity and Vuforia that the majority of educators do not possess. Similarly, Call et al. (2021) highlighted that the combination of gamification with industry standard tools (such as Github Classroom) relies in part on instructors working with software developers, resulting in additional layers of logistics. Further, badly designed gamification could overload learners, or distract them from actual learning. Zhan et al. (2022) found that excessive competition (e.g., on leaderboards) might cause anxiety or demotivate low performing students. Similarly, Figueiredo et al. (2020) reported that an excessive use of extrinsic rewards (e.g., points) could undermine intrinsic motivation, particularly when gamification is perceived by students as superficial or manipulative. Finding the right mix between engagement and academic challenge is important, however it's an exercise that involves trial and error that many institutions simply cannot afford.

Students in CS/IT educational disciplines possess diverse cultural, educational, and motivational backgrounds, which complicates the process of designing gamification approaches suitable for all students. For example, Tasadduq et al. (2021) found that students from rote education environments (e.g., Pakistan) reported difficulty transferring to gamified, creative, and collaborative environments. Although they observed that extrinsic rewards such as the badges increased performance of the assignments they task the students with, intrinsic motivation was not affected by it, thus indicating that the effects of

gamification might be culture bound. To address this, educators are encouraged to conduct pre-implementation surveys to identify students' cultural learning orientations before selecting game mechanics, and to scaffold gamification gradually, beginning with familiar individual tasks before progressively introducing collaborative challenges as students build comfort with the format.

The gender variation adds a layer of complexity to implementation. Zahedi et al. (2021) indicated that girls tended to respond negatively to some game mechanics (e.g., gamification features such as points), and reported lack of interest in competitive elements. As a practical response, educators can make leaderboards opt-in rather than mandatory and offer alternative achievement pathways such as collaborative badges or mastery-based certifications, ensuring that competitive structures do not exclude or discourage students who respond negatively to public ranking. Likewise, Alomair and Hammami (2020) pointed out that adaptive gamification systems should take into consideration the emotional reactions of learners to game elements. However, tailoring gamification according to individual preferences is cost-expensive, and requires dynamic entities that adapt to real-time feedback, a functionality largely absent in popular educational tools. Despite these constraints, educators can implement low-cost emotion check-in mechanisms like brief anonymous surveys embedded at regular intervals throughout the course to monitor student frustration or disengagement and adjust reward structures or difficulty levels accordingly. As further evidenced in Table 2, Zhan et al. (2020) and Figueiredo and García-Peñalvo (2020) both caution that competition-driven mechanics risk generating anxiety among lower-performing students, reinforcing the need for differentiated gamification designs that offer multiple valid pathways to achievement rather than a single competitive structure.

Although gamification may help to some extent in increasing the short-term engagement, long-term student motivation is still a problem. Zhan et al. (2022) Highlighted that novelty effects may wear off, leading to ‘gamification fatigue’ when rewards become repetitive after repeated exposure. For example, Rodrigues et al. (2021) found a point of diminishing returns in programming classes in which gamified quizzes initially increased participation, but did not promote long term retention. Those students with little experience of programming in advance were particularly quick to lose confidence when the lessons got harder, which again pointed in the direction of different difficulty levels that could be expanded upon in the future.

Faculty development and institutional support also impact on the sustainability. Videnovik et al. (2023) are that teachers do not have the technical skills to be able to produce or maintain the gamify systems which cause some courses to not use it. López-Fernández et al. (2023) reemphasized this, stating that teachers had to invest time that they did not have to produce their own game-based tools. Without organizational structures, processes or mechanisms for training and resources, gamification might be merely short-lived or fragmented.

The success of gamification depends on its predisposition towards learning objectives, however many applications have focused more on the player engagement than on educational value. García-Iruela et al. (2020) showed that, despite the fact that gamification led to increased student activity (e.g. forum posts), it was not always related to gains in learning. For example, students in the gamified condition also invested more on some shallow activities (e.g., earning badges) rather than deepening their understanding of algorithms. This disconnect highlights the danger of flying too close to the sun of “gamification” without holding fast to curriculum objectives. Further, gamification could

lead to unintended surface-level learning. Call et al. (2021) discovered that despite their positive effect on early submission of programming exercises, leaderboards failed to enhance code quality or grasp of concepts. Similarly, Tasadduq et al. (2021) observed that video game elements increased average scores on assignments, though they had no impact on exams, indicating that the rewards motivated reaching fast completion rather than deep thinking. To prevent this result, the gamification system developed by teachers should reward mastery (such as creative problem solving), and not participation.

Another obstacle is internal resistance in institutions. Many universities are steeped in traditional instructional habits, and faculty members may be skeptical about or dismissive of gamified methods. Pinto and Terroso (2022) faced resistance when launching gamified programming classes, observing that learners did not adapt to the move from passive lectures to interactive, game learning well. Similarly, Videnovik et al. (2023) noted the lack of standardised gamification frameworks in CS education and the variances in practices among departments. Academic perspectives on play contradict any such direct inclusion. Figueiredo et al. (2020) reported that some students rejected gamification as “something childish,” which also marginalised its academic worth. To address this concern, educators need to treat gamification as a pedagogical strategy, not a play game. Yet both changing minds and shaping mindsets take institutional buy-in and advocacy resources that are in short supply.

The Effectiveness of Gamification in Optimizing Student Retention Academic Performance

As presented in Table 3, the advance of technology in education is one tool which is considered to be relatively handy called gamification and one which can be used to bring the quality of learning up by means of encouraging learners’ participation in schooling activity.

Retention, comprehension, and mastery of new and past learned material and skills is facilitated through gamification. So, in that regard, it is a lesson in strategy and prioritization. They are exercising their attention and focus, so to speak as they accumulate points, badges, rankings on leaderboards what they find is that they become more engaged in their interests and goals.

Gamification is a tool that keeps pace with the advancement of technology in the field of education, helping to enhance the quality of learning by encouraging students to confidently engage in school activities. Gamification promotes memorization, comprehension, and the development of skills in learning various concepts. Because of this, it emphasizes students' ability to strategize and determine their priorities. They also learn to focus more, which can be likened to earning points, badges, and rankings on leaderboards, motivating them to pursue their personal interests and goals more effectively. Gamification can be likened to a guide for programming and computer science students to identify what they need to accomplish in their studies while finding enjoyment in the learning process. It encourages collaboration and social learning, as well as personalized learning experiences, allowing students to engage and interact with their peers. This is especially important, as many students often struggle with communicating or connecting with others, and gamification helps address this challenge. Gamification has clarified its importance in education, which is why many students embrace this approach not only because of what it can contribute to the academic industry, but also because it is widely enjoyed, especially in this technology-driven era. For computer science students, this is no longer unfamiliar, as it aligns with their interests and is already being taught within computer science and programming courses. As a result, this method is now more accepted and well-known.

Smirani and Yamani (2024) emphasis was placed on analyzing the increase in motivation, participation, and learning of students in online environments through gamification. It was declared that using tools such as Kahoot!, Classcraft, and Badgeville resulted in a 25% increase in student participation and a 20% increase in perceived student enjoyment. In addition, this research continues to strengthen the findings regarding the level of student participation. However, according to Neerupa et al. (2024), it is shown that at the academic level, gamification, when combined with active teacher participation, can improve student engagement, since mere interaction with fellow students is not sufficient to increase the level of participation. According to Houston (2024), gamification is an educational strategy that uses game elements such as points, badges, and leaderboards to increase students' motivation and participation. Through FGPE, which aims to examine the effects of gamification in teaching programming, the main findings show an increase in students' motivation and participation using FGPE, also known as the Framework for Gamified Programming Education. It emphasizes helping students with the programming curriculum. However, it should also be noted that gamification is a platform that promotes effective programming skills and learning. As a result, it led to higher grades that reflect a deeper understanding of the concepts (Swacha & Szydłowska, 2023). The TechTeach method encourages each student in the Computer Science course to bring their own devices to participate in activities conducted in the classroom, which resulted in a positive effect on student motivation and participation. This study presented high rates that demonstrates the value of gamification and interactive activities in education for Computer Science (Portela, 2020). As Özdamlı and Yazdeen (2021) contend, gamification functions not merely as a supplementary tool but as a substantive pedagogical method within computer science education, capable of producing measurable improvements in both learning outcomes and

student motivation. It both motivates and promotes engagement by the appropriate designing of gamified activities. The research also focuses on the three levels of knowledge provided by the components in gamification and their role in enhancement of the specific computer science skills for each student. The study conducted by Ishaq and Alvi (2023) revealed that personalized gamification in computer science is an effective method to develop skills and performance in student participation and motivation of cognitive learning of programming. They also noted that personalized gamification can differ in terms of the factors or gamified elements, and that the designs in gamification need to be more interactive and student friendly in programming and computer science courses. The designed storytelling gamified approach is found to be successful in increasing the feeling of belonging among international students in programming courses. Especially this topic applies to beginners in programming. Based on the study of Cao et al. (2022), the story-based approach is a technique to enhance the learning of beginners in programming among international students. The research establishes that the integration of narrative elements into gameplay can aid in the development of students' communication skills and potentially guide their successful socialization as a major contributor to their academic career and academic success. Slamet (2024) provides evidence that integrating gamification into learning management systems effectively enhances student engagement and academic performance. It also facilitates the designing of interventions in response to learning needs that derive from students' schooling. It is a useful contribution of knowledge to the profession regarding the right ways to understand and improve the quality of the educational experience and skills of different kinds of learners. As reported in Cuervo-Cely's and Ramírez-Echeverry's research (2022), the incorporation of gamification to programming, specifically with Code, has an initial positive impact on the students' motivation. Research results of the study also reveal that it has a

positive effect on students' interest, confidence and intrinsic motivation, on learning. In such an environment, more emphasis is placed on student learning and interest, and however the students' satisfaction to deal with any school activity concerning computer science and programming is promoted. In such cases, students have much more opportunities to master the discipline and were able to meet the requirements in programming way better. Quality of use, dimension, and gamification would be more appropriate for combating boredom during learning, given that its content motivates all participants. It emphasizes focusing on the activities presented within the game. Moreover, this tool helps shape students' passion, interest, quality of knowledge, and memory by enabling them to identify concepts they do not initially understand. As these ideas enter their minds, their curiosity is strengthened, encouraging them to ask questions and conduct research so they can apply and fully understand the lessons presented through the gamification activities.

CONCLUSION

The synthesis of key factors that influence the effectiveness of gamification reveals that the effectiveness of gamification in CS/IT education is far more complex than simply adding game elements to courses. On one hand, implementing it faces associated challenges that extend far beyond technical implementation to cover cultural, educational, and institutional aspects. On the other hand, when properly implemented, it shows significant positive effects on student retention and academic performance of students, with measurable improvements in engagement, motivation, and learning outcomes. Moving forward, education will need to rethink the perspective and application of gamification in computer science curricula. Schools will have to create a special group to develop learning technology that works for people from a wide variety of backgrounds and learning styles. To facilitate

the use of new teaching methods, it is recommended to codify policies, encourage collaboration among schools to share best practices, improve gamification analytics, and implement regular feedback systems for continuous improvement. The schools need to make an investment in training programs to ensure teachers utilize gamification tools in an efficient manner, resulting in improved student involvement and achievements in the field of computer science education.

REFERENCES

- Alsadoon, E., Alkhawajah, A., & Suhaim, A. B. (2022). Effects of a gamified learning environment on students' achievement, motivations, and satisfaction. *Heliyon*, 8(8), e10249. <https://doi.org/10.1016/j.heliyon.2022.e10249>
- Ahmad, A., Zeshan, F., Khan, M. S., Marriam, R., Ali, A., & Samreen, A. (2020). The impact of gamification on learning outcomes of computer science majors. *ACM Transactions on Computing Education*, 20(2), 1–25. <https://doi.org/10.1145/3383456>
- Alomair, Y., & Hammami, S. (2020). A review of methods for adaptive gamified learning environments. *2020 3rd International Conference on Computer Applications & Information Security (ICCAIS)*, 1–6. <https://doi.org/10.1109/ICCAIS48893.2020.9096871>
- Cao, C., Sbaffi, L., Zhao, X., & Hopfgartner, F. (2023, March 6). Using a narrative-based gamified teaching approach to improve international students' sense of belonging. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education (SIGCSE '23)*, Volume 2 (p. 1417). Association for Computing Machinery. <https://doi.org/10.1145/3545947.3576361>
- Call, M. W., Fox, E., & Sprint, G. (2021). Gamifying software engineering tools to motivate computer science students to start and finish programming assignments earlier. *IEEE Transactions on Education*, 64(4), 423–431. <https://doi.org/10.1109/te.2021.3069945>
- Chong, M. M., Subramanian, P., Ting, M., & Ying, L. J. (2024, August 7). An investigation into the perception of Gen Z students in higher education towards gamification techniques in learning computing subjects. In *2024 IEEE 12th International Conference on Information and Education Technology (ICIET)* (pp. 1–5). IEEE. <https://ieeexplore.ieee.org/document/10692814>
- Cuervo-Cely, K. D., Restrepo-Calle, F., & Ramírez-Echeverry, J. J. (2022). Effect of gamification on the motivation of computer programming students. *Journal of Information Technology Education: Research*, 21, 1–23. <https://doi.org/10.28945/4917>
- Figueiredo, J., & García-Peñalvo, F. J. (2020). Increasing student motivation in computer programming with gamification. *2020 IEEE Global Engineering Education Conference (EDUCON)*, 997–1000. IEEE. <https://doi.org/10.1109/EDUCON45650.2020.9125283>
- García-Iruela, M., Fonseca, M. J., Hijón-Neira, R., & Chambel, T. (2020). Gamification and computer science students' activity. *IEEE Access*, 8, 96829–96836. <https://doi.org/10.1109/ACCESS.2020.2995667>

- Hastings, J., Weitz-Harms, S., Spanier, A., Rokusek, M., & Henszey, R. (2022). ZORQ: A gamification framework for computer science education. In *2022 IEEE Frontiers in Education Conference (FIE)* (pp. 1–9). IEEE. <https://doi.org/10.1109/FIE56618.2022.9962487>
- Jawad, H. M., & Tout, S. (2021b). Gamifying computer science education for Z Generation. *Information, 12*(11), 453. <https://doi.org/10.3390/info12110453>
- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2023). Integrating augmented reality, gamification, and serious games in computer science education. *Education Sciences, 13*(6), 618. <https://doi.org/10.3390/educsci13060618>
- López-Fernández, D., Gordillo, A., Pérez, J., & Tovar, E. (2023). Learning and motivational impact of game-based learning: Comparing face-to-face and online formats on computer science education. *IEEE Transactions on Education, 66*(4), 360–368. <https://doi.org/10.1109/te.2023.3241099>
- Neerupa, C., Naveen Kumar, R., Pavithra, R., & John William, A. (2024). Game on for learning: A holistic exploration of gamification’s impact on student engagement and academic performance in educational environments. *Management Matters, 21*(1), 38–53. <https://doi.org/10.1108/MANM-01-2024-0001>
- Özdamli, F., & Yazdeen, D. F. (2021). Gamification in computer science courses: A literature review. *Near East University Online Journal of Education, 4*(2), 90–106. <https://doi.org/10.32955/neuje.v4i2.345>
- Pinto, M., & Terroso, T. (2022). Learning computer programming: A gamified approach. In *Proceedings of the Third International Computer Programming Education Conference (ICPEC 2022)* (Vol. 102, pp. 11:1–11:8). Schloss Dagstuhl – Leibniz-Zentrum für Informatik. <https://doi.org/10.4230/OASIEs.ICPEC.2022.11>
- Portela, F. (2020). A new and interactive teaching approach with gamification for motivating students in computer science classrooms. In *Proceedings of the First International Computer Programming Education Conference (ICPEC 2020)*. Open Access Series. <https://doi.org/10.4230/oasics.icpec.2020.19>
- Rodrigues, L., Toda, A. M., Oliveira, W., Palomino, P. T., Avila-Santos, A. P., & Isotani, S. (2021). Gamification works, but how and to whom?: An experimental study in the context of programming lessons. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education* (pp. 184–190). ACM. <https://doi.org/10.1145/3408877.3432419>
- Slamet, J. (2024). Empowering Slow Learners: Gamification’s impact on students’ engagement and academic performance in an LMS for undergraduate students. *International Journal of Information and Education Technology, 14*(2), 193–203. <https://doi.org/10.18178/ijiet.2024.14.2.2040>
- Smirani, L., & Yamani, H. (2024). Analysing the impact of gamification techniques on enhancing learner engagement, motivation, and knowledge retention: a structural equation modelling approach. *The Electronic Journal of e-Learning, 22*(9), 111–124. <https://doi.org/10.34190/ejel.22.9.3563>

- Swacha, J., & Szydłowska, J. (2023). Does gamification make a difference in programming education? Evaluating FGPE-Supported Learning Outcomes. *Education Sciences*, 13(10), 984. <https://doi.org/10.3390/educsci13100984>
- Tasadduq, M., Khan, M. S., Nawab, R. M. A., Jamal, M. H., & Chaudhry, M. T. (2021). Exploring the effects of gamification on students with rote learning background while learning computer programming. *Computer Applications in Engineering Education*, 29(6), 1871–1891. <https://doi.org/10.1002/cae.22428>
- Tomić, B., Stojanović, T., Antović, I., & Milić, M. (2025). Students' test anxiety and performance in introductory programming: Do exam and assessment modalities play a role? *Computer Applications in Engineering Education*, 33(3). <https://doi.org/10.1002/cae.70026>
- Velázquez-García, L., Cedillo-Hernández, A., & Cendejas-Castro, E. A. (2023). Gamification in higher education: Learning computer science with an escape room. In *Proceedings of the 15th International Conference on Education Technology and Computers* (pp. 72–77). ACM. <https://doi.org/10.1145/3629296.3629308>
- Videnovik, M., Vold, T., Kiønig, L., Bogdanova, A. M., & Trajkovik, V. (2023). Game-based learning in computer science education: A scoping literature review. *International Journal of STEM Education*, 10(1). <https://doi.org/10.1186/s40594-023-00447-2>
- Winanti, W., Abbas, B. S., Suparta, W., Heryadi, Y., & Gaol, F. L. (2021). Gamification framework for programming course in higher education. *Journal of Games Game Art and Gamification*, 5(2), 54–57. <https://doi.org/10.21512/jggag.v5i2.7479>
- Zahedi, L., Batten, J., Ross, M., Potvin, G., Damas, S., Clarke, P., & Davis, D. (2021). Gamification in education: A mixed-methods study of gender on computer science students' academic performance and identity development. *Journal of Computing in Higher Education*, 33(2), 441–474. <https://doi.org/10.1007/s12528-021-09271-5>
- Zainuddin, Z., Shujahat, M., Haruna, H., & Chu, S. K. W. (2020). The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system. *Computers & Education*, 145, 103729. <https://doi.org/10.1016/j.compedu.2019.103729> ACM Digital Library+3
- Zhan, Z., He, L., Tong, Y., Liang, X., Guo, S., & Lan, X. (2022). The effectiveness of gamification in programming education: Evidence from a meta-analysis. *Computers and Education: Artificial Intelligence*, 3, 100096. <https://doi.org/10.1016/j.caeai.2022.100096>
- Zsigmond, I., Bocicor, M. I., & Molnar, A.-J. (2020). Gamification-based learning environment for computer science students. In *Proceedings of the 15th International Conference on Evaluation of Novel Approaches to Software Engineering (ENASE)* (pp. 556–563). SciTePress. <https://doi.org/10.5220/0009579305560563>

The Role of Prompt Formulation in Shaping ChatGPT- A Review on Response Quality and Efficiency

Abstract

The paper examined the role of prompt formulation in shaping ChatGPT's response quality and efficiency, particularly as AI tools become integral in education, healthcare, and software development. The objectives were to determine prompt factors affecting response efficiency, examine how prompt structure influences output accuracy, explore methods to improve the prompt formulation, and identify limitations and potential improvements in current prompting techniques. The researcher screened 46 articles published between 2022 and 2025 through AI-powered tools and manual database searches. Results show that prompt clarity reduces ambiguity and specificity and improves task alignment, while structural elements such as role assignment and domain context increase response accuracy by 15–65%, as demonstrated by programming success rates and BLEU score improvements. Iterative refinement through chain-of-thought reasoning enhances outputs by reducing complex tasks into logical sequences. However, token constraints limit contextual depth in extended interactions, and inherent training-data biases persist in culturally sensitive domains. These findings suggest that adaptive prompt-engineering tools are necessary for technical applications, and prompt literacy should be integrated into educational curricula. At the same time, ethical governance frameworks remain critical for healthcare implementations. Thus, practitioners and educators must employ structured frameworks like CLEAR and PARTS, construct regular feedback loops, integrate prompt literacy training, and create domain-specific templates to evaluate AI-generated responses and critically ensure their reliability and relevance.

Keywords: *Prompt Formulation, ChatGPT, Response Accuracy, Iterative Refinement, Domain-Specific Templates*

INTRODUCTION

Emerging technologies are innovations that fit in the early stages of development or are considered for adoption, with the potential to disrupt industries, economies, or societal norms severely. One standalone emerging technology is Artificial Intelligence, also known as "AI"; it refers to robots or systems that mimic human cognitive processes such as learning, problem-solving, and decision-making. These innovations are in the early stages of development or adoption, with the potential to significantly disrupt industries, economies, or societal norms. It can include narrow AI, task-specific systems like chatbots like ChatGPT, and theoretical universal AI (human-like adaptability). AI technologies use algorithms and data to automate processes, analyze trends, and provide insights (Bozkurt

& Sharma, 2023; Meskó, 2023). The prompt formulation significantly impacts the quality and efficiency of responses generated by ChatGPT. This generative AI model is increasingly used in most areas of education, healthcare, and software development (Bozkurt & Sharma, 2023). Previous research highlighted the importance of timely characteristics like clarity, specificity, and contextual framing in increasing response efficiency (Bozkurt & Sharma, 2023; Cao et al., 2023; Ekin, 2023), but there is still debate about the universal applicability of these principles across different use scenarios. Using the well-structured prompts, especially those including the repetitive refinements, clear clarifications, and domain-specific constraints, has improved the code generation correctness of all (Liu et al., 2023; White et al., 2023). Henrickson and Merono-Peñuela (2023) found that conflicting findings in contexts requiring hermeneutic openness, as over-specification can also restrain the originality of it. Previous research has also recognized the limitations, such as intrinsic model biases, vulnerability to ambiguous inputs, and reliance on manual prompt design (Bozkurt & Sharma, 2023; Federiakin et al., 2024; Mondal et al., 2024).

Despite the growing dependence on AI tools like the ChatGPT chatbot in academic, professional, and creative settings, there is still a significant gap in understanding how prompt formulation affects response quality and efficiency. While the recent research has begun to look into the importance of prompt engineering (Brown et al., 2023; Chen et al., 2024), much of the literature is either too broad or primarily concerned with the technical backend improvements rather than user-facing input strategies. Moreover, the current research regularly lacks consistency in defining what constitutes an "effective" prompt, resulting in fragmented or contradictory findings. For example, some studies highlight the prompt length as a key factor, whereas others emphasize the role of

specificity and contextual framing. These variances indicate a need for a more comprehensive and structured investigation into the factors affecting ChatGPT's response accuracy and effectiveness. This study aims to address this gap by systematically examining how prompt structure, clarity, and context influence the model's output and identifying best practices for more effective prompt formulation.

This study thoroughly structures and focuses on the procedures used to conduct prompt engineering systematically and strategically. Specifically, it emphasizes how these AI tools, like ChatGPT chatbots, generate responses efficiently and accurately (Bozkurt & Sharma, 2023). This study examines how key parameters like clarity, structure, and specificity affect how the language model interprets user prompts and uses them to construct more accurate and effective responses (Cao et al., 2023). Mainly, this study aims to give light to the problem of AI communications, which is the lack of a systemized approach when creating an effective prompt even across different contexts (Ekin, 2023).

THE REVIEW

The Design

This researchers conducted a systematic literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Using this established methodology, the authors could systematically identify, filter, scan, and analyze scholarly works on prompt formulation in generative AI. This method provides transparency and rigor, ensuring the synthesized findings are based on an in-depth and consistent review of the current empirical and theoretical literature.

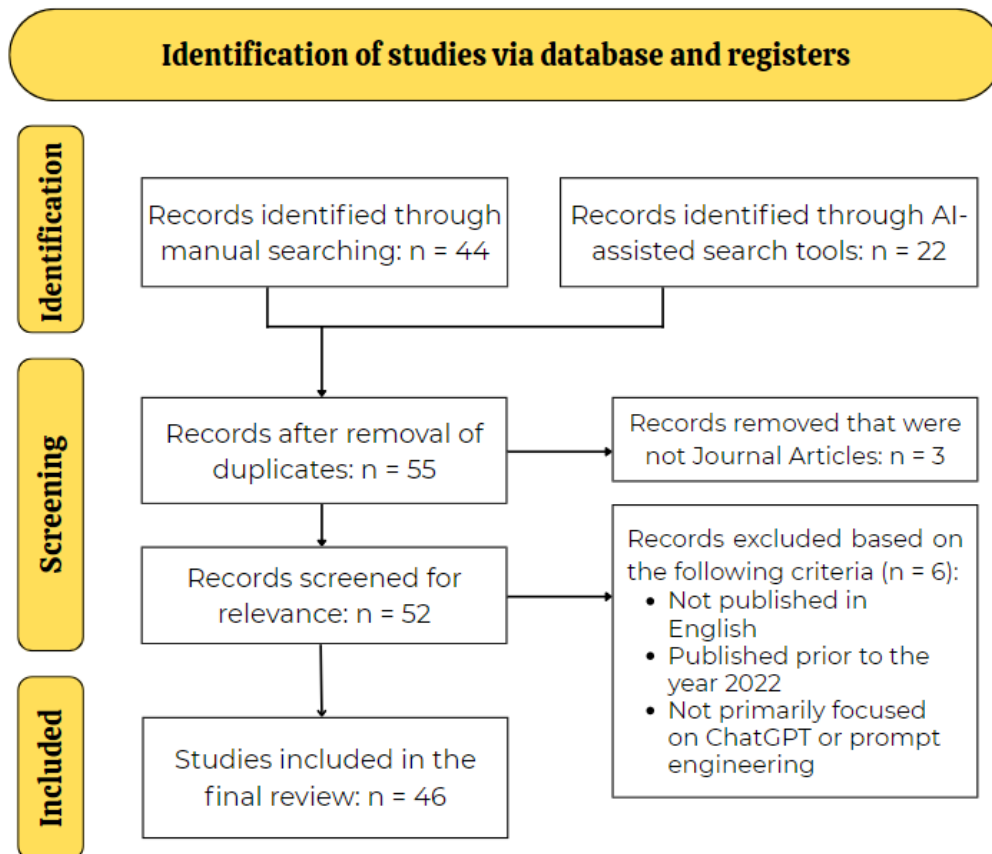


Figure 1. The process used in identifying studies

Research Objectives

This literature review addresses the research question: how do prompt design factors affect the efficiency and accuracy of AI-generated outputs, and what improvements can be made to overcome current limitations in prompting techniques? It aims to achieve the following objectives: (1) to determine the prompt factors that affect the efficiency of ChatGPT responses, (2) to examine how the structure of prompts influence the accuracy of ChatGPT outputs, (3) to explore methods to improve prompt formulation for better solution

accuracy, (4) to identify the limitations and potential improvements in current prompting techniques.

Retrieving and Selecting Pertinent Literature

A dual-phase retrieval strategy was used to ensure its full coverage. The AI-powered tools like Skolar.ai and Scispace returned 22 initial records for the prompt "Prompt engineering with ChatGPT," while manual searches through Google Scholar using refined keywords resulted in 44 additional results. After removing the 11 duplicates and applying eligibility criteria (peer-reviewed, English-language articles published after 2022 focusing on ChatGPT prompt design), 46 studies were chosen.

The content of the titles, abstracts, and full texts was screened, and AI-generated summaries were manually checked for their accuracy. The Notion web application was used to gather these studies, which were then organized into Google Docs tables by theme. The findings were organized around key review objectives, and inter-rater checks ensured the consistency and diligent methodology throughout the synthesis process.

Synthesizing the Literature

The selected pertinent literature was published from 2022 to 2025. The total number of these articles is 46, which met the criteria for the review and were selected from the studies, extracting data from each article and examining the main study findings combined in Tables 1-4.

Table 1. Factors Affecting ChatGPT Response Efficiency

Author	Factors Affecting ChatGPT Response Efficiency
Abhari et al. (2024)	The effectiveness of AI responses is influenced by prompt clarity, contextual specificity, and ethical alignment. Tailored prompts ensure domain relevance, reduce bias, and improve output accuracy across all healthcare applications.

- Banawan (2023) Academic language, specificity, and collostructional strength are linguistic features that affect the effectiveness of AI responses. Lower perplexity is correlated with higher Linguistic Prompt Efficiency Scores (LPES), which signify confident, well-structured outputs.
- Bozkurt, A., & Sharma, R. C. (2023) The authors highlight the effectiveness of the AI responses, it is dependent on the factors like prompt clarity, accuracy, contextual relevance, and simplicity. Questionable or poorly defined prompts can produce poor results, whereas well-crafted prompts improve the AI's performance.
- Bringula (2024) The clarity and specificity of the user input, task complexities, and scope of the requested content, these have an impact on the ChatGPT's response efficiency. The limit includes the not exactly, overgeneral, and response patterns, particularly when the prompts are mostly repetitive or questionable.
- Cao et al. (2023) The efficiency of ChatGPT responses depends on the prompt clarity, including the explicit repair goals such as symptom descriptions, task specifications, and dataset characteristics. Unclear prompts without contextual details lessen the fault detection rates, while structured templates with explicit objectives enhance the performance by aligning outputs with user intent.
- Chen & Wang (2024) Prompt engineering, a low-cost method for improving the large language model or also known as LLM, performance in specialized domains, has a large impact on AI response efficiency. Prompt example construction methods affect the LLM performance, but the results vary depending on experimental conditions and evaluation complexity. Diversified prompt example sets can significantly boost the LLM output performances.
- Cid et al. (2024) The accuracy, clearness, and problem of the prompts has a significant impact on the effectiveness of the AI responses. It includes the contextual details, communicative side, and user intent has a significant impact on the model's abilities to process and return the relevant result.
- D. Park et al (2024) Query Transformation Modules (QTMs) improves the efficiency by breaking down the prompts into objectives and key points, allowing the Korean LLMs to generate more context-aware responses with 11.46% higher specificity than unimproved inputs.
- Deng & Lin (2023) ChatGPT improves the proficiency and provides rapid, context-aware responses, deducting the needs for manual interaction. However, the efficiency is limited because of the reliance on training data, lack of real-time adaptability, and limited access to external information.
- Diyab et al. (2025) Several factors influence the effectiveness of the AI responses in educational assessments, particularly within the AI Assess system, such as the prompt designs and computational requirements. The choices between zero-shot and few-shot prompting affects the token usage and accuracy, with few-shots prompting improving accuracy at the expense of increasing the computational demands. Optimized prompts through prompt engineering is very crucial for balancing these factors and improving automated assessment of short answer questions.
- Ekin, S. (2023) AI response proficiency is influencing the prompt clarity, explicit constraints, domain-specific context, and alignment with user intents. Unclear and not good instructions or insufficient context reduces the effectiveness, while structured prompts leverage the model strengths enhances the performance.

Federiakin et al. (2024)	AI response efficiency affects based on prompt quality, user articulation of problem context, and awareness of model limitations. Token prediction mechanics and iterative refinement further dictate response speed and relevance.
Guo (2024)	According to the study, role-based prompts produce the highest quality and functionality in generated code, and prompt design has a significant impact on the effectiveness of AI responses in code generation. The need for more structured prompting techniques is highlighted by the fact that simple question-and-answer prompts frequently produce inaccurate or incomplete outputs.
Hamdi & Kim (2023)	Adherence to prompt guidelines: context, intention, constraints, specificity, and structure. Structured prompts aligned with software development phases (requirements, design, testing) improve task-specific accuracy.
Hanifi et al. (2023)	Awareness of prompt engineering principles (e.g., explicit role assignment, iterative refinement) mitigates hallucinations. Students lacking structured prompting reported more errors, security flaws, and context collapse in generated code.
Haugsbaken & Hagelia (2024)	Mastery of prompt design (clarity, specificity, iterative refinement) and critical assessment of outputs. Ambiguous prompts lead to "hallucinations" or suboptimal task performance.
Henrickson & Merofio-Pefuela (2023)	AI response efficiency is influenced by prompt specificity, contextual framing such as cultural and historical references, and task alignment with hermeneutic goals. Ambiguity in natural language descriptions reduces depth, while structured prompts with iterative refinements enhance meaningfulness. Over-specification may reduce hermeneuticity by prioritizing neutrality over insight.
Joshi (2025)	Factors influencing the effectiveness of the AI responses are links to the prompt design and the AI model used. Prompt engineering enhances the accuracy and relevance of AI-generated outcomes in finance by refining the AI responses. These AI tools like the ChatGPT-4 exceeded the Google Gemini in terms of producing precise financial perceptions.
Kepel & Valogianni (2024)	The quality of input prompts has a large impact on the efficiency of the AI responses. Each well-crafted prompt providing a clear and exact context, it guides the model to produce accurate and reasonable results, whereas the poorly composed prompts submit vague or irrelevant responses. A critical challenge remains: the efficacy of LLMs is heavily dependent on the quality of input prompts they receive. Many users may struggle to fully utilize the capabilities of LLMs if they lack the ability to create effective prompts.
Kochanek et al. (2024)	Kaszyca et al. (2024) investigate the effectiveness of AI responses by employing large language models (LLMs) to address unbalanced training datasets, a common issue affecting model performance. The study investigates using LLMs for synthetic data generation and knowledge distillation via prompt engineering to improve the balance of training datasets. Initial results show the promise in readjusting of the methods, particularly with similarity prompts.
Kovari (2024)	Use of advanced techniques (prompt templates, chain-of-thought reasoning, metadata augmentation). Few-shot learning and explicit task decomposition reduce ambiguity, enhancing coherence and relevance.
Leung (2024)	The clarity, specificity, and structure of prompts all have a significant impact on efficiency. Role assignment, constraints, and iterative dialogue refinement all improve ChatGPT's ability to generate relevant and accurate responses.

- Li et al., (2024) Prompt factors like dynamic encapsulation (via Prompt Builder) and Self-Debugging Optimization (using simple feedback, unit testing, code explanation) improve efficiency, evidenced by 65.06% EM gain.
- Li, Y. (2024) Cleaning, preprocessing, and improving data quality have a direct impact on AI efficiency by lowering noise and overfitting, while varied training data increases response reliability and cross-domain adaptability.
- Liu et al. (2023) Pretending (97.44%), attention shifting (6.41%), and privilege escalation (17.96%) are key prompt factors affecting efficiency, with pretending dominating due to context manipulation simplicity.
- Liu et al. (2023) AI response efficiency is influenced by prompt clarity, contextual framing such as class context and member variables, explicit preprocessing instructions including comment removal and variable renaming, and specificity of API or exception handling requirements. Ambiguity in natural language descriptions reduces effectiveness, while structured prompts with iterative refinements enhance performance.
- Meskó, B. (2023) Prompt specificity, contextual framing, and understanding model limitations like outdated training data critically influence AI response efficiency. Verification by professionals remains essential to mitigate risks from non-real-time knowledge and lack of personalization.
- Mnguni et al. (2024) The study found that the prompting strategy used has a significant impact on the efficiency of AI responses, particularly code generation. The findings revealed inconsistencies in the quality and correctness of code generated by ChatGPT, emphasizing the importance of optimizing prompting methods to achieve desired results. In terms of accuracy improvement, code-to-code prompting outperformed text-to-code prompting.
- Mondal et al. (2024) Prompt design gaps such as missing specifications and additional functionality requirements necessitate iterative refinement. Ambiguous or incomplete prompts reduce efficiency, while explicit specifications and consolidated instructions improve response relevance.
- Mungoli (2023) Prompt engineering strategies (explicit instructions, contextual cues) and reinforcement learning methods (Proximal Policy Optimization) significantly improve AI response efficiency by reducing perplexity and aligning outputs with target distributions. Their collaboration improves token prediction accuracy and task adaptability.
- Park, J., & Choo, S. (2024) AI response are hinges on prompt quality, particularly the inclusion of PARTS components (Persona, Aim, Recipients, Theme, Structure) and CLEAR language principles (Concise, Logical, Explicit, Adaptive, Restrictive), which reduce ambiguity and guide context-aware outputs.
- Pehlivanoglu et al. (2023) Engineered prompts with explicit diversity directives (lexical, syntactic) and fluency constraints. Metrics show structured prompts increase semantic retention while reducing repetitive or irrelevant outputs.
- Samsami (2024) Since generic prompts frequently produce less pertinent results, the effectiveness of AI responses in the AEC sector depends on specialized prompt engineering catered to the particular needs of the domain. Understanding user intent, utilizing AI model capabilities, and refining prompt structures to minimize errors and improve task-specific performance—like construction scheduling and hazard recognition—are all necessary for effective utilization.

- Sikha et al. (2023) The efficiency of AI responses is influenced by prompt clarity, tokenization constraints, and the model's architectural design (for example, transformer self-attention mechanisms). Contextual embeddings and training data diversity influence how well inputs match the AI's processing capabilities.
- Sinha et al. (2023) The study identifies factors that influence AI efficiency by statistically analyzing bias in ChatGPT responses to controversial topics. It employs prompt engineering and the Bipartisan Press API to quantify bias, revealing a left-leaning bias in the majority of topics tested. This suggests that training data has a significant influence on AI response bias.
- Velásquez-Henao et al. (2023) Effective AI responses rely on clear, context-rich prompts and iterative refinement. Insufficient prompts result in hallucinations and inaccuracies, requiring data incorporation and Understandable AI principles to ensure clarity.
- Vemprala et al. (2023) Robotics performance is influenced by the clarity of API definitions, explicit task constraints, comprehensive environmental context, and precise prompt instructions. Ambiguous API descriptions or incomplete task details reduce code synthesis effectiveness and overall system performance.
- Viswanathan, N. P. S. (2025) AI responses are influenced by prompt clarity, contextual framing, and parameter optimization. Ambiguity management and computational overhead are critical challenges affecting response speed and resource utilization.
- Wang et al. (2024) Prompt factors affecting ChatGPT's efficiency include prompt styles (ROT, COT, IO), model parameters (temperature settings), and fine-tuning techniques, with ROT prompting in GPT-4-Web achieving the highest consistency (62.9%).
- Wang M. et al. (2024) Mastery of prompt engineering significantly improves the quality of information retrieved from ChatGPT. Effective prompts require clarity, task relevance, contextual detail, and structured templates like the CRISPE framework (Capacity & Role, Insight, Statement, Personality, Experiment). Poor or ambiguous prompts lead to reduced answer quality. Additionally, simple prompt enhancements and prior knowledge alone do not yield significant gains. Structured and well-designed prompts are crucial.
- White et al. (2023) Efficiency of ChatGPT responses depends on structured prompts that enforce modularity and decoupling from third-party dependencies. Clarity in prompt design reduces ambiguity and aligns outputs with software engineering best practices such as separating side-effect code and isolating business logic.
- White et al. (2023) Prompt factors affecting efficiency including the patterns like Output Automator (it generates the automation scripts) and Flipped Interaction (LLM-driven questioning), which is reducing the manual effort and streamline task completion.
- Woo et al. (2024) AI response efficiency is influenced by a variety of factors, including prompt quality and the AI model's inherent capabilities. The clarity and specificity of each instruction has a huge significant impact on relevance and accuracy of formulated outcomes, whereas the model's pre-training and fine-tuning determines the overall comprehension and responsiveness. Effective prompt engineering strategies and techniques improves its efficiency.
- Wu & Zhang (2024) AI response efficiency is affected by the pre-training scale, multiple modes of data integrations, and task-specific fine-tuning. This model architecture that allows for diverse input processing and summarization capabilities improves the operational speed in healthcare.

Wu et al. (2023) The clarity of the user prompts and the inclusion of explicit constraints, like as the filename specifications, directly impacts the response efficiency. Unclear instructions lessen the system performance, whereas the structured prompts ensures the execution of Visual Foundation Models aligns precisely with user intent. Iterative refinement through chained Visual Foundation Models enhances response speed.

Zuccon & Koopman (2023) Efficiency of ChatGPT responses depends on the integration of external knowledge such as supporting or contrary evidence in prompts. Model accuracy declines significantly when relying on external evidence, highlighting conflicts between prompt-derived knowledge and inherent model knowledge.

Table 2. Influence of Prompt Structure on Output Accuracy

Author	Influence of Prompt Structure on Output Accuracy
Abhari et al. (2024)	Prompt structure has a direct impact on the model's interpretive scope and fidelity. Discrete and continuous prompt types produce varying levels of accuracy, depending on their alignment with user intent and contextual depth.
Banawan (2023)	Accuracy is impacted by prompt structure through task-specific verbs, lexical diversity, and grammatical coherence. By reducing ambiguity, structured prompts help responses match educational contexts.
Bozkurt, A., & Sharma, R. C. (2023)	Underscores that the organization of a prompt including the provision of context, explicit instructions, and relevant examples plays a crucial role in determining the accuracy of AI-generated responses. Thoughtfully structured prompts guide the AI towards producing more precise and pertinent outputs.
Bringula (2024)	Well-structured and focused prompts yield more accurate and relevant results. The study discovered that precise instructional questions produce effective teaching aids, whereas broader or ambiguous prompts frequently yield generic or incomplete responses.
Cao et al. (2023)	Structured prompts that include task-specific context, dataset descriptions, and repair objectives directly improve accuracy. Enhanced templates prioritize critical functional flaws over code smells. Multi-turn dialogues with fault localization hints improve outputs, but they face issues like catastrophic forgetting and inconsistent focus during iterative interactions.
Chen & Wang (2024)	The structure of prompts has a significant impact on the accuracy of AI outputs, with key components such as labels being critical. Providing examples of intermediate reasoning steps can significantly improve an LLM's ability to handle complex reasoning tasks. The absence of critical components can result in decreased performance, emphasizing the importance of example format.
Cid et al. (2024)	Prompt structure has a direct impact on AI output accuracy—well-defined tasks, clear formats, and personalized language lead to more relevant, contextually aware responses. Vague or underspecified prompts can result in incorrect or generalized results.
D. Park et al (2024)	Prompt structure has a direct impact on accuracy; methods like preceding phrases (PPQ) and cloze queries (CQ) help LLMs prioritize task intent, reduce ambiguity, and improve output relevance, according to Google SSA metrics.

- Deng & Lin (2023) ChatGPT's accuracy is highly dependent on input clarity and context. Because the model derives intent from language patterns rather than external reasoning, poorly structured prompts can produce ambiguous or irrelevant results.
- Diyab et al. (2025) The AI Assess system's automated grading function demonstrates how prompt structure influences AI output precision. Clear instructions, syllabus information, and sample graded questions all contribute to higher grading accuracy. Prompt engineering patterns, such as meta language creation, enable structured interactions with language models, thereby improving the accuracy and reliability of AI-generated grades and feedback.
- Ekin, S. (2023) The structure of a prompt can be shown to influence the accuracy of AI responses with its ability to be specific, the use of exemplary cases, and the careful wording of questions. An appeal to both intuitive System 1 and analytical System 2 thinking, combined with iterative improvement, reduces errors and guarantees consistency between desired output and expectations.
- Federiakina et al. (2024) Clear instructions, context and output indicators in structured prompts reduce ambiguity, which directly increases accuracy. Excessive complexity or ambiguity of the wording disrupts AI attention, and linguistic restrictions should be precise.
- Guo (2024) Direct prompt, guide words, zero-shot chain-of-thought, role-playing, and program-aided prompt comparative experiments indicate that the prompt structure directly affects the accuracy of AI outputs. Role-playing prompts, compared to other prompt structures, produce more detailed and helpful code because they provide the AI with a particular role of a developer.
- Hamdi & Kim (2023) Prompts that are structured, incorporating context, specificity and constraints, increase software development efficiency by 41 percent over manual approaches because they reduce ambiguity and match outputs to task requirements. The limitations like the exclusion of getters and setters decreased the complexity of design by 22%, and the test case format specificity guaranteed the accurate generation of artifacts. Nonetheless, ambiguous instructions in initial stages added 35 percent to the revision time and token-based reasoning constraints resulted in inconsistencies in AI-produced artifacts despite the structured instructions, indicating a trade-off between efficiency and reliability of output.
- Hanifi et al. (2023) Prompt engineering improves productivity, with 38.7% of students employing it to optimize outputs. However, vague or underspecified prompts led to hallucinations (90.6% occurrence) and code defects (42.7% bugs), underscoring the necessity of explicit instructions and context to mitigate inaccuracies.
- Haugsbakken & Hagelia (2024) Structured prompts integrating context, specificity, and iterative refinement are critical for reducing ambiguity and improving output reliability in educational settings. The study underscores the importance of sociomateriality theory, emphasizing symmetrical input-output engagements where prompts must align with learning goals and critical assessment. Unpredictability in LLMs, such as sensitivity to phrasing and bias risks, highlights the necessity of explicit constraints and domain-specific instructions. Contrasts basic prompting (e.g., generic queries) with scaffolded strategies (e.g., role-based frameworks) to enhance task alignment, arguing that structured prompts foster self-regulated learning and critical thinking despite inherent model limitations.
- Henrickson & Merofio-Pefuela (2023) Prompt structure influences accuracy through zero-shot and few-shot learning techniques, logical ordering such as chain-of-thought reasoning, and clear contextual instructions. Iterative refinements to structured prompts improve relevance but can produce overly neutral results.

- Joshi (2025) Prompt structure can affect the quality of AI responses, especially when it comes to complex financial queries. Optimized prompt strategies can reduce error rates in such assessments by approximately 20%. Prompt engineering streamlines the processes in the financial services sector and enhances the efficiency of task automation.
- Kepel & Valogianni (2024) Prompt structure plays an important role in the accuracy of AI outputs. Formatted prompts that lead the model through a step-by-step process or give certain instructions enhance the quality of output. Recent studies have explored the different ways of enhancing the performance of LLM by optimizing prompt. Studies have introduced techniques such as Chain of Thought (CoT) prompting, Tree of Thoughts (ToT) frameworks, and self-consistency methods to improve the reasoning and decision-making abilities of LLMs.
- Kochanek et al. (2024) Prompt structure greatly influences the accuracy of AI output, which highlights the role of prompt engineering in controlling model behavior and aligning it with the objectives set by the user. Various prompt patterns can influence the output format and prioritize specific details. The unpredictability of model responses remains a challenge, with some prompt formats outperforming others.
- Kovari (2024) Structured prompt templates (e.g., step-by-step reasoning, metadata augmentation) improve accuracy by reducing ambiguity. Chain-of-thought prompting decomposes tasks into logical sequences, enhancing reasoning fidelity, while few-shot learning with examples aligns outputs with domain-specific requirements.
- Leung (2024) Structured prompts, such as role-based, Socratic, or format-specific, allow for more contextualized and targeted responses. Prompts that are well-defined, goal-oriented, and aligned with task expectations increase accuracy.
- Li et al., (2024) Structured prompts with system information, coding conventions, and file structure enhance accuracy, boosting BLEU by 38.45% and CodeBLEU by 15.70%.
- Li, Y. (2024) Structured prompts that have clear instructions, situational contexts, and example directions match human intent in outputs by removing ambiguity and enhancing factual accuracy in generated content.
- Liu et al. (2023) Prompt structure influences accuracy by logical sequencing like chain-of-thought strategies, explicit constraints like code formatting in markdown syntax, and domain-specific instructions that are compatible with Java or C# syntax. Session continuity and multi-step optimizations enhance relevance and alignment of output and tasks.
- Liu et al. (2023) Privilege escalation patterns (SIMU:93.5%, SUPER:93.3%) yield higher accuracy by combining techniques, while complex structures (e.g., PROG:69.0%) reduce clarity and output relevance.
- Meskó, B. (2023) Structured prompts with explicit instructions, role-playing scenarios, and iterative refinement increase output accuracy by ensuring AI responses align with clinical intent. Open-ended questions and temporal references help to reduce ambiguity while increasing contextual relevance.
- Mnguni et al. (2024) The study explicitly investigated at how different prompting strategies affect the accuracy of AI outputs in programming tasks. The findings revealed that code-to-code prompting achieved a 93.55% success rate, while text-to-code only achieved 29.03%, highlighting the importance of prompt structure in output accuracy. This highlights the importance of timely design in enhancing the

quality of AI-generated code.

- Mondal et al. (2024) Manual analysis of 686 prompts was structured to find 11 gaps in 85 conversations. The consolidation strategies categorized prompts into four gaps that can be fully consolidated and three gaps that can be partially mitigated. Validations were done through ChatGPT-3.5 and ChatGPT-4 through logical workflows.
- Mungoli (2023) Formatting instructions or structured prompts with templates enhance the accuracy of the output, which is indicated by the reduced perplexity and increased BLEU scores. Immediacy of response directly influences the ability of the model to generate contextually relevant responses.
- Park, J., & Choo, S. (2024) Prompt structure has a direct impact on accuracy through logical sequencing, explicit constraints, and domain-specific language, as seen in CLEAR frameworks, ensuring outputs align with pedagogical goals while minimizing irrelevant or misaligned content.
- Pehlivanoglu et al. (2023) Prompts requiring lexical variation, phrasal variation, and syntactic rearrangement improved the quality of paraphrasing in ChatGPT, Bing, and Bard. Such metrics as BERTScore (semantic similarity) and METEOR (synonymy) were high, whereas diversity scores (ROUGE, BLEU) were low, which means that the balance between accuracy and creativity was achieved.
- Samsami (2024) Prompt structure enhances the alignment of the model with AEC tasks by encouraging the model to focus on relevant context and domain-specific language, which has a strong influence on the accuracy of AI output. Scheduling and hazard detection case studies demonstrate that the AI can deliver more precise and consistent answers when provided with structured prompts that contain context and clear, detailed instructions.
- Sikha et al. (2023) Prompt structure improves accuracy through linguistic precision and contextual framing. Ambiguous or overly broad prompts yield inconsistent results, whereas iterative refinement and explicit task decomposition increase relevance by aligning with the model's token-based reasoning.
- Sinha et al. (2023) The study examined into how prompt structure affects AI accuracy, designing balanced questions for each topic to avoid skewed results. A human panel examined the prompts to ensure that they were not inherently biased. This method allowed for the measurement of inherent bias in the model's responses, highlighting the importance of prompt design in producing unbiased results.
- Velásquez-Henao et al. (2023) Structured prompts—using roles, context, and output formats—improve accuracy. Classifications like instructive or system prompts, when combined with iterative techniques like opposing questioning, improve output quality.
- Vemprala et al. (2023) Prompt structure directly impacts code coherence and task accuracy by clearly delineating task objectives, function libraries, and constraints. A structured prompt that modularizes tasks enhances output reliability and logical sequence generation.
- Viswanathan, N. P. S. (2025) Structured prompts with precise instructions, relevant context, and logical flow enhance accuracy. Few-shot learning and role-based prompting improve output relevance by aligning model behavior with task requirements.
- Wang et al. (2024) Structured prompts using frameworks like CRISPE (Capacity, Insight, Statement, Personality, Experiment) significantly enhance answer quality in flipped classrooms. Experimental results showed a 0.74–1.25 improvement in ChatGPT Questioning Skills (CQS) scores, with iterative refinements reducing

ambiguity and aligning outputs with task objectives.

Wang M. et al. (2024)	Structured prompts like ROT (77.5% consistency for strong evidence) and COT improved alignment with guidelines by simulating expert reasoning, while simpler IO prompts showed lower accuracy, especially in complex evidence levels.
White et al. (2023)	Structured prompts like Fact Check List (flagging verifiable facts) and Reflection (rationale explanations) enforce validation and iterative reasoning, directly improving output accuracy.
White et al. (2023)	Structured prompts with scoping statements and conditional rules directly improve output accuracy. Patterns such as the API Generator and Requirements Simulator use iterative dialogue to refine specifications and ensure alignment with user intent. Domain-specific constraints enforce consistency through principles like SOLID design.
Woo et al. (2024)	The structure of prompts has a significant impact on the accuracy of AI outputs, with well-defined prompts producing more precise and relevant results. Techniques like chain-of-thought prompting and retrieval-augmented generation improve accuracy by guiding the AI's reasoning and providing contextual information. Non-experts may learn prompt engineering intuitively when necessary, but they will never design and test prompts rigorously.
Wu & Zhang (2024)	Prompt structure improves accuracy by requiring clarity, specificity, and contextual alignment with medical domains. Ambiguous prompts run the risk of producing unreliable results due to the model's opacity in decision pathways.
Wu et al. (2023)	Structured prompts enforce UUID filenames and logical task decomposition to manage inputs and outputs of 22 Visual Foundation Models including ControlNet and BLIP. Chain-of-Thought reasoning decomposes tasks into subtasks executed sequentially. Strict input-output formats minimize ambiguity and improve accuracy.
Zuccon & Koopman (2023)	Structured prompts incorporating retrieved documents directly influence answer accuracy. Evidence-biased prompts often override the model's encoded knowledge, even when such evidence conflicts with factual correctness, exposing structural vulnerabilities in answer reliability.

Table 3. Methods for Improving Prompt Formulation

Author	Methods for Improving Prompt Formulation
Abhari et al. (2024)	Iterative testing, stakeholder input, and ethical oversight help to improve solution accuracy significantly. A structured multi-phase engineering process promotes adaptability and clinical relevance.
Banawan (2023)	Using LPES elements—academic terminology, syntactic clarity, and collocation diversity—is necessary to optimize prompts. Perplexity metrics verify that these lower response uncertainty.
Bozkurt, A., & Sharma, R. C. (2023)	To enhance prompt formulation, the authors recommend methods like iterative testing, continuous refinement, and systematic debugging. Establishing clear objectives and specifying desired formats are also emphasized as strategies to improve the accuracy and relevance of AI-generated solutions.

Bringula (2024) Enhancing prompt formulation with clear, direct instructions and context-rich input significantly improves ChatGPT's performance. Including parameters such as target topic, programming language, or assessment type helps the chatbot's response match educational objectives.

Cao et al. (2023) Iterative refinement through dialogue-based hints and domain-specific adaptations improve solution accuracy. Automated prompt filling systems and API version awareness optimize formulation for deep learning program repair. Enhanced templates guide ChatGPT to prioritize actionable repairs aligned with user intent.

Chen & Wang (2024) Innovative approaches such as clustering and semantic similarity techniques can help improve prompt formulation for higher solution accuracy. Clustering and semantic similarity can be used to build prompt examples that are significantly higher in quality. In comparative tests, semantic similarity, clustering, and clustering-semantic similarity methods outperform the others.

Cid et al. (2024) Iterative testing, the definition of specific goals, and the use of domain-specific language can all help to improve task formulation. Incorporating context, expected output format, and user roles improve precision and reduce ambiguity in model outputs.

D. Park et al (2024) Structuring prompts into explicit purpose-driven formats (e.g., "purpose explicit queries") improves few-shot learning by lowering data requirements while maintaining response quality in specialized conversational tasks.

Deng & Lin (2023) Clear, specific, and context-rich inputs are required for effective prompt formulation, as they guide the model to generate relevant and coherent responses. Iterative refinement and feedback loops improve the quality of the generated answers.

Diyab et al. (2025) Prompt formulation can be improved by using prompt engineering techniques and LMQL (Language Model Query Language) to improve solution accuracy. AI Assess uses iterative prompt optimization to help with educational assessment and teaching techniques. By converting engineered prompts to LMQL, the system ensures structured interactions with language models while retaining precise control over inputs and outputs.

Ekin, S. (2023) The improving prompt formulation needed iterative testing, integrating external APIs for real-time data, and modify parameters like temperature. Ethical guidelines and domain-specific adaptations further refine outputs to meet precise user needs.

Federiakina et al. (2024) A technique like the chain-of-thought and few-shots prompting hold analogical reasoning to advance the solution accuracy. Iterative testing and role-model hints hone prompts by aligning outputs with user intent.

Guo (2024) The role assumptions and the involvement of logical reasoning steps of partial code snippets in prompts have two ways to enhance prompt formulation. These methods more efficiently approach the model directly, improving the accuracy and completeness of the solutions created, specifically in complex code generation tasks.

Hamdi & Kim (2023) This study introduces a structured prompt-based approach in software development using five design guidelines: the Context, Intention, Constraints, Specificity, and Structure—applied across the full development lifecycle to improve AI-generated artifacts.

- Hanifi et al. (2023) This study shows that student usage of ChatGPT, revealing that effective prompt formulation improves accuracy and productivity. Students who study prompt engineering show better results. Recommendations include enabling prompt-sharing platforms, designing prompts with better context retention, and developing educational content to teach prompt skills.
- Haugsbaken & Hagelia (2024) Proposes “Educational Promptization” as a new literacy practice emphasizing critical engagement with AI tools through scaffolded prompting methods such as planning, reviewing, and contextualization to foster student autonomy.
- Henrickson & Merofio-Pefuela (2023) Methods include hermeneutics-driven prompt design, iterative testing with contextual framing techniques, and balancing specificity with openness. Few-shot learning and proxy questions refine outputs to align with interpretive goals, though excessive specificity risks diminishing originality.
- Joshi (2025) Methods for improving prompt formulation include using specific, computationally relevant questions and data sources. Prompt engineering improves financial decision-making by incorporating models into processes. It is also becoming increasingly necessary for finance professionals to extract meaningful insights from complex financial datasets.
- Kepel & Valogianni (2024) Methods such as Chain of Thought (CoT) and Tree of Thoughts (ToT) have been developed to improve LLM reasoning and decision-making, resulting in higher solution accuracy. Recent research has focused on methods like "Ask Me Anything" (AMA) and universal prompt retrieval systems (UPRISE) for improving zero-shot performance and reducing hallucinations. This study demonstrates GPT-4's ability to optimize prompts autonomously, highlighting the potential for LLMs to lower the barriers to effective AI use, making sophisticated AI tools more accessible to non-experts.
- Kochanek et al. (2024) The study investigates how to improve prompt formulation by testing basic, composite, and similarity prompts. Prompt-based learning, in which models adapt to new scenarios using limited labeled data, emerges as an effective framework. Comparing the different prompting strategies helps to understand how they affect model result.
- Kovari (2024) Uses structured prompt templates, chain-of-thought reasoning, and metadata augmentation to enhance clarity, context alignment, and reasoning accuracy in ChatGPT outputs.
- Leung (2024) Assigning each roles, implementing the output constraints, providing specific examples, and utilizing structured or chain-of-thought formats are all effective techniques. These methods refine the input, guide the AI's reasoning, and produce more precise results.
- Li et al. (2024) Methods include role assignment (e.g., code expert), multi-turn conversations, and iterative refinement (e.g., error correction via try-catch-finally), improving solution accuracy.
- Li, Y. (2024) By improving the prompts through repetitive evaluation, the scope constraints, and task decomposition, the AI becomes more focused and produces precise, context-aware formulations that reduces the irrelevant or incorrect outcomes.

- Liu et al. (2023) Combining patterns (e.g., privilege escalation + pretending) and iterative prompt evolution (e.g., DAN versions) improve solution accuracy through enhanced complexity and adaptation.
- Liu et al. (2023) The methods include iterative manual prompt testing, integrating contextual programming environments, adjusting conciseness directives, and applying chain-of-thought strategies. Session-based context retention and preprocessing commands refine outputs to meet functional requirements.
- Meskó, B. (2023) Adopting this one-shot/few-shot prompting, requesting examples, and manipulating the AI-generated prompts suggestions optimizes the formulation. Continuous testing in real-world scenarios and role-based queries bridge theoretical knowledge with practical app.
- Mnguni et al. (2024) The study concludes that optimized different prompt methods are critical for achieving more accurate and proficient code generation, ultimately improving code quality. The study emphasizing the importance of understanding the ChatGPT prompting, promoting a "prompt literacy" skills, particularly among computer programming students. The future researchers should look into how to strike a balance between the prompt specificity and code efficiency to enlarge solution accuracy.
- Mondal et al. (2024) This study shows a manual qualitative analysis of developer-ChatGPT conversations to categorize gaps. Repeated merging of prompts into single optimized versions. Validation through reproducing original responses using consolidated prompts across ChatGPT versions.
- Mungoli (2023) Solution accuracy is maximized through iterative prompt refinement, contextual enrichment, rewriting, and template integration combined with reward-driven reinforcement learning fine-tuning. These techniques lessen uncertainty and connect user intent with outputs.
- Park, J., & Choo, S. (2024) This study shows that iterative refinement via the Rephrasing keywords, integrating contextual examples, and feedback loops or the REFINE method in general, enhances the prompt formulation, letting tailored outputs that points specific educational needs and improve solution relevance.
- Pehlivanoglu et al. (2023) This paper explains that carefully written prompts—such as changing the wordings, making it sound natural, changing the whole sentence structure, and always keeping the same meaning —work better than a simple prompt in paraphrasing. Prompt engineering enhances chatbot communication by maintaining the same meaning and context while increasing linguistic diversity. This paper points out that researchers use methods like iterative testing, metric-based evaluation (BERTScore, ROUGE, BLEU, METEOR), and controlled prompt designs.
- Samsami (2024) To make a better prompts; it is essential to do iterative design that incorporates domain-specific terminology, making the user's goal clear, and the use of AI tools like prompt libraries and fine-tuning are all necessary to improve the prompt formulation. Even people who don't have much experience with AI can still make a good prompt by utilizing the prompt managers and libraries. These tools enable better questions that improve solution accuracy and usability.
- Sikha et al. (2023) Enhancing prompt formulation requires using bias-aware phrasing, domain-specific terminology, and explicit output guidelines. Proper prompts with step-by-step reasoning or examples reduce knowledge gaps and optimize token

allocation to create logical solutions.

- Sinha et al. (2023) To enhance prompt formulation for better solution accuracy, the study employs a methodology that involves developing a stable set of questions and analyzing the responses using statistical methods. By identifying and measuring bias, and enhancing, the accuracy prompts can be refined to lessen bias and improve the reliability of AI-generated results. This contributes to the creation of more trustworthy and unbiased AI algorithms.
- Velásquez-Henao et al. (2023) The GPEI methodology promotes iterative design, evaluation, and data integration. Step-by-step decomposition and patterns such as personalities or patterns improve the accuracy of engineering solutions.
- Vemprala et al. (2023) Improving robotics prompt formulation requires iterative testing within simulation environments, integration of high-level API libraries, and iterative human-in-the-loop feedback. The study employs closed-loop dialogue and function chaining to refine code generation for diverse robotics tasks.
- Viswanathan, N. P. S. (2025) Advanced techniques like prompt chaining, parameter optimization, and iterative refinement improve solution accuracy. Domain-specific adaptations and automated prompt generation systems offer scalable solutions for complex tasks.
- Wang et al. (2024) The study emphasizes the role of prompt engineering in enhancing information retrieval for students using ChatGPT in flipped classrooms. It demonstrates that structured prompts using frameworks like CRISPE (Capacity, Role, Insight, Statement, Personality, Experiment) lead to higher quality, more relevant responses. Proficiency in prompt formulation significantly improves learning efficiency and reduces retrieval of inaccurate or biased content.
- Wang M. et al. (2024) ROT prompting, parameter optimization (e.g., temperature=0 for reliability), and integrating fine-tuning with prompt engineering enhance accuracy; future methods should tailor prompts to clinical scenarios and model architectures.
- White et al. (2023) Methods include Cognitive Verifier (subquestion decomposition) and Question Refinement (rewriting queries contextually), which enhance solution accuracy through systematic information gathering.
- White et al. (2023) Methods include combining patterns for comprehensive outputs and iterative refinement. Domain-specific adaptations optimize formulation through token-efficient documentation and few-shot examples. Patterns such as DSL Creation and Architectural Possibilities help with code structure and system design.
- Woo et al. (2024) Prompt formulation can be improved by using clear, specific language, including relevant context, and iteratively refining prompts based on AI feedback. Breaking complex tasks into smaller steps, using delimiters, and providing examples can all help to improve solution accuracy. Higher education courses must be updated to incorporate new knowledge and skills so that students can effectively interact with emerging technologies.
- Wu & Zhang (2024) Improving prompts requires domain-specific terminology, structured clinical data, and iterative refinement. Incorporating multimodal inputs (text and imaging) ensures that outputs meet biomedical standards, improving solution precision.

Wu et al. (2023)	Iterative testing integrates 22 Visual Foundation Models, including Stable Diffusion and MaskFormer. The Prompt Manager defines roles and orchestrates workflows, which include depth estimation followed by style transfer. Parameter optimization strikes a balance between creativity and precision.
Zuccon & Koopman (2023)	Current methodologies use retrieve-then-generate pipelines in which external documents inform prompts. However, the lack of validation mechanisms encourages reliance on unverified sources, jeopardizing trustworthiness in health-related contexts.

Table 4. Limitations and Potential Improvements in Prompting Techniques

Author	Limitations and Potential Improvements in Prompting Techniques
Abhari et al. (2024)	Current prompt techniques have limitations regarding its adaptability, bias mitigation, and integration with clinical systems. Enhancements require sustained refinement, verifiable validation, and seamless collaboration between AI and healthcare professionals.
Bozkurt, A., & Sharma, R. C. (2023)	It acknowledges the challenges like generation of irrelevant or meaningless responses, sensitivity to manipulation for instance, "jailbreaking", and inherent biases within AI systems. It calls for further research to develop more experienced and tough prompting techniques to address the issues and to improve overall AI performance.
Bringula (2024)	The AI-like ChatGPT-generated outputs regularly repeat patterns and may lack depth or in originality. Improvements including the diversifying prompts, validating outputs, and using AI support as a supplement rather than a primary source of instruction.
Cao et al. (2023)	Current limitations include the dependency on outdated API knowledge, unpredictability in multi-turn interactions, and overemphasis on code smells without being straightforward. Future improvements require adaptive frameworks for evolving the libraries, standardized fault localization protocols, and mitigation of catastrophic forgetting through context retention strategies.
Chen & Wang (2024)	Current prompting techniques have limitations in their universal applicability across various models and tasks, necessitating broader evaluations. The impact of prompt example construction decreases as the parameter scale of LLMs increases. There is a need for universally applicable and effective methods to improve the performance of smaller LLMs.
Cid et al. (2024)	Current prompting techniques are limited by ambiguous language, a lack of contextual framing, and insufficient user understanding. To improve AI response quality, consider semantic richness, prompt personalization, and systematic evaluation metrics.

- D. Park et al. (2024) The current limitations include reliance on manual prompt structuring and language-specific adaptations; the study suggests automating QTM processes and expanding cross-linguistic validation to address the scalability gaps.
- Deng & Lin (2023) Current prompting techniques are limited by the model's static knowledge and bias. Improving prompting may involve integrating external databases or real-time feedback mechanisms to increase reliability and scope.
- Diyab et al. (2025) AI Assess addresses limitations in current prompting techniques, such as the need for ground truth answers and the challenges associated with grading diverse student responses. Future enhancements include improving prompts to provide instant feedback, creating supplemental practice problems, and identifying student weaknesses. The system should be used effectively, not avoided.
- Ekin, S. (2023) Current limitations include the model biases, uncertainty of handling, and over-dependence on training data. Each enhancement involves advanced strategies like prompt chaining, bias reduction frameworks, and adaptive prompts for multi-turn interactions.
- Federiakina et al. (2024) Current limitations include hallucination risks and trial-and-error inefficiencies. Improvements require standardized frameworks for prompt literacy and integrating critical evaluation skills to mitigate output errors.
- Henrickson & Merofio-Pefuela (2023) The current limits include the reliance on the unoriginal training data, external exploration analysis often tagged as jumbled texts, AI like the ChatGPT's tendency to avoid speculative awareness to maintain the impartiality. Enhancements involve the automated prompts generation system, integrating the hermeneutic evaluation frameworks, and addressing biases in training data to encourage deeper values.
- Joshi (2025) Current prompting techniques also have limitations, like ethical considerations, potential biases, and data privacy concerns. The future improvements should concentrate on creating the frameworks to reduce the biases, develop good evaluation metrics, and implement explainable AI solutions for transparency. There's a need for global ethical guidelines and reteaching the programs to address legal complications and job displacement caused by the AI adoption.
- Kepel & Valogianni (2024) Current prompting techniques rely heavily on human-created prompts and external interventions, which limits the full use of LLM capabilities. This study makes significant theoretical contributions, adding to the body of knowledge on the autonomous capabilities of Large Language Models such as GPT-4. It seeks to advance the comprehension of how such these models can separately optimize the prompts, challenging the current reliance on human interventions to improve the AI performance and outputs.

Kochanek et al. (2024)	Current prompting techniques have limitations, including the difficulty of identifying prompts that result in desired outputs and the inherent unpredictability of model responses. Although prompt-based data synthesis cannot replace traditional data collection, it is an effective tool in data-scarce environments or as a data augmentation technique. Future research should concentrate on using continuously developed LLMs to improve the generation of high-quality synthetic data.
Leung (2024)	Limitations result from ambiguous prompts, overgeneralization, or a lack of user-AI interaction. Improvements can be made through iterative prompt refinement, user training, and the use of adaptive, context-sensitive techniques that respond to user needs and learning objectives.
Li et al. (2024)	Limitations include version iteration gaps (GPT-3.5 vs. GPT-4), fabrication of non-existent code (e.g., PHPWord functions), and prompt dependency; improvements focus on explainability integration and balancing single/multi-turn generation.
Liu et al. (2023)	Limitations include inconsistent robustness (e.g., unrestricted PCL/HGD scenarios) and GPT-4's partial resilience (15.5% improvement); improvements require legal-aligned policies and input-stage jailbreak detection models.
Liu et al. (2023)	Current limitations involve reliance on manual prompt design, ambiguity in natural language specifications, and inconsistency in complex code translation tasks. Enhancements require automated prompt generation systems, rigorous functional correctness metrics, and integration of code quality analysis tools for real-time validation.
Meskó, B. (2023)	Current limitations include data recency constraints, empathy gaps, and privacy risks. Improvements require updated training datasets, enhanced plugins for real-time data access, and integrating prompt engineering into medical education.

DISCUSSION

A. Factors that Influence the ChatGPT Responses and Efficiency

As presented in Table 1, the quality and structure of user prompts are the foundation of effective ChatGPT interactions. Several studies have shown that well-designed prompts improve accuracy, prevent ambiguity, and align outcomes with user intent. Clarity and specificity are commonly recognized as critical for improving ChatGPT's performance. Confusing prompts often give generalized or irrelevant outputs, whereas the specific instructions lead the model to effective responses (Abhari et al., 2024). In this regard,

Bozkurt and Sharma (2023) state that unclear prompts produce "suboptimal outputs," but domain-specific language increases relevance. Structured prompts with stated aims, such as symptom descriptions in medical settings, significantly boost fault detection rates (Cao et al., 2023). Haugsbaken and Hagelia (2024) emphasize the importance of prompt clarification and continual development. They demonstrate that bad prompts can cause hallucinations and reduce performance.

This is of particular concern in high stakes areas, like medicine, law, and finance, where a hallucinated output, confidently asserted but actually false answers to a problem, may have dire consequences in the real-world decision-making process. In Table 1, Meskó (2023) indicates explicitly that prompt specificity and understanding of model limitations are vital factors in reducing such risk, noting that ChatGPT itself is based on outdated training data and lacks real-time knowledge, which makes professional verification not only recommendable but also necessary. By accepting an AI-generated dose recommendation of a drug, a clinician risks harming a patient without cross-referencing the output with current clinical guidelines, such as the risk of causing harm to a patient. In a similar vein, Federiakin et al. (2024) point out that being aware of model limitations, specifically the token prediction mechanisms by which ChatGPT generates responses are actually known to be false and not supported by verifiable factual evidence. Velasquez-Henao et al. (2023) further support this fact and find out that the lack of prompts leads to hallucinations and inaccuracies, and recommends that the principles of Understandable AI should be incorporated in order to make sure that the results are interpretable and verifiable by human specialists. Abhari et al. (2024), when writing to be specifically considered in the context of healthcare applications, claim that customized prompts will reduce bias and increase the accuracy of the output, but do not go as far as to claim that customized prompts will reduce bias and increase the

accuracy of the output fully. Collectively, these studies lead to one of the most obvious consequences: prompt engineering can enhance the likelihood of correct outputs but cannot guarantee them, and in high-stakes areas, a mandatory human verification layer must be treated as a structural requirement of any AI-assisted workflow and not as an optional quality check. Institutions that implement ChatGPT in medical, legal, or financial situations, should therefore implement explicit verification protocols - such as having licensed professionals review and sign-off on AI-generated output before they inform any consequential decision - to ensure that the efficiency gains of AI assistance do not come at the cost of accuracy and accountability.

Wang (2024) further underlines that the CRISPE framework (Capacity & Role, Insight, Statement, Personality, and Experiment) fosters high-quality responses through organized prompt design. Grammatical precision impacts accessibility. Cid et al. (2024) observed that the choice of vocabulary and syntax influences the model's capacity to understand the purpose, whereas Bozkurt and Sharma (2023) connect grammatical problems with misunderstandings. Length also serves an additional purpose: excessively long prompts introduce noise, while overly short ones lack context. Park and Choo's (2024) CLEAR framework promotes concise yet explained prompts, such as "Summarize the causes of climate change in 200 words for policymakers." Specificity remains important. Incorporating explicit restrictions and templates improves the quality of output. Cao et al. (2023) state that prompts with repair goals (such as "List symptoms of diabetes in bullet points") reduce ambiguity by hindering the model's focus. Ekin (2023) promotes this by calling for "structured prompts" that maximize the model's strengths, such as establishing types of output (like tables or step-by-step tutorials). A query like "Generate a Python function that calculates Fibonacci numbers, avoiding recursion" instructs the model to emphasize iterative

solutions, ensuring that outputs are consistent with user intent. Pehlivanoglu et al. (2024) demonstrate that the designed prompts with diverse directives and fluent limits improve semantic memory and reduce redundancy, improving output coherence. Advanced methods for prompt design include the PARTS (Persona, Aim, Recipients, Theme, Structure) and CLEAR (Concise, Logical, Explicit, Adaptive, and Restrictive) principles. According to Park and Choo (2024), identifying a personality (such as "Act as a financial advisor") and organizing suggestions around topics to improve awareness of context. CLEAR principles further remove reiteration, for instance, a request like "Explain the concept of quantum computing to high school students in three paragraphs" balances conciseness and specificity. Hanifi et al. (2024) found that students who knew how to use the structured prompting principles (role playing and iterative refinement) performed better than those who often experienced security issues, hallucinations, and context collapse with prompts, especially with coding tasks. They further corroborated the educational value of prompt literacy.

B. Influence of Prompt Structure on Output Accuracy

As presented in Table 2, the clarity and precision of written instructions are critical to improving output accuracy. Multiple studies show that well-structured and detailed instructions reduce uncertainty and produce more focused and relevant responses (Abhari et al., 2024; Bozkurt & Sharma, 2023; Cid et al., 2024). Bringula (2024) stated a pattern in programming education: unclear questions generate vague or partial answers, while precisely structured instructions improve reliability. Key methods include providing incremental steps, demarcating sections with labels, and applying formatting rules, each clarifying expectations and improving response quality. Measurable improvements support these claims. Li et al. (2024) report that structured prompts using task-specific formats increased BLEU scores by

38.45% and CodeBLEU scores by 15.70%. Joshi (2025) also finds that formats like cloze queries and preceding phrases reduce financial assessment errors by 20%. According to Park et al. (2024), structured instructions help identify the task's purpose more clearly, improving relevance. However, Kochanek et al. (2024) warn that rigid instructions may reduce creativity, while vague formats often lead to off-topic content. To balance these risks, Liu et al. (2023) commend organizing prompts logically and enforcing formatting rules to help guide responses without limiting flexibility. These improvements are related to how systems interpret commands. Structured prompts focus on clear directions rather than patterns. According to Deng and Lin (2023), clearer inputs allow systems to avoid guessing and instead follow the provided logic. In education, Diyab et al. (2025) discovered that including grading criteria and sample tasks in prompts leads to more consistent evaluations. These findings demonstrate that logical structure, clarity, and precision contribute to more accurate responses aligned with the task's goals.

Domain- and Role-Specific Adaptation

Prompt effectiveness improves when tailored to specialized fields. In healthcare, prompts modeled after clinical interactions improve compliance with medical response standards (Meskó, 2023; Wu & Zhang, 2024). Answers gain clarity and relevance through temporal markers and role-based contextualization (Wang et al., 2024). Haugsbaken and Hagelia (2024) claim that prompts should reflect how instructors teach and evaluate students. When instructions use this structure, the answers align more with educational objectives. Similarly, Mnguni et al. (2024) report that using code-to-code prompts results in 93.55% programming accuracy, whereas plain text inputs yield only 29.03% accuracy. This emphasizes the importance of using the appropriate format and technical language for the field. In software engineering, prompts that follow the modular design and include reusable

components make responses more practical and consistent (Vemprala et al., 2023; White et al., 2023). Hamdi and Kim (2023) find that such prompts lower design complexity by 22%, although early vague inputs increase editing time by up to 35%. Park and Choo (2024) recommend using the CLEAR framework, which organizes domain-specific terms and task steps to keep responses on topic. Liu et al. (2023) also find that applying language rules from programming languages like Java or C# reduces errors in formatting. While adding supporting materials can improve accuracy, Zuccon and Koopman (2023) caution that low-quality documents may cause mistakes. Overall, prompts that use the correct structure, tone, and logic for their subject area result in more appropriate and valuable responses.

Contextual Framing and Evidence Integration

Integrating background materials into prompts ensures higher response accuracy. Supplementary documents or examples establish contextual clarity and mitigate errors (Zuccon & Koopman, 2023). According to Cao et al. (2023), using medical guidelines as prompts improves response quality and safety in clinical tasks. Similarly, Relevance-Order-Timing (ROT) and Chain-of-Thought (CoT) systematize expert reasoning steps, yielding results like Wang et al.'s (2024) 77.5% consistency. In educational and technical contexts, enriched prompts decrease errors while improving focus. Cao et al. (2023) and Diyab et al. (2025) show that including known issues or course goals in prompts helps target the response correctly.

Unclear prompts often result in serious mistakes. Hanifi et al. (2023) found that vague instructions cause hallucinated responses in 90.6% of cases and are responsible for nearly half of code errors. Leung (2024) demonstrates that prompts linked to course outlines improve grading quality and feedback usefulness. Mondal et al. (2024) examined hundreds of prompts and developed structured correction methods, leading to more precise and accurate

results. Viswanathan (2025) adds that giving examples and showing expected outcomes helps guide the system and reduce errors from poor sources. However, these examples must be chosen carefully. Unreliable or biased materials may result in incorrect results. To avoid this, prompts must balance internal logic and trusted references. Prompts, when written clearly and based on reliable sources, improve responses' accuracy, focus, and value across various subject areas.

Iterative Refinement and Feedback Mechanisms

Another effective method for achieving accurate results is to improve instructions step by step. Chain-of-Thought (CoT) formatting, which divides a task into smaller steps, allows systems to follow logical reasoning paths (Kepel & Valogianni, 2024; Wang et al., 2024). According to Ekin (2023), this method works well because it promotes quick thinking and deeper analysis, thereby reducing errors by 18%. In fields such as software development, feedback-driven prompts yield more precise outcomes. Diyaab et al. (2025) demonstrate this through the AI Assess system, which enhances performance via metadata integration and iterative questioning. Velásquez-Henao et al. (2023) additionally verify that reflective and challenge-based prompts reduce errors through answer validation. Such techniques are critical for reliability-sensitive tasks. However, using feedback repeatedly can lead to overly cautious responses. Henrickson and Merofio-Pefuela (2023) observe that systems may avoid firm conclusions to reduce risk, resulting in ambiguous or uncertain answers. Still, the benefits of feedback-based methods are well supported. Li et al. (2024) report better performance on programming tasks, while Sinha et al. (2023) demonstrate that refinement reduces bias in healthcare responses. Kovari (2024) suggests using detailed templates with labels to help clarify instructions. Pehlivanoglu et al. (2023) propose that integrating meaning-based and grammar-based metrics such as BERTScore (0.92) and METEOR (0.85)

optimizes the balance between correctness and stylistic clarity. Revising instructions gradually, with feedback and examples, is an effective way to improve accuracy. While caution is advised to avoid repetition or overly neutral responses, this method remains critical for developing high-quality results.

C. Methods to Improve Prompt Formulation for Better Solution Accuracy

As presented in Table 3, with the potential to improve prompt formulation to make solutions more accurate with the emergence of large language models (LLMs), such as ChatGPT, the idea of prompt formulation is getting closer to the future of the interaction between AI and humans. The accuracy, relevance, and ease of reading the results that models produce are hinged on the promptness of formulation. The above research review shows that rapid quality improvement is a process in itself and consists of an iterative improvement, design, semantic optimization, domain adaptation, ethical considerations, and incorporation of education. The specified research proves the evolution of rapid engineering, as the trial and error wording is not applied anymore, and more complicated and structure-based approaches are utilized, which are targeted at presenting the most efficient performance without hallucinating and being prejudiced.

One of the approaches that can also be traced in the reviewed literature is iterative refinement: iterative refinement is the method where a series of test-user feedback-performance cycles iteratively refine prompts. The practice is similar to the agile development methods and enables setting context-dependent and flexible prompts. According to Abhari et al. (2024) and Bozkurt & Sharma (2023), feedback should be ongoing to ensure that AI-generated content can keep up with evolving user goals. The processes imply more precision and help streamline the outputs in terms of specificity, clarity, and intent axes.

Park and Choo (2024) present REFINE, scaled down to the scale of an educational system built on feedback loops and instant rewording, contextual visualization, and repetitive refinements. Mondal et al. (2024) further introduce their consolidation model according to which the prompts are delivered to the users. However, due to the different interactions, all of them are combined into one, optimized one. Not only a step up in quality of solutions, it also allows backward compatibility of versions of models, a new challenge because large language models (LLMs) are advancing and improving rapidly.

It is worth observing that iterative refinement is flexible and dynamic, with inefficiencies created without organizational feedback. The input that can help future research would be developing automatic interpretation systems that can be fed back so that further automation of refinement can be realized.

Structured Prompt Design and Clarity

Prompt creation needs clarity and structural integrity above all. As Park et al. (2024) and Leung (2024) state, purpose-driven, task-specified, role-specified, and structured response format prompts are mandatory. Honesty as a duty is free of misconception and produces an excellent product as anticipated by the user.

Hamdi and Kim (2023), introduced their design framework which is Context, Intention, Constraints, Specificity, and Structure (CICSS) that is supposed to support the entire process of prompt development and passing through the software engineering life cycle. The official process will make the prompts syntactically sensible, semantically and contextually deep.

Furthermore, Sikha et al. (2023) illuminate that the outcome structuring and the bias-aware language may result in increased coherence and decreased cognitive dissonance. Kovari (2024) agrees and recommends optimizing metadata approaches, and such an

approach would result in multi-dimensional prompts integrating the context, instructions, and the anticipated form into one coherent input. In general, these practices lead to the conclusion that structured clarity is not only a matter of aesthetics but also makes sense in reducing the cost of tokens and maximizing alignment with tasks.

Domain-Specific Adaptations and Contextualization

The domain knowledge may be instrumental in increasing the speed and relevance of solutions. Bringula (2024) and Deng & Lin (2023) stated that domain-specific vocabulary, parameters, or styling conventions in prompts positively influence learning to a great extent. It is essential in science, technology, engineering, and mathematics because, with the help of misleading language, one can quickly go off-topic or with technically incorrect findings.

Cao et al. (2023) include the domain-specific change and API consideration in fast optimization for repairing deep learning programs. On the same note, Wu and Zhang (2024) use clinical data integration to achieve biological alignment when dealing with health-related work. The results may be accepted that context-aware prompting is not just a desirable phenomenon but one regularly demanded to accomplish tasks.

Nonetheless, such solutions cause accessibility concerns. The laypeople will also lack the ability to develop domain-specific prompts, and they will also emphasize the necessity of the toolkits or templates that will be used in teaching lay users of technology.

Semantic Optimization and Prompt Selection

Semantic strategies are a novel area in prompt engineering. The authors Chen and Wang (2024) apply clustering and semantic similarity to choose good example prompts and ensure the maximum consistency and the least variation of the response. Experimenting, Kochanek et al. (2024) compare basic, composite, and similarity-based prompts and conclude

that the optimized combinations are more model-agnostic and show consistent responses in the few-shot learning context.

According to the findings of the provided study, the information about previous triggering can be applied to the design process optimization in the future. These adaptive prompting systems can also constitute a significant portion of the system. They would involve semantic indexing and would be able to learn based on a previous user experience. The strategy also allows for the personalization of AI tools without completely retraining the underlying models, and it is efficient and scalable.

Reasoning-Based Prompting Strategies

Chain-of-Thought (CoT) and Tree-of-Thought (ToT) are more recent methods of reasoning in an AI system that satisfy the requirement of more complex reasoning. These structures require models to explain their rationale step-by-step, which is much more human. New facts given by Kepel and Valogianni (2024) confirm the possibility of those methodologies to raise the level of logical inference and the transparency of the decision-making process, particularly in the case of zero-shot learning, when the model does not see the training data.

In the wake of these developments, Velasquez-Henao et al. (2023) introduce the GPEI approach, which takes the performance of the technical task to the next level by breaking down the task sequentially and illustrating the method step-by-step. They combine to bring big language models out of the shallow pattern recognition world and into more explainable and logically coherent interactions. This is necessary to establish a reliable AI partnership in the most significant areas such as law, medicine, and engineering.

Automation, Real-Time Adaptation, and Multi-Model Orchestration

The emerging trends in stimulation have transformed the discipline into an automated and choreographed discipline. One such example is that LMQL (Diyab et al., 2025) offers organized prompt scripting, which provides the database-like control of conversational interfaces. Similarly, the UPRISE framework proposed by Kepel and Valogianni (2024) automatically retrieves the prompts, even in zero-shot scenarios when no examples are present.

One example of integration of real-time prompting systems can be regarded as the works of Vemprala et al. (2023) and Wu et al. (2023) in robotics and visual artificial intelligence research. These are adaptive systems regarding output change to simulation feedback, external APIs, and multi-model inputs. All these works make the impression of a tremendous change in the sphere of immediate engineering: the process became quite active and interactive. It can respond to the complex and changing environment in real time.

Ethical Considerations in Prompt Engineering

As technological advancements advance, ethical issues cannot be disregarded in on-time engineering. As Abhari et al. (2024) and Sinha et al. (2023) note, the identification of bias and the involvement of the stakeholders are required, particularly in such an area as healthcare, where the stakes are admittedly high. They underline the need to incorporate other voices to have a responsible and fair instant development.

On the same note, Zuccon and Koopman (2023) question the retrieve-then-generate pipelines and indicate that the latter can generate hallucinated or misleading information, unless an efficient validation system exists, which is especially perilous in the case of medical practices. Therefore, there is a need for ethical, timely engineering coupled with stringent source verification, open system architecture, and continuous user monitoring to provide confidence and reliability in sensitive applications.

Prompt Literacy and Education

Finally, instant literacy construction becomes popular in the education and training of the labor force. According to Mnguni et al. (2024) and Woo et al. (2024), prompt engineering is included in the list of future core skills that involve AI. Wang et al. (2024) and Haugsbaken and Hagelia (2024) are examples of how the CRISPE framework enhances information retrieval in the flipped classroom and how to apply the concept of Educational Promptization as a model of literacy on strategic and reflective use of AI. The approaches are connected to the need to go over the use of tools to meta-level knowledge, where the learners and practitioners could design, evaluate, and critically revise prompts to produce the desired cognitive effects.

The on-time formulation is neither an interface nor a design issue, a pedagogical aid, an ethical issue, and an emerging literacy has been supported by our literature review. It may be iterative loops, formal templates, semantic refinement, or automation. Still, the trick to minimizing the gap between more-accurate and more-informative AI responses is to regain control over what goes in. As the use of AI in teaching, trade, and everyday life increases, educating users on how to engineer in time will be a vital part of maximizing ethical and creative use of LLMs.

D. Limitations and Potential Improvements in Prompting Techniques

As presented in Table 4, the application of large language models (LLMs) like ChatGPT has enabled us to write and generate content in different fields; now, it is a widespread trend in emails, articles, and even on school assignments. It needs a simple command to get content based on how it interprets the prompt. This is why arriving at the answer by specifically considering it is one of the challenges that has developed. It may be

partisan, incomprehensible, or inflexible to scale. This is why the answer will be critically affected in healthcare or law.

Limitations in Prompting Techniques

Large language models (LLMs) like ChatGPT have enabled us to write and generate content in numerous ways, and today, it has become a norm in email messages, articles, and even school work. It is necessary to give it a simple command, and it will have the content delivered since it knows what is being commanded. That is why the fact that reached the answer that is considered in particular is one of the problems. It may be partisan, incomprehensible, or inflexible to scale. This is why the resolution will be pathetically affected, particularly in medical care or legislation.

Bias and Ethical Concerns

The major problem accompanying LLMs like ChatGPT is that they are biased by what they have been trained on. That is why the biased stereotypes that are grounded in unfair discrimination in the conditions of the wide range of unpredictable factors can assume such a shape that we cannot even imagine. In other research, it has been proven that AI has a higher probability of identifying and tracking the slow eradication of the insights, irrespective of the controversial nature of the topic of discussion. The thing is that there exist those situations when it is better to stay in the gray and not in the black and white, following these tender issues and AI. This trend can mislead the users and affect and change their views.

Ambiguity and Contextual Misalignment

When asked ambiguous questions, ChatGPT is also highly vulnerable to the wording of questions, and in most cases, gives non-relevant or nonsensical answers. This can be attributed to the fact that prompts are shallow in the sense of semantics, as Cid et al. (2023) found out, but Leung (2023) has gone further to explain the implications of instructional

ambiguity by saying that it will result in responses that are either too general or too shallow. Mnguni et al. (2023) discovered that intricate descriptions of issues resulted in the unsuccessful text-to-code strategies that resulted in inefficient or incorrect code. This ambiguity is especially out of place in such specific fields as the law or medicine, where accuracy is required. Artificial intelligence is one of the spheres where one can be lost unless the context helps to put it into perspective.

Although there is an undeniable fact that simplifying or making ambiguous prompts inevitably leads to a decrease in the quality of output, the literature synthesized in Table 4 also warns that the prompt complexity inevitably leads to a decline in the quality of output and, in fact, creates additional limitations. The best example of this trade-off, as provided by Diyab et al. (2025), is that few-shot prompting yields better accuracy, but also generates more computational requirements, which in turn raises the question of the scalability of such a prompting in the context of resource-constrained environments. Equally, Chen and Wang (2024) discovered that the marginal performance improvement of complex prompt construction decreases with the scale of the language model parameter, implying that beyond a certain point, the benefit of further prompt complexity increases diminishes with the scale of the language model parameter. Leung (2024) also adds that overly complicated prompts run a risk of overgeneralization, which results in outputs being technically detailed yet do not align with the actual intent of the user. This is a tension between needs of adequate specificity and the danger of over-engineering, and this tension is one of the key unsolved problems in timely design. The practitioners should now see prompt complexity not as a variable to be maximized but as a variable whose value to be calibrated to seek the minimum level of detail required to obtain accurate, relevant, and computationally efficient results to a given task and domain.

Dependency on Human Intervention

Most of these prompting techniques are manual and thus are not scalable and usable in real-time. The abundance of human-authored prompts, as a factor limiting the freedom of LLMs, was also blamed by Kepel and Valogiann (2023). Similarly, Cao et al. (2023) discovered that legacy APIs were being utilized during the code-generation procedure, and thus, the code needed to be revised manually. They have found that the problem of the real-time processing of tasks in robotics is due to the rigid prompting structures (Vemprala et al., 2023). Dependencies of this sort cripple the innovations in fields such as autonomous systems or dynamic customer service, where adaptive self-optimizing AI is a necessity.

Inconsistency and Reliability Risks

Unpredictable output of a small-scale prompt rephrasing or hallucination poses a major reliability threat. Wang et al. (2023) used an example of instant weakness, when a slight change in the language results in unexpected consequences, and Federiakin et al. (2023) mentioned the threat of hallucinations, when models can deliver information that sounds and may even look right, but is factually not accurate. Li et al. (2023) discovered that GPT-4 interpolated functions of nonexistent codes, and this is a serious technical application disadvantage. This discrepancy is inadmissible in such high-risk areas as medical diagnostics or legal analysis, in which it is essential to be accurate.

Domain-Specific Adaptation Gaps

ChatGPT can barely adapt to the area of expertise, implying it lacks the contextual and cultural background. Mesk (2023) established that empathy gaps in medical interactions have been detected, and Velasquez-Henao et al. (2023) have found the failure of reproducibility of scientific activity. Wu and Zhang (2023) found that there were local biases in healthcare suggestions, and the models failed to consider the local resource shortage. The

limits of the ChatGPT application are subject to these restrictions, in the areas of work where the knowledge of the field in detail is required, e.g., in clinical research or the educational process with multilingual students, and the significance of individual solutions.

Bias Mitigation Through Ethical Frameworks

The bias issue can be addressed through proactive measures such as retraining the models using balanced data and proposing ethical policies. Interdisciplinary cooperation proposed by Sinha (2023) and Joshi (2023) may be the solution to locating and reducing biases. Still, Kepel and Valogiann (2023) advocate independent prompt tuning as a method of reducing biases caused by humans. Furthermore, Wu and Zhang (2023) also say that paying attention to the AI frameworks consistent with the geographical differences in health care is necessary. This will be done to develop equitable AI systems that will not operate contrary to society's values.

Enhancing Contextual Awareness

The situational interpretation would be enhanced by dynamic prompting, lowering the ambiguity. In that regard, Cid et al. (2023) presented the semantically augmented user intent prompt. However, Leung (2023) suggests iteration and improvement only in real-time feedback. Liu et al. (2023) state that introducing automatic systems with real-time validation will enable determining the correctness of functionality when writing the code. All these perceptions enhance the relevance of the compound activities, like in the programming of the robot or the learning of the individual, where success is relative.

Automation and Standardization

The templates should be standardized, and the self-optimizing systems should be introduced so that the minimum amount of manual intervention is required. Park et al. (2023) propose using cross-linguistic validation tools to improve scaling, and Cao et al. (2023)

propose adaptive frameworks to modify technical libraries. Mondal et al. (2024) pay attention to the self-correcting modules in which the creation of the code requires the least interaction of human beings. Automation makes it more productive and enables AI to operate in dynamic conditions, e.g., real-time translation and self-driving.

Robust Validation and Explainability

Part of the reliability risk mitigation plans can be created with stringent validation procedures and explainable AI (XAI). Federiakin et al. (2023) insist on establishing models that consider the outputs to be suspects. Velasquez-Henao et al. (2023) mention that tracing the decision path using XAI is always better. Diyaab et al. (2023) propose that in the teaching process, the mechanisms should be incorporated in students' responses in real-time. This increases accountability in any sector, like medicine and finance, where making errors can be costly.

Domain-Specific Customization

Adapting prompts to a given discipline's requirements increases accuracy and culturally sensitive prompts. Vemprala et al. (2023) advise that robotics should be reconsidered regarding safety. In contrast, Abhari et al. (2023) advise clinicians to cooperate with AI to improve medical prompts. Meanwhile, Mnguni et al. (2023) claim the trend towards balancing the specificity and efficiency of software engineering prompts. Personalization is also a part of the fact that AI is being added to human knowledge, and that it builds trust in such applications as legal analysis and disaster response.

CONCLUSION

The way prompts are written for ChatGPT significantly impacts the quality of its responses. Vague prompts or those without context frequently result in unclear or misaligned

responses. On the other hand, well-crafted prompts that outline specific goals, provide relevant information, and indicate desired formats consistently produce more accurate, cohesive, and user-focused results. Effectively conveying expectations through the prompt is a key link between the user's intention and the AI's capacity to deliver meaningful results. Users must explicitly define desired outcomes to improve performance and strategically break down complex questions into sequential sub-prompts. Modern systems increasingly use real-time adaptive mechanisms, which enable dynamic feedback loops that refine responses as conversations progress. As artificial intelligence becomes more prevalent in critical sectors such as healthcare diagnostics and legal compliance, the ability to create effective prompts has evolved from purely technical to necessary literacy. This transition is crucial in determining whether AI enhances human expertise or adds complexity and confusion.

REFERENCES

- Abhari, S., Fatahi, S., Saragadam, A., Chumachenko, D., & Morita, P. P. (2024). A road map of prompt engineering for ChatGPT in healthcare: A perspective study. *Studies in Health Technology and Informatics*, 316, 998–1002. <https://doi.org/10.3233/SHTI240578>
- Banawan, M. (2023). Composite score for ChatGPT prompt efficiency: A computational linguistic analysis of engineered chatbot prompts. *International Conference on Computers in Education*. <https://doi.org/10.58459/icce.2023.4799>
- Bozkurt, A., & Sharma, R. C. (2023). Generative AI and prompt engineering: The art of whispering to let the genie out of the algorithmic world. *Asian Journal of Distance Education*, 18(2), i-vii. Retrieved from <https://asianjde.com/ojs/index.php/AsianJDE/article/view/749>
- Bringula, R. (2024). ChatGPT in a programming course: Benefits and limitations. *Frontiers in Education*, 9. <https://doi.org/10.3389/educ.2024.1248705>
- Cao, J., Li, M., Wen, M., & Cheung, S. (2023). A study on prompt design, advantages, and limitations of ChatGPT for deep learning program repair. *arXiv*. <https://doi.org/10.48550/arXiv.2304.08191>
- Chen, D., & Wang, J. (2024). A prompt example construction method based on clustering and semantic similarity. *Systems*, 12(10), 410. <https://doi.org/10.3390/systems12100410>
- Deng, J., & Lin, Y. (2023). The benefits and challenges of ChatGPT: An overview. *Frontiers in Computing and Intelligent Systems*, 2(2), 81–83. <https://doi.org/10.54097/fcis.v2i2.4465>
- Diyab, A., Frost, R. M., Fedoruk, B. D., & Diyab, A. (2025). Engineered prompts in ChatGPT for educational assessment in software engineering and computer science. *Education Sciences*, 15(2), 156. <https://doi.org/10.3390/educsci15020156>

- Ekin, S. (2023c). Prompt Engineering For ChatGPT: A Quick Guide To Techniques, Tips, And Best Practices. *TechRxiv*. <https://doi.org/10.36227/techrxiv.22683919>
- Federiakina, D., Molerov, D., Zlatkin-Troitschanskaia, O., & Maur, A. (2024). Prompt engineering as a new 21st century skill. *Frontiers in Education*, 9. <https://doi.org/10.3389/feduc.2024.1366434>
- Fuentealba Cid, D., Flores-Fernández, C., & Aguilera Eguía, R. (2024). The art of prompts' formulation: Limitations, potential, and practical examples in large language models. *Salud, Ciencia y Tecnología*, 4, Article 969. <https://doi.org/10.56294/saludcyt2024.969>
- Guo, H. (2024). An empirical study of prompt mode in code generation based on ChatGPT. *Applied and Computational Engineering*, 73, 69–76. <https://doi.org/10.54254/2755-2721/73/20240367>
- Hamdi, M., & Kim, L. D. (2023). A prompt-based approach for software development. *2023 International Conference on Computational Science and Computational Intelligence (CSCI)*, 1612–1614. <https://doi.org/10.1109/CSCI62032.2023.00267>
- Hanifi, K., Cetin, O., & Yilmaz, C. (2023). On ChatGPT: Perspectives from software engineering students. In *2023 IEEE 23rd International Conference on Software Quality, Reliability, and Security (QRS)* (pp. 196–205). IEEE. <https://doi.org/10.1109/QRS60937.2023.00028>.
- Haugsbaken, H., & Hagelia, M. (2024). A new AI literacy for the algorithmic age: Prompt engineering or educational promptization? *2024 4th International Conference on Applied Artificial Intelligence (ICAPAI)*, 1–8. <https://doi.org/10.1109/ICAPAI61893.2024.10541229>
- Henrickson, L., & Meroño-Peñuela, A. (2025). Prompting meaning: A hermeneutic approach to optimising prompt engineering with ChatGPT. *AI & Society*, 40, 903–918. <https://doi.org/10.1007/s00146-023-01752-8>
- Joshi, S. (2025). Prompt engineering for generative AI: Applications, challenges, and research opportunities. *World Journal of Advanced Research and Reviews*, 25(1), 1775–1785. <https://doi.org/10.30574/wjarr.2025.25.1.0279>
- Kepel, D., & Valogianni, K. (2024). Autonomous prompt engineering in large language models. *arXiv*. <https://doi.org/10.48550/arXiv.2407.11000>
- Kochanek, M., Cichecki, I., Kaszyca, O., Szydło, D., Madej, M., Jędrzejewski, D., Kazienko, P., & Kocoń, J. (2024). Improving training dataset balance with ChatGPT prompt engineering. *Electronics*, 13(12), 2255. <https://doi.org/10.3390/electronics13122255>
- Kovari, A. (2024). ChatGPT the omniscient? A guide to effective prompting. *2024 IEEE 7th International Conference and Workshop Óbuda on Electrical and Power Engineering (CANDO-EPE)*, 47–52. <https://doi.org/10.1109/CANDO-EPE65072.2024.10772984>
- Leung, C. H. (2024). Promoting optimal learning with ChatGPT: A comprehensive exploration of prompt engineering in education. *Asian Journal of Contemporary Education*, 8(2), 104–114. <https://doi.org/10.55493/5052.v8i2.5101>
- Li, Y. (2024). Reduce AI illusion based on data science technology and prompt engineering. *Applied and Computational Engineering*, 97, 152–156. <https://doi.org/10.54254/2755-2721/97/20241463>

- Li, Y., Shi, J., & Zhang, Z. (2024). An approach for rapid source code development based on ChatGPT and Prompt engineering. *IEEE Access*, 12, 53074–53087. <https://doi.org/10.1109/access.2024.3385682>
- Liu, C., Bao, X., Zhang, H., Zhang, N., Hu, H., Zhang, X., & Yan, M. (2023). Improving ChatGPT prompt for code generation. *arXiv*. <https://doi.org/10.48550/arXiv.2305.08360>
- Liu, Y., Deng, G., Xu, Z., Li, Y., Zheng, Y., Zhang, Y., Zhao, L., Zhang, T., & Liu, Y. (2023c). Jailbreaking ChatGPT via Prompt Engineering: An empirical study. *arXiv (Cornell University)*. <https://doi.org/10.48550/arxiv.2305.13860>
- Meskó, B. (2023). Prompt engineering as an important emerging skill for medical professionals: tutorial. *Journal of Medical Internet Research*, 25, e50638. <https://doi.org/10.2196/50638>
- Mondal, S., Bappon, S. D., & Roy, C. K. (2024). Enhancing user interaction in ChatGPT: Characterizing and consolidating multiple prompts for issue resolution. *Proceedings of the 21st International Conference on Mining Software Repositories (MSR '24)*, 222–226. <https://doi.org/10.1145/3643991.3645085>
- Mnguni, N., Nkomo, N., Maguraushe, K., & Mutanga, M. (2024). An experimental study of the efficacy of prompting strategies in guiding ChatGPT for a computer programming task. *Journal of Information Systems and Informatics*, 6(3), 1346–1359. <https://doi.org/10.51519/journalisi.v6i3.783>
- Mungoli, N. (2023). Exploring the synergy of prompt engineering and reinforcement learning for enhanced control and responsiveness in Chat GPT. *Journal of Electrical and Electronic Engineering*, 2(3), 201–205. <https://doi.org/10.33140/jeee.02.03.02>
- Park, D., An, G.-T., Kamyod, C., & Kim, C. G. (2024). A study on performance improvement of prompt engineering for generative AI with a large language model. *Journal of Web Engineering*, 22(8), 1187–1206. <https://doi.org/10.13052/jwe1540-9589.2285>
- Park, J., & Choo, S. (2024). Generative AI prompt engineering for educators: Practical strategies. *Journal of Special Education Technology*, 40(3). Advance online publication. <https://doi.org/10.1177/01626434241298954>
- Pehlivanoğlu, M. K., Syakura, M. A., & Duru, N. (2023). Enhancing paraphrasing in chatbots through prompt engineering: A comparative study on ChatGPT, Bing, and Bard. *2023 8th International Conference on Computer Science and Engineering (UBMK)*, 432–437. <https://doi.org/10.1109/UBMK59864.2023.10286606>
- Samsami, R. (2024). Optimizing the utilization of generative artificial intelligence (AI) in the AEC industry: ChatGPT prompt engineering and design. *CivilEng*, 5(4), 971–1010. <https://doi.org/10.3390/civileng5040049>
- Sikha, V. K., Siramgari, D., & Korada, L. (2023). Mastering prompt engineering: Optimizing interaction with generative AI agents. *Journal of Engineering and Applied Sciences Technology*, 2023(5), Article E117. [https://doi.org/10.47363/JEAST/2023\(5\)E117](https://doi.org/10.47363/JEAST/2023(5)E117)
- Sinha, R., Poosarla, H., Fu, H., Suen, A., Gandhi, A., Lo, V., Avigad, L., Senthilkumar, H., Chugh, H., & Subramanian, K. (2023). Statistical analysis of bias in ChatGPT using prompt engineering. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 11(6). <https://doi.org/10.22214/ijraset.2023.53885>

- Vemprala, S. H., Bonatti, R., Bucker, A., & Kapoor, A. (2023). ChatGPT for robotics: Design principles and model abilities. *IEEE Access*, 12. <https://doi.org/10.1109/ACCESS.2024.3387941>
- Viswanathan, N. P. S. (2025). Prompt Engineering for Conversational AI Systems: A Systematic Review of Techniques and Applications. *International Journal of Scientific Research in Computer Science Engineering and Information Technology*, 11(1), 733–741. <https://doi.org/10.32628/cseit25111276>
- Wang, M., Wang, M., Xu, X., Yang, L., Cai, D., & Yin, M. (2024). Unleashing ChatGPT's power: A case study on optimizing information retrieval in flipped classrooms via prompt engineering. *IEEE Transactions on Learning Technologies*, 17, 629–641. <https://doi.org/10.1109/TLT.2023.3324714>
- Wang, L., Chen, X., Deng, X., Wen, H., You, M., Liu, W., Li, Q., & Li, J. (2024). Prompt engineering in consistency and reliability with the evidence-based guideline for LLMs. *Npj Digital Medicine*, 7(1). <https://doi.org/10.1038/s41746-024-01029-4>
- White, J., Fu, Q., Hays, S., Sandborn, M., Olea, C., Gilbert, H., Elnashar, A., Spencer-Smith, J., & Schmidt, D. C. (2023). A prompt pattern catalog to enhance prompt engineering with ChatGPT. *arXiv (Cornell University)*. <https://doi.org/10.48550/arxiv.2302.11382>
- White, J., Hays, S., Fu, Q., Spencer-Smith, J., & Schmidt, D. C. (2023). ChatGPT prompt patterns for improving code quality, refactoring, requirements elicitation, and software design. *arXiv*. <https://doi.org/10.48550/arXiv.2303.07839>
- Woo, D. J., Wang, D., Yung, T., & Guo, K. (2024). Effects of a prompt engineering intervention on undergraduate students' AI self-efficacy, AI knowledge and prompt engineering ability: A mixed methods study. *arXiv*. <https://doi.org/10.48550/arXiv.2408.07302>
- Wu, C., Yin, S.-K., Qi, W., Wang, X., Tang, Z., & Duan, N. (2023). Visual ChatGPT: Talking, drawing and editing with visual foundation models. *arXiv*. <https://doi.org/10.48550/arXiv.2303.04671>
- Wu, X., & Zhang, B. (2024). ChatGPT promotes healthcare: Current applications and potential challenges. *International Journal of Surgery*, 110(1), 606–608. <https://doi.org/10.1097/JS9.0000000000000802>
- Velásquez-Henao, J. D., Franco-Cardona, C. J., & Cadavid-Higuaita, L. (2023). Prompt engineering: A methodology for optimizing interactions with AI-language models in the field of engineering. *DYNA*, 90(230), 9–17. <https://doi.org/10.15446/dyna.v90n230.111700>
- Zuccon, G., & Koopman, B. (2023). Dr. ChatGPT, tell me what I want to hear: How prompt knowledge impacts health answer correctness. *arXiv*. <https://doi.org/10.48550/arXiv.2302.13793>

Virtual Reality vs. Traditional Online Learning: A Comparative Review on Engagement and Retention

Abstract

Virtual Reality (VR) is increasingly considered a game-changer in education today, due to its ability to create immersive and interactive learning spaces. This literature review seeks to evaluate the efficacy of learning based on VR compared to standard online approaches, emphasizing student engagement, retention of knowledge, and experiential learning. In the course of this review, over 20 peer-reviewed articles published between 2020 and 2025 were sourced, screened, and critically evaluated against academic databases such as Google Scholar, ScienceDirect, and IEEE Xplore. The selected studies were coded thematically according to relevance to engagement, retention, and comparative impacts, and findings were synthesized for pattern and inconsistency identification. According to the review, VR improves student understanding through visualization, improves motivation and engagement through interactivity, and facilitates a more profound understanding of abstract or complex concepts. Most of the studies further highlight the ability of VR to mirror real-world environments, with experiential learning experiences being challenging to achieve under standard online platforms. Conversely, limitations of limited access to VR technology, high initial setup costs, and physical discomfort due to extended usage were also reported. The implications of embracing VR cut across technology, economics, society, environment, and policy, with room for cost-effective, equitable, and sustainable learning approaches. Institutions and stakeholders are recommended to invest in infrastructure, instructor capacity building, and inclusive policies to ensure responsible and scaled-up adoption of VR in future learning systems.

Keywords: virtual reality; immersive learning; literature review; education technology; student engagement

INTRODUCTION

Integrating Virtual Reality (VR) technologies into learning practices has been one of the main innovations in modern learning environments. Virtual Reality (VR) refers to computer-generated simulations that create immersive experiences, allowing users to interact with virtual worlds as if they existed in reality (Farsi et al., 2021). In online learning, the widespread use of digital platforms has necessitated exploring how emerging technologies like VR can facilitate remote learning by closing the theory-practice gap. Online learning has been a significant mode of delivery, especially over the last decade, as it is more accessible and convenient. Usually, it lacks the experiential components of a face-to-face classroom environment (Tan et al., 2022). Conversely, traditional learning practices, such as lectures, texts, and static materials, usually need a face-to-face experience and have been faulted for failing to deliver engaging experiences and to leverage the full potential of modern

technology to make the learning environment more interactive (Soliman et al., 2021; Tan et al., 2022). Therefore, the need to introduce VR to make learning environments more interactive, engaging, and practical has increased, especially in fields like engineering and architecture, where spatial and visual knowledge is the norm (Soliman et al., 2021; Tan et al., 2022). The application of VR in learning has also sparked a broader debate on the future of learning environments. Evidence indicates that public perception regarding VR in learning is becoming more positive, with higher acceptance among teachers and learners. This excitement suggests that VR technologies will have a decisive impact on the future of learning since they can provide more interactive, immersive, and efficient learning experiences that prepare students better to deal with the needs of the modern workplace (Lampropoulos et al., 2022). As such technologies advance in this regard, the likelihood of the effect of VR on learning, specifically on enhancing engagement, retention, and conventional approaches to learning, becomes clearer.

Despite the increasing body of literature supporting the educational advantages of VR, the research landscape continues to exhibit gaps and inconsistencies regarding its practical implementation and impact on learning outcomes. Several studies have highlighted VR's capacity to boost engagement and comprehension (Hamilton et al., 2020; Anjos et al., 2022), yet others point out the technological barriers and lack of empirical longitudinal evidence as hindrances to its full integration in standard curricula. Furthermore, while many scholars praise VR for its immersive potential, few have investigated how its use compares to traditional online learning methods regarding student participation and knowledge retention over time. This absence of comparative analysis poses a significant problem for institutions considering a shift toward VR-based instruction. The lack of standardized measures and tests also causes divergence in reported outcomes. For instance, research conducted by Rahman et

al. (2024) and Kalatian & Farooq (2021) presents evidence of increased interaction in VR-enhanced classrooms. Evidence indicates cognitive overload and loss of novelty effect that can hinder long-term gains. Thus, exploring whether VR benefits can endure and be measured in various educational environments and communities is paramount.

The primary aim of this research is to examine the effect of integrating virtual reality in online learning, particularly on student participation and knowledge retention. It seeks to determine if virtual reality can offer more advantages over traditional online learning procedures through more interactive and engaging learning processes. Based on the gaps found in the literature, the study will investigate measurable outcomes to identify the effectiveness of VR-based learning environments. Also, through comparing levels of engagement and retention findings between virtual reality and conventional online platforms, the study aims to present empirical findings that can guide decision-making in educational technology. Thus, this paper investigates how virtual reality enhances learner interest and information retention as a foundation for potential improvements in digital instructional methods.

METHOD

The Design

This literature review explores the impact of virtual reality (VR) on distance learning, student engagement, and learning. The researchers used thematic synthesis to conduct this review. The studies were determined, investigated, and categorized based on prominent research purposes. The process involved gathering recent peer-reviewed papers from reliable academic databases, examining how each study had approached the topic, and clustering findings based on emerging patterns and themes. Using this approach, the researchers

explored the benefits and strengths of VR in learning, as well as contradictions, loopholes, and issues still observed in the literature.

Research Objectives

This literature review aims to achieve the following specific objectives: (1) to examine the impact of virtual reality on student engagement in online learning environments, (2) to assess the effectiveness of virtual reality in enhancing knowledge retention among students, and (3) to compare student participation and interaction levels in virtual reality-based learning versus traditional online learning methods.

Retrieving and Selecting Pertinent Literature

To verify the validity and usability of the review, the authors employed peer-reviewed journal articles from 2020 to 2025. Sources were acquired from reputable academic databases such as Google Scholar, IEEE Xplore, ScienceDirect, and other scholarly databases. Search terms employed were phrases in combination, such as "virtual reality in education," "student engagement," "VR learning outcomes," "knowledge retention," and "traditional online learning."

A first set of articles was filtered based on relevance to research goals. Studies that used virtual reality within the classroom or lacked comparative figures compared to conventional online learning were excluded. Twenty primary articles were chosen that specifically studied VR within the context of education in online environments.

Synthesizing the Literature

The selected papers were read and grouped thematically according to research

objectives. They were read individually for significant results, methodology, and conclusions. The synthesis presents both consistent results and variations among studies. Some favored the application of VR as a method of improving learning achievement, while others reported limitations, such as access issues, high implementation costs, and variation in long-term retention. The results were synthesized in tables of outcomes according to each objective— student engagement, knowledge retention, and comparative effectiveness between VR-based learning and traditional online learning to provide a clear summary of the information.

Table 1. Table synthesis about the impact of virtual reality on student engagement in online learning environments.

Author	Impact of virtual reality on student engagement
Yang, Zhang, Hu, Yang, Chen, Shan & Li, (2024)	The study provides that pre-training in VR has been a subject of interest in enhancing practical skills for college students in science and engineering education, as students positively impacted their learning by reducing their' cognitive load to a certain extent.
Farsi, Yusof, Romli, Tawafak, Malik, Jabbar, & Rsuli (2021)	The study emphasizes that virtual reality (VR) applications provide an interactive, immersive learning experience that enhances student engagement and overall performance. By creating realistic and interactive environments, VR fosters active participation and deeper involvement in the learning process.
Feng, González, Amor, Spearpoint, Thomas, Sacks, Lovreglio & Cabrera-Guerrero, (2020)	This study innovates the application of IVR SGs for earthquake readiness training, demonstrating their efficacy in enhancing behavioral responses and evacuation readiness.
Anjos, F. E. V. d., Martins, A. d. O., Rodrigues, G. S., Sellitto, M. A., & Silva, D. O. d. (2024)	The study found that VR-based learning increased students' engagement compared to traditional teaching methods. It captured students' attention, making them more interactive and the learning process more stimulating.
Arbesser-Rastburg, Safikhani, Gustin, Hopfe, Schweiger & Pirker (2024)	Project Beyond shows the versatility of VR escape room games to maximize learning involvement in building energy simulations. It incorporates puzzles, educational information, and interactive mentorship to generate a rich, immersive, and participatory educational experience. The research shows the possibilities of extending gamified VR settings to the education sector beyond gaming, by breaking down involved issues into a playable form.
Hamed-Ahmed, Ramil-López, Fraga-Lamas, & Fernández-Caramés (2025)	The study found that an XR simulator (Extended Reality simulation, a simulator made for maritime emergency training) enhances user engagement by creating an immersive environment that simulates real-world fire emergencies.
Hamilton, McKechnie, Edgerton, E., & Wilson, C. (2020).	The review found that I-VR can potentially enhance student engagement, particularly in complex and spatially demanding subjects.
Hussain, S., Meehan, K., & Qadir, J.	This study has found that VR helps to enhance the motivation and

(2024)	participation of the students, which helps to have improved outcomes.
Hyeonju Lee, Donghyun Woo, and Sunjin Yu (2022)	The study of VR education is experience-based, and students are motivated by their initiative. Along with preventing issues and disasters that occur during actual training, virtual reality training may also lower expenses for the service.
Kalatian, A., & Farooq, B. (2021).	This study investigates the structure and design of pedestrians on different roads to take training in virtual reality to reduce real-world risk.
Misirliis, N., Nikolaidis, Y., & Sabidussi, A. (2023)	The study has found that VR enhances the students' engagement by creating immersive experiences that help improve emotional, cognitive, and involvement.
Onu, P., Pradhan, A., & Mbohwa, C. (2023)	The study has found the impacts of the metaverse integrating augmented and virtual reality technology on education, highlighting its potential to offer personalized and adaptive learning experiences.
Rafael Padilla Perez, Özgür Keleş Ph.D. (2025)	This study compares comprehensively, limited, and non-embodied virtual learning environments across various engineering disciplines. The created VR framework offers a practical, realistic experience that improves student involvement and engagement.
Rahman, H., Wahid, S. A., Ahmad, F., & Ali, N. (2024).	The study found that students were more participative in a virtual chemistry laboratory because it is interactive and more engaging. How students can easily visualize and manipulate chemistry concepts makes learning more interesting and captivating.
Daza, Shengkai, Morales, Fierrez & Nagao (2025)	SMARTe-VR applies adaptive learning with virtual reality and biometrics, enabling learners to be monitored in real-time and receive customized feedback. Merging facial biometrics, learning metadata, and adaptations with AI provides more learner engagement and teacher ability. In addition, having a public dataset grounded in VR inspires future work on adaptive learning, AI modeling, and learning analytics.
Soliman, Pesyridis, Dalaymani-Zad, Gronfula, & Kourmpetis (2021)	The study highlights that VR fosters active student engagement by offering an immersive, student-centered learning experience.
Souza, Maciel, Nedel, Kopper, Loges & Schlemmer (2020).	The study found that students who use the VR application tend to have a heightened sense of presence, which increases their engagement during the learning process.
Tan, Xu, Li, & Chen (2022)	Integrating AR/VR technologies into education has the potential to transform student engagement by offering immersive, interactive, and visually enhanced learning experiences. Studies indicate that VR-based learning environments increase student motivation and participation, particularly in fields like architecture, engineering, and construction (AEC).
Akdag, M. T., Wahl, N., Pees, B. T., Sauer, N. R., & Lugert, J. A. (2024)	The study has proved that the metaverse can also be used to visualize hard-to-reach structures during operations. They can help to guarantee that the patient receives better care. The metaverse can be used to create virtual operating rooms. Medical students can operate on simulated patients there.
Wang, Chen, & Li, (2023).	The evaluation determined that VR significantly increases student engagement by providing a more interactive and immersive learning

experience.

Table 2. Table synthesis about the effectiveness of virtual reality in enhancing knowledge retention among students.

Author	Effectiveness of virtual reality in enhancing knowledge retention
Yang, Zhang, Hu, Yang, Chen, Shan & Li, (2024)	The study has revealed that VR had a moderate effect on practical skills, with an effect size of 0.477. Furthermore, the disciplinary category emerged as a significant moderator of the effect size, revealing that it differed significantly when comparing medical, engineering, science, and agronomy students, notably among different instructional approaches.
Farsi, Yusof, Romli, Tawafak, Malik, Jabbar, & Rsuli (2021)	The findings highlight that VR applications contribute significantly to education by improving learning efficiency and effectiveness. VR allows students to experience and visualize complex concepts, which enhances their understanding and retention of information.
Feng, González, Amor, Spearpoint, Thomas, Sacks, Lovreglio & Cabrera-Guerrero, (2020)	This study provides insights into the effectiveness and applicability of IVR SGs to improve individuals' preparedness for indoor earthquakes and post-earthquake evacuation.
Anjos, F. E. V. d., Martins, A. d. O., Rodrigues, G. S., Sellitto, M. A., & Silva, D. O. d. (2024).	The findings determined that the students who use VR demonstrated a better knowledge retention and understanding of complex concepts, with an average of 5.2841, compared to those students in the control group, who got an average of 4.3988.
Arbesser-Rastburg, Safikhani, Gustin, Hopfe, Schweiger & Pirker (2024)	The study reveals that the VR escape room game engages user interest, usability, and curiosity when acquiring energy simulation concepts. The tutorial level effectively exposes users to naturalistic interactions, and the core game encourages players to apply knowledge via problem-solving. There is a high task load, but the game's interactive nature triggers active learning and enhances concept retention.
Hamed-Ahmed, Ramil-López, Fraga-Lamas, & Fernández-Caramés (2025)	The study proved the effectiveness of the XR simulator(Extended Reality simulation) in improving task performance by reducing task completion times by 14.18% to 32.72% through task tracking and navigation guidance.
Hamilton, McKechnie, Edgerton, E., & Wilson, C. (2020).	The review highlights that I-VR provides a unique advantage in procedural learning, where students can repeatedly practice tasks in a controlled virtual environment. This repeated exposure enhances skill acquisition and reinforces learning, leading to better retention.
Hussain, S., Meehan, K., & Qadir, J. (2024)	The study has found that VR allows the learners to engage more, which helps to improve their understanding.
Hyeonju Lee, Donghyun Woo, and Sunjin Yu (2022)	The study reveals that the cost of the equipment and the difficulty of implementation have held back VR education from becoming widely used, even though it is effective because it enables teachers to immerse students in learning situations that are challenging to experience in real life.
Kalatian, A., & Farooq, B. (2021).	This study aims to eliminate real-world risk with the upcoming technologies on roads to improve the vital importance of rethinking

	and reassessing pedestrian behavior using virtual reality.
Misirlis, N., Nikolaidis, Y., & Sabidussi, A. (2023)	The study has found that VR develops the students' knowledge by providing immersive and interactive learning experiences.
Onu, P., Pradhan, A., & Mbohwa, C. (2023)	The study has found that the metaverse can enhance students' knowledge and understanding, allowing them to engage with content more meaningfully.
Rafael Padilla Perez, Özgür Keleş Ph.D. (2025)	This study illustrates that virtual reality environments facilitated knowledge recall and comprehension through interactive, experiential learning mechanisms. The scalability of VR makes it possible to make engineering education low-cost and accessible, and pre-/post-test scores confirm that embodied VR module students perform higher on tests than students on conventional paths.
Rahman, H., Wahid, S. A., Ahmad, F., & Ali, N. (2024).	The findings showed that students who used the virtual chemistry laboratory remembered lessons better, and it helped them understand and recall complex topics more effectively.
Daza, Shengkai, Morales, Fierrez & Nagao (2025)	The research illustrates how facial biometrics and AI-powered analysis enhance knowledge retention and adaptive learning to a great extent. Adaptive content tweaks, SMARTe-VR's Auto QA tool, and interactive tools result in an improved understanding detection model, 85% monitoring of students' knowledge. This illustrates VR's capability to improve learning outcomes by providing a personalized, adaptive learning environment.
Soliman, Pesyridis, Dalaymani-Zad, Gronfula, & Kourmpetis (2021)	VR's cognitive and pedagogical benefits contribute to improved student performance, grades, and subject comprehension. By creating realistic simulations, VR enables students to engage in experiential learning, leading to better knowledge retention.
Souza, Maciel, Nedel, Kopper, Loges, and Schlemmer (2020).	The findings showed that VR can enhance knowledge retention regarding complex information, as the experimental group showed significant improvements compared to the control group.
Tan, Xu, Li, & Chen (2022)	Research suggests that VR applications support knowledge retention by providing hands-on, experiential learning that mimics real-world scenarios. VR's ability to simulate practical applications in the AEC industry, such as structural analysis and safety training, reinforces theoretical concepts through interactive experiences.
Akdag, M. T., Wahl, N., Pees, B. T., Sauer, N. R., & Lugert, J. A. (2024)	The study proves that one can access the body in the metaverse and closely examine the structures. The primary benefit of these representations is that they enable medical students to observe the body in action by emulating its functions. Also, a 3d model that allows for anything to be made, improving understanding and providing students with a better concept.
Wang, Chen, & Li, (2023).	The research found that VR helped students retain information more effectively by allowing them to visualize and interact with concepts in a stimulated environment.

Table 3. Table synthesis about the comparison of student participation and interaction levels in virtual reality-based learning versus traditional online methods.

Author	Virtual reality-based learning versus traditional online
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methods

- Yang, Zhang, Hu, Yang, Chen, Shan & Li, (2024) The study also provides the practice approach of combining traditional learning methods and practical VR exercises.
- Farsi, Yusof, Romli, Tawafak, Malik, Jabbar, & Rsuli (2021) The review suggests that VR has a notable advantage over traditional online learning methods by offering a more engaging and interactive experience. Traditional online methods often lack immersive features, making them less effective in capturing students' attention and fostering active participation. In contrast, VR applications provide real-time simulations, enhancing participation and interaction levels.
- Feng, González, Amor, Spearpoint, Thomas, Sacks, Lovreglio & Cabrera-Guerrero, (2020) Instead of using a restricted number of resources to teach people about earthquakes traditionally, this study uses IVR SG to provide more accurate information about the risks that could occur during an earthquake.
- Anjos, F. E. V. d., Martins, A. d. O., Rodrigues, G. S., Sellitto, M. A., & Silva, D. O. d. (2024). The experiment concluded that the interactive elements of VR encouraged students to have higher participation, leading to a more active learning experience compared to traditional online methods.
- Arbesser-Rastburg, Safikhani, Gustin, Hopfe, Schweiger & Pirker (2024) Unlike conventional learning methods, this VR escape room is a more interactive and immersive method of learning energy simulation subject matter. Unlike passive learning, game-based learning actively engages users in problem-solving through visual and audio cues to facilitate learning. While conventional learning is non-interactive, in this research, VR escape rooms can potentially enhance learning outcomes through more interactive and immersive learning.
- Hamed-Ahmed, Ramil-López, Fraga-Lamas, & Fernández-Caramés (2025) The study shows that virtual reality-based learning provides a higher student participation through real-time emotion monitoring and feedback compared to traditional online methods.
- Hamilton, McKechnie, Edgerton, E., & Wilson, C. (2020). The review found that studies indicate that I-VR facilitates higher levels of participation and interaction compared to traditional online methods. Virtual environments allow students to engage in experiential learning, providing opportunities for skill acquisition and real-world application.
- Hussain, S., Meehan, K., & Qadir, J. (2024) The study has found that using virtual reality in education increases the students' interaction levels compared to traditional education.
- Hyeonju Lee, Donghyun Woo, and Sunjin Yu (2022) The study revealed that the VR metaverse system is a solution to compensate for the shortcomings of existing remote communication methods. In the proposed system, users can immerse themselves and interact with virtual objects. Since all user actions are performed in a virtual environment, high-cost and high-risk scenarios can be simulated safely, and complex and challenging training can be practiced repeatedly.
- Kalatian, A., & Farooq, B. (2021). The study may be more careful and unlikely to have more risk than traditional training in a real-world environment.
- Misirlis, N., Nikolaidis, Y., & Sabidussi, A. (2023) The study has found that VR-based learning helps to enhance the participation of the students compared to traditional online methods.
- Onu, P., Pradhan, A., & Mbohwa, C. (2023) The study has found that the metaverse helps to increase and develop the participation level of the students through creating an immersive and engaging environment compared to traditional online

learning.

- Rafael Padilla Perez, Özgür Keleş Ph.D. (2025) This study highlights the benefits of hands-on engagement over passive observation by comparing interactive and non-interactive VR learning. Students who actively interacted with virtual objects showed higher engagement and better learning outcomes than those who only watched 3D video demonstrations, proving that fully immersive VR enhances participation and comprehension more effectively than traditional online methods.
- Rahman, H., Wahid, S. A., Ahmad, F., & Ali, N. (2024). The study determined that students in the virtual environment actively participated in experiments and discussions, unlike in traditional online classes, where interaction is often limited. The immersive features of the metaverse encouraged students in collaboration and hands-on learning.
- Daza, Shengkai, Morales, Fierrez & Nagao (2025) Unlike traditional e-learning, SMARTe-VR is more interactive and responsive since it dynamically adjusts content based on student interest and comprehension. Unlike static web-based programs, the platform monitors real-time biometrics to gauge learning states, providing more accurate feedback and customized learning paths. The synergy of real-time calibration and AI-generated feedback differentiates it from traditional online learning.
- Soliman, Pesyridis, Dalaymani-Zad, Gronfula, & Kourmpetis (2021) VR enhances student participation and interaction levels compared to traditional online learning methods. By offering a more engaging and hands-on approach, VR allows students to actively interact with their learning environment, which is superior to passive methods such as lectures or pre-recorded lessons.
- Souza, Maciel, Nedel, Kopper, Loges & Schlemmer (2020). The study observed that VR learning encouraged students to participate and collaborate more. The hands-on virtual assembly of the brain model allowed the students to interact and discuss more, making it more effective as a learning experience than traditional methods.
- Tan, Xu, Li, & Chen (2022) Compared to traditional online education, VR-based learning offers a more immersive and engaging experience. Students in VR settings can interact with complex structures, conduct virtual experiments, and participate in impossible training simulations in conventional online learning.
- Akdag, M. T., Wahl, N., Pees, B. T., Sauer, N. R., & Lugert, J. A. (2024) The study proves that since no patients are at risk, there is also a better opportunity to learn from one's mistakes. Nowadays, to rehearse an operation, actual patients are needed. The metaverse can alter this, and that contributes significantly to improving medical education. Also, the metaverse's virtual reality technology allows the projection of animated, three-dimensional human part representations, such as an animated heart.
- Wang, Chen, & Li, (2023). The study concluded that VR-based learning encouraged students to have a higher level of participation and interaction. It made them collaborate more and engage in discussions compared to traditional online methods.

DISCUSSIONS

Impacts of Virtual Reality on Student Engagement

As synthesized in Table 1, virtual reality has been implemented for different purposes, like entertainment and education. The utilization of technology has been the ladder to innovate this kind of visual setup. Recently, one of the experiences was online learning due to Covid-19 where everyone try to connect with others via online platforms using gadgets like phones and laptops. In relation to this, the use of virtual reality is more advanced and can be helpful to maximize the engagement of students in learning online. People have their preferences regarding learning, but the majority are more on the entertainment side of learning. Students' engagement will improve if they are exposed to more advanced technology. While virtual reality can enhance student engagement in learning, it may not always lead to fully developing their skills or potential. Limiting the students' capability to grow with other people might affect their skills. In connection with this, the use of virtual can be helpful to some students in increasing their learning engagement. Areas like engineering and other logical and theoretical things that require less communication and physical activities are the most suitable for this type of learning. Simulation of different scenarios is viable, but its use throughout learning can be off for social and athletic students. Virtual reality is a handful of practical activities that require real-time situations. Using virtual reality can help increase students' engagement in learning, but changing the whole education setup to virtual reality might be irrelevant. Changing the entire education setup to virtual reality might affect the emotional aspects of the students. Being engaged in a virtual world can limit how they see and predict emotions coming from others. The connection build upon during direct communication differs when in virtual reality. Prolonged use of virtual reality may affect a student's social interactions and emotional aspects. All of these are assumptions based on standard knowledge of virtual reality.

Depending on the collected data, several categories or classifications have been

developed from the merged literature review. These categories draw attention to how virtual reality (VR) affects student involvement in academic environments. Across several studies, the effect of virtual reality on students' participation has always been noted as good and advantageous. By offering immersive and interactive experiences, VR raises learner's interest, motivation, and active involvement in learning activities according to the literature. Moreover, it promotes a more pleasurable and significant learning atmosphere and helps to grasp complex ideas better. The impacts revolve around risk training, general education, and games. The risk training includes the simulation of real-time events in an emergency. Simulation of emergency plans like fire and earthquakes enhances students' engagement, behavioral response, and evacuation readiness (Feng et al., 2020). This can mean that virtual reality benefits the students' engagement and supports their readiness for different scenarios they encounter. The simulation of these events can help the students become aware of what to do during calamities to avoid risk. Since virtual reality simulates hard-to-reach structures, it can create virtual operating rooms where the medical students can guarantee the best actions they can perform during operations, which makes them more engaged in their respective roles (Akdag et al., 2024). Virtual reality can benefit students in chemistry, architecture, engineering, science, and medicine (Tan et al., 2022). Virtual reality has proven to enhance students' motivation in these fields. The fields require a deep understanding of the concepts that need a proper real-world scenario. Virtual reality supports this by creating a realistic environment for an immersive experience during practical activities.

Since virtual reality (VR) encourages students' emotional, cognitive, and behavioral aspects of learning, its benefits reflect student engagement. On the other hand, virtual reality generates engrossing and fascinating settings that could capture students' curiosity and excitement, strengthening their emotional engagement in the learning process. In addition,

virtual reality creates a virtual universe where material is made artificially and where there is no need for physical objects or a location to carry out a specific scenario. The decreased cost gradually impacts Students' emotional well-being (Hyeonju et al., 2022). In terms of cognition, VR aids students in comprehending complex ideas by enabling them to see and engage with material in three dimensions, which improves understanding and retention. The interactive character of virtual reality promotes active involvement in terms of behavior because students are more inclined to explore, experiment, and maintain concentration throughout lectures. Their increased drive results in improved engagement throughout the learning process. These elements foster a deeper and more meaningful interaction with the topic, advancing skill development and results. By enabling the creation of games that go beyond pure fun to meet educational goals, virtual reality (VR) transforms the gaming business. Virtual reality can be used to produce educational games that effectively pass along key concepts and skills by imitating real-life scenarios and interactive settings. By utilizing the inherent motivation and enthusiasm derived from playing games, students become increasingly involved and active contributors to their educational journey. The engaging qualities of virtual reality improve involvement, enabling learners to experience lessons in a more real and significant manner. When educational games are used with virtual reality, they can provide a deep, engaging, and very interactive learning experience, making education more efficient, fun, and unforgettable (Georg et al., 2024).

Effectiveness of virtual reality in enhancing knowledge retention among students

As synthesized in Table 2, the use of Virtual Reality in education has proven that it is highly effective for helping students to visualize and encourage them to participate and listen to the lessons, and understand better the subjects they study by the use of Virtual Reality by

immersing the learners in interactive and realistic environments. It brings abstract or complex concepts to life, making them easier to grasp and remember. One of the research studies shows the effectiveness of using VR. By involving gaming mechanisms, participants can interact with objects and environments that assist them to focus on learning content and feedback to enhance learning outcomes (Bellotti et al., 2013). The effectiveness of using VR is excellent for students to strengthen comprehension and make their learning more engaging and enjoyable. Then the use of VR for fire drills is effective for students and also for the trainees because in the research they said that adding the component of emotional control within simulated procedures enhances realism, considering real fire emergencies certainly would induce emotions like fear and stress, which could affect performance (Musaab et al., 2025). As a result, students are more likely to participate because of the visuals of using virtual reality for education, so they actively participate in lessons and stay focused, as the dynamic nature of VR captures their attention and curiosity. According to Maturana and Varela's (1987) autopoiesis theory, when the player comes into contact with VR, the relationships they will have will emerge from the relationship with the environment in question and, from this, the process of learning and cognition. That said, the use of VR is very effective. Still, other users do not use VR because of problems with their eyes or because they feel dizzy from using VR. One of the researchers said that our trial study showed that continuing experiments for over 30 minutes causes fatigue among participants. Thus, the results may be affected (Kalatian et al., 2020). So many subjects can be used in virtual reality settings, one of which can be used in VR is Chemistry. Chemistry is often regarded as one of the most challenging and least popular subjects among school students. Among many reasons, one is that chemistry consists of numerous abstract and obscure concepts, such as chemical bonding, which makes it challenging for students to comprehend

and visualize (Stroumpouli et al., 2022). Researchers used VR to visualize and provide solutions through technology to address the difficulty of understanding Chemistry. It provides an immersive environment allowing students to access the virtual classroom remotely (Edwards et al., 2019; Pan et al., 2022; Ververidis et al., 2022; Castaneda et al., 2018). Overall, virtual reality significantly improves student learning by creating immersive and interactive environments that make complex concepts easier to understand. It boosts engagement, encourages participation, and helps students stay focused, leading to a deeper and more meaningful educational experience.

Virtual Reality in education has gained increasing attention because it improves students' engagement, learning outcomes, and comprehension. The research also aims to evaluate the effectiveness of Virtual Reality as a modern educational tool by testing the impacts on students' understanding, participation, knowledge retention, and overall learning experiences towards a range of academic subjects. Virtual Reality makes the creation of immersive and interactive learning environments possible, which can make it go beyond the capabilities of traditional online teaching methods. It facilitates a deeper cognitive processing and understanding by allowing the students to explore a complex topic through direct interactions and simulations. For example, subjects like chemistry help students visualize and experience more molecular structures and simulate some chemical reactions through Virtual Reality by creating a virtual laboratory setting, which has been shown to improve the comprehension and retention of any scientific concepts (Yang et al., 2024). Another research suggests that Virtual Reality can enhance the effectiveness of education through hands-on and experiential learning. It enables the students to engage in immersive environments that closely replicate the real-life scenarios that can help reinforce the students' theoretical knowledge through a practical application. For example, virtual reality is helpful in the

architecture, engineering, and other construction industries in simulating complex tasks or activities like structural analysis and safety training. These simulations can also deepen the students' understanding and allow them to apply each concept interactively, leading to improved memory retention and comprehension (Tan et al., 2022). Virtual Reality in educational contexts shows how these technologies can bridge a gap between an abstract theory and a real-world practice that supports more effective learning outcomes. Moreover, further research shows how virtual reality can improve the effectiveness of education when combined with advanced technologies like facial biometrics and AI-driven analytics. For example, SMARTe-VR (Student Monitoring and Adaptive Response Technology for e-learning in Virtual Reality) integrates adaptive content delivery and an automatic question and answer tool to test and respond to the students' comprehension in real time. With up to 85% accuracy in monitoring the students' understanding, this system enables a dynamic adjustment in educational content that makes the learning process more personalized and responsive. An adaptive learning environment keeps the students more engaged and provides support that contributes to better knowledge and academic performance (Daza et al., 2025). This shows how immersive and intelligent Virtual Reality systems can transform traditional online education into a more effective and student-centered experience that strengthens understanding and engagement through real-time feedback, adaptive learning, and interactive simulations.

Virtual reality-based learning versus traditional online methods

As synthesized in Table 3, VR is better at engaging students with interactive, responsive, and experiential learning. These findings bring about a paradigm shift in digital teaching methods, where student engagement is no longer limited to mere attendance and

surface-level participation. As Rahman et al. (2024) discovered in their study of an online virtual chemistry class, students utilizing VR tools had significantly higher degrees of interaction, such as manipulating virtual molecules, initiating group discussions, and actively engaging with assignments. In comparison, the same study established that students in the conventional online format were significantly more passive, often inserting text-based inputs and lacking visual cues to stay fully engaged. The authors of this paper concur that these findings reflect situations they have personally faced in learning environments where conventional online courses are often spoiled by low degrees of learner attentiveness and tardy participation due to the static and asynchronous nature of content delivery.

In favor of this position, Anjos et al. (2022) added that VR-based learning environments triggered more frequent and active participation from the students compared to traditional online learning. According to their study, the users of VR modules were much more likely to engage in discussions and problem-solving activities than in video-based online learning. Wang et al. (2023) further claimed that VR technologies not only raised the interest of students but also initiated cooperation from students, especially in learning STEM. The authors of this study quoted that such evidence suggests an increasing demand to review indicators of online learning participation. Traditional participation measures, such as log-ins, forum posts, and assessment submissions, do not suffice. In contrast, virtual reality learning provides more intensive measures such as movement tracking, spoken communication, object manipulation, and immediate feedback. These measures provide a more complete picture of the intensity of student engagement in learning.

The use of immersive environments is also consistent with the cognitive principles of experiential learning. Hamilton et al. (2020) emphasized that immersive VR facilitates procedural and experiential knowledge acquisition, enhancing long-term retention and

increased engagement. Unlike passive viewing of content in traditional online courses, VR allows students to participate in novel construction of knowledge through interaction with virtual objects and environments. In medical school, for instance, students constructing the 3D model of a brain in VR worked more collaboratively. They had more in-depth discussions with peers than students using static textbook content. In accounting for such findings, the authors of this paper propose that one of the inherent advantages of VR is its ability to accommodate kinesthetic and visual learning styles, which are elements too frequently neglected in text-based online courses. Based on classroom experience and teaching practice, it is unsurprising to observe a decline in student interest and minimal communication in traditional remote classes when interaction is limited to typed chats or pre-recorded lectures. In contrast, VR immerses students within the learning environment and transforms them from passive recipients of information into active participants.

Another notable characteristic detailed in the literature is the ability of VR platforms to learn from students' actions. SMARTe-VR, developed by Daza et al. (2025), possessed an emotion and attention sensing feature that used biometrics. It is applied to adjust the content or difficulty level dynamically so that the students remain within their optimal interaction zone. Such adaptive features are lacking in traditional online platforms, where feedback is generic or delayed. The authors of this research value the importance of such real-time feedback since this allows a learning environment that adapts to the student. This aligns with new pedagogical paradigms focused on fostering personalized learning paths. Such individualized instruction is challenging to implement in static environments such as learning management systems (LMS) based on traditional e-learning. The researchers believe adapting content based on real-time performance and emotional states significantly enhances

interaction and contributes to an environment that promotes higher-order learning and sustained attention.

While the advantages of virtual reality (VR)-based learning are undoubtedly attractive, certain limitations must be considered. Despite VR's high degree of interactivity, its adoption in educational institutions is fraught with challenges. These range from the cost, which is high in terms of VR headsets, to the requirement of technical support and unequal access to infrastructure (Lee et al., 2022). Further, not all fields of academic study are equally advantaged by the application of VR. Subject areas focused on abstract concepts or philosophical discussion may not be similarly advantaged by simulated experience. Kalatian and Farooq (2021) also pointed out that while VR can effectively replicate real-world risk situations, it threatens to oversimplify complex social or ethical problems. Despite these concerns, the advantages of VR in fostering participation and interaction are evident across many applied and technical disciplines. In this research, the authors continue to emphasize that these technologies can redefine the future of online education, not merely as a contingency for remote learning, but as a purposeful approach to enhancing the depth and quality of student engagement.

CONCLUSION

Virtual Reality (VR) in education has been a remarkable breakthrough, especially in stimulating students' engagement, deeper knowledge retention, and providing new benefits over conventional online learning. Throughout the reviewed literature, VR consistently proved its ability to develop stimulating and interactive learning experiences that maintain

students' engagement and motivation, particularly in technical and experiential courses. By creating simulated real-world environments, VR enables experiential learning models that allow students to interact more meaningfully with content, optimizing cognitive and affective engagement. Research indicated that VR applications in engineering, science, and medicine enhance conceptual knowledge and enable safe, practical environments to hone hands-on skills. VR also allows active engagement through simulations, 3D models, and real-time feedback, unlike the passive viewing commonly experienced in conventional online learning. Nonetheless, several limitations were observed, such as inequality of access, equipment expenses, and the likelihood of VR-induced fatigue. Despite these issues, the larger implications of VR adoption are encouraging: economically, it provides scalable alternatives to expensive physical resources; socially, it enables more inclusive learning; environmentally, it minimizes physical infrastructure; and from a governance perspective, it requires curriculum reform to enable immersive technologies. In the future, educational institutions should consider VR a valuable and viable part of future-proof learning systems. Investment in infrastructure, content creation, and teacher training needs to be established to make VR-based learning feasible and inclusive. As education continues to transform, VR can revolutionize how students learn and how education is designed, delivered, and experienced.

REFERENCES

- Akdag, M. T., Wahl, N., Pees, B. T., Sauer, N. R., & Lugert, J. A. (2024). Transforming medical professional training: Exploring the metaverse in education. *PACIS 2024 Proceedings (Paper 6)*. Association for Information Systems. https://aisel.aisnet.org/pacis2024/track14_educ/track14_educ/6
- Anjos, F. E. V. d., Martins, A. d. O., Rodrigues, G. S., Sellitto, M. A., & Silva, D. O. d. (2024). Boosting engineering education with virtual reality: An experiment to enhance student knowledge retention. *Applied System Innovation*, 7(3), 50. <https://doi.org/10.3390/asi7030050>
- Arbesser-Rastburg, G., Safikhani, S., Gustin, M., Hopfe, C., Schweiger, G., & Pirker, J. (2024, July 3). Project Beyond: an escape room game in virtual reality to teach building energy simulations. *arXiv*. <https://arxiv.org/abs/2407.02981>

- Daza, R., Shengkai, L., Morales, A., Fierrez, J., & Nagao, K. (2025, January 19). SMARTe-VR: Student monitoring and adaptive response technology for e-learning in virtual reality. *arXiv*. <https://arxiv.org/abs/2501.10977>
- Farsi, G. A., Yusof, A. B. M., Romli, A., Tawafak, R. M., Malik, S. I., Jabbar, J., & Rsuli, M. E. B. (2021). A review of virtual reality applications in an educational domain. *International Journal of Interactive Mobile Technologies (iJIM)*, *15*(22), 99. <https://doi.org/10.3991/ijim.v15i22.25003>
- Feng, Z., González, V. A., Amor, R., Spearpoint, M., Thomas, J., Sacks, R., Lovreglio, R., & Cabrera-Guerrero, G. (2020). An immersive virtual reality serious game to enhance earthquake behavioral responses and post-earthquake evacuation preparedness in buildings. *Advanced Engineering Informatics*, *45*, 101118. <https://doi.org/10.1016/j.aei.2020.101118>
- Hamed-Ahmed, M. H., Ramil-López, D., Fraga-Lamas, P., & Fernández-Caramés, T. M. (2025, March 5). Towards an emotion-aware metaverse: A human-centric shipboard fire drill simulator. *arXiv*. <https://arxiv.org/abs/2503.03570>
- Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2020). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education*, *8*(1), 1–32. <https://doi.org/10.1007/s40692-020-00169-2>
- Hussain, S., Meehan, K., & Qadir, J. (2024). Editorial: Metaverse in education: Opportunities and challenges. *Frontiers in Education*, *9*, 1411841. <https://doi.org/10.3389/educ.2024.1411841>
- Kalatian, A., & Farooq, B. (2021). Decoding pedestrian and automated vehicle interactions using immersive virtual reality and interpretable deep learning. *Transportation Research Part C: Emerging Technologies*, *124*, Article 102962. <https://doi.org/10.1016/j.trc.2020.102962>
- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented reality and virtual reality in education: public perspectives, sentiments, attitudes, and discourses. *Education Sciences*, *12*(11), 798. <https://doi.org/10.3390/educsci12110798>
- Lee, H., Woo, D., & Yu, S. (2022). Virtual reality metaverse system supplementing remote education methods: Based on aircraft maintenance simulation. *Applied Sciences*, *12*(5), 2667. <https://doi.org/10.3390/app12052667>
- Misirlis, N., Nikolaidis, Y., & Sabidussi, A. (2023, November 26). Should I use metaverse or not? An investigation of university students behavioral intention to use MetaEducation technology. *arXiv*. <https://arxiv.org/abs/2311.15251>

- Onu, P., Pradhan, A., & Mbohwa, C. (2023). Potential to use metaverse for future teaching and learning. *Education and Information Technologies*, 29(7), 8893–8924. <https://doi.org/10.1007/s10639-023-12167-9>
- Perez, R. P., & Keleş, Ö. (2025, March 17). Immersive virtual reality environments for embodied learning of engineering students. *arXiv*. <https://arxiv.org/abs/2503.16519>
- Rahman, H., Wahid, S. A., Ahmad, F., & others. (2024). Game-based learning in metaverse: Virtual chemistry classroom for chemical bonding for remote education. *Education and Information Technologies*, 29, 19595–19619. <https://doi.org/10.1007/s10639-024-12575-5>
- Soliman, M., Pesyridis, A., Dalaymani-Zad, D., Gronfula, M., & Kourmpetis, M. (2021). The application of virtual reality in engineering education. *Applied Sciences*, 11(6), 2879. <https://doi.org/10.3390/app11062879>
- Souza, V., Maciel, A., Nedel, L., Kopper, R., Loges, K., & Schlemmer, E. (2020). The effect of virtual reality on knowledge transfer and retention in collaborative group-based learning for neuroanatomy students. In *Proceedings of the 22nd Symposium on Virtual and Augmented Reality (SVR 2020)* (pp. 92-101). <https://doi.org/10.1109/SVR51698.2020.00028>
- Tan, Y., Xu, W., Li, S., & Chen, K. (2022). Augmented and virtual reality (AR/VR) for education and training in the AEC industry: A systematic review of research and applications. *Buildings*, 12(10), 1529. <https://doi.org/10.3390/buildings12101529>
- Wang, Y., Chen, X., & Li, Z. (2023). Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education. *Electronics*, 12(18), 3953. <https://doi.org/10.3390/electronics12183953>
- Yang, C., Zhang, J., Hu, Y., Yang, X., Chen, M., Shan, M., & Li, L. (2024). The impact of virtual reality on practical skills for students in science and engineering education: a meta-analysis. *International Journal of STEM Education*, 11(1). <https://doi.org/10.1186/s40594-024-00487-2>

Social Media in Business: A Review of Its Strengths, Challenges, and Marketing Practices

Abstract

Social media has become a key driver of growth and has changed how businesses build their brands and connect with people. This study examines the advantages, challenges, and strategic approaches of using social media for marketing and business performance. A systematic literature review reviewed 28 research articles published from 2015 to 2024. Relevant studies were chosen from credible databases using specific inclusion criteria, and findings were then thematically synthesized to evaluate insights in social media marketing. The results show that in real-time, social media promotes brand awareness, customer relations, and business outcomes with improved interaction style, influencer branding, and customized content processes. Amid these benefits, businesses experience significant issues like the risks of reputational damages that could come out of the backlash by the population, the impossibility of measuring the return on investment precisely, and the emerging threat of data privacy and proper use of content. The review notes that the success of brands in the digital environment increases when they actively address feedback on the Internet, apply data-oriented approaches, in line with such feedback, and express their messages based on what consumers believe is important to them. The findings are of great importance in technological and economic aspects, especially to the small and medium enterprises (SMEs) in the competitive market. Companies should consider an integrated approach to maximize the benefits of social media marketing that involves focusing on ethical interaction, an ongoing learning process, and optimization process concerning each platform by using tools in analytics and technical support.

Keywords: social media marketing, digital business strategy, brand engagement, small and medium enterprises (SMEs), content personalization and analytics

INTRODUCTION

In the present digital landscape, integrating social media in business has transformed how companies engage with consumers, build their brands, and drive performance. It emerged as a crucial platform for communication, offering businesses a tool for real-time interaction with consumers, content sharing, customer feedback, and even promotional activities. Its significance is particularly evident in its vital role in enhancing brand awareness, improving brand image, and influencing purchasing decisions (Faisal & Ekawanto, 2022; Ibrahim, 2021). However, while relevant studies recognize its benefits on brand reputation, customer relationship, and business growth (Emmanuel et al., 2022; Almazrouei et al., 2020), others highlight the variability in outcomes based on platform type,

audience behavior, and content quality (Li et al., 2020; Tumasjan, 2023). Some inconsistencies are around the long-term impact of social media marketing on brand loyalty and business sustainability.

Furthermore, while studies have mainly explored entertainment, trendiness, and interactive content (Ibrahim, 2021; Koay et al., 2021), few have examined how these elements work across different types of businesses or industries. For instance, influencer marketing can be effective. However, its impact often depends on credibility and how well the influencer presents the message, leading to a gap in understanding how social media strategies translate into actual consumer behavior. This gap indicates the need for further research that consolidates existing studies while addressing the nuances and the evolving dynamics of how social media affects consumer behavior and business results.

In recent years, the widely adopted social media platforms continue to dominate globally and have significantly transformed how people interact, communicate, and make decisions. While existing studies looked into the impact of social media in business and marketing context, particularly in Business-to-Business marketing, there remains a gap when it comes to understanding how it affects people socially and personally, especially among younger users who are easily influenced. The selected model literature by Dwivedi et al. (2021), highlights the role of social media and how it can improve communication, market efficiency, and business outcomes. However, the study mainly focuses on business, leaving a gap of how social media, particularly platforms like TikTok, influence personal values, behavior, and social interactions beyond the business environment.

Even though Faisal and Ekawanto (2022) and Ibrahim (2021) also emphasize the importance of such social media marketing activities like entertainment, interaction, trendiness, customization, and word-of-mouth to strengthen consumer engagement and brand

loyalty, the literature still focuses primarily on consumer behavioural patterns. It fails to capture how the above-mentioned activities could influence the daily behavior of ordinary users in non-commercial environments. Equally, the work by Radebe et al. (2024) and Xu (2020) points to the revolutionary nature of interactive content, user-created media, and algorithm-based personalization as the drivers of the consumer experience and purchasing behaviors. Yet, such results raise the question concerning the overall psychological and behavioral implications of such content, especially among adolescents whose mental and emotional maturity can make them more vulnerable to peer validation and social pressure.

Moreover, although Almazrouei et al. (2020) and Emmanuel et al. (2022) show how social media supports engagement, loyalty, and the concept of real-time communication in business, the implications of these outcomes on social behavior of the youth are underdeveloped. TikTok, characterized by the short-form videos, viral trends, and algorithmically curated content, introduces a specific instance of the immersive power of social media. However, the scholarly discussion is insufficient to examine the implications of this on the behavioral patterns, attention span, value systems, and social interactions of high school students. Such a gap between business oriented research and sociobehavioral inquiry indicates an excellent demand for further research.

This research aims at systematically discussing the advantages, challenges and limitations of social media in business environments. The research will also explore businesses' strategies and approaches in social media marketing.

THE REVIEW

The Design

The researchers conducted a comprehensive literature review following a systematic

approach, adopting best practices in structuring and reporting literature-based studies. The primary aim was to consolidate existing knowledge regarding social media adoption, usage, and its effectiveness in business contexts. In order to recommend the structure and the methodology of the review, the researchers reasoned back to a model paper by Dwivedi et al. (2021) that concerns the topic of social media adoption, use, and impact in business-to-business (B2B) context. The present paper provides an example of such synthesis of studies conducted in the past to divide them into significant areas of thematic focus, including adoption, strategy, and impact. Based on its methods of citing the sources of the system and its organization by themes, the current review aims to reflect the transparency, logic, and scholarly sensitivity shown in such an example.

Research Objectives

The research question that this literature review sought to answer is as under: What is the impact of social media engagements on consumer behavior and the performance of businesses? The review is aimed at achieving the following objectives: (1) To evaluate benefits promoted by social media platforms in marketing business products and services and communicating with its customers, (2) To discuss and identify the problems and restrictions that businesses feel when using social media within the marketing strategies, and (3) To discuss the standard strategies and approaches, which businesses use to promote social media marketing as the means of brand recognition promotion and connecting to its customers.

Retrieving and Selecting Pertinent Literature

To engage the test of academic reliability and relevance, the researchers utilized the literature on reliable databases, such as ScienceDirect, IEEE Xplore, Google Scholar and

others of peer-reviewed publication platforms. The primary search terms included "social media", "social media marketing", "social media in business", and "digital marketing." An initial pool of approximately 15,000 articles was identified across the platforms, including 28,000 results from ScienceDirect and 8,000 from Google Scholar—a rigorous screening process based on predefined inclusion and exclusion criteria reduced this pool to 31 articles. After thorough reading and analysis, 28 articles were finalized for in-depth review and integration into the study.

Synthesizing the Literature

The selected pertinent literature was published from the year 2015-2024. The total articles are 28, which met the criteria for the review and were selected from the studies, extracting data from each article and examining the main study findings combined in Table 1-3.

Table 1. Table synthesis about the advantages of social media in business marketing.

Author	Advantages of Social Media in Business Marketing
Akter, M. (2024)	Social media can be a powerful tool for promoting sustainability initiatives, potentially enhancing a brand's reputation and fostering consumer trust.
Almazrouei, F. A., Alshurideh, M., Kurdi, B. A., & Salloum, S. A. (2020)	Highlights that social media strengthens business performance by boosting sales, enhancing brand awareness, and building customer loyalty.
Broekemier, G., Chau, N. N., & Seshadri, S. (2015)	Shows that social media helps small B2B enterprises enhance brand awareness, maintain customer relationships, and improve communication efficiency.
Bushell, C. (2022)	Social media provides brands an expansive platform for reaching and engaging a global audience, enhancing brand visibility.
Cartwright, S., Liu, H., & Raddats, C. (2021)	The study reveals that social media is revolutionizing B2B marketing as a strategic tool for sales facilitation, integrated communication, and employee engagement, enhancing business performance and competitiveness.
Dalangin, J. J., McArthur, J. M. B., Salvador, J. B., & Bismonte, A. (2021)	The study indicates that social media influencers effectively enhance purchase intentions by establishing trust and credibility with their audience.
Demsar, V., Ferraro, C.,	Highlights how social media can act as a tool for market self-correction,

- Nguyen, J., & Sands, S. (2023) helping brands realign with societal values through public feedback and calls for brand cancellation.
- Dolega, L., Rowe, F., Branagan, E.(2021) Suggests that while digital engagement is valuable for attracting visitors, it may not directly translate into higher sales without complementary strategies.
- Emmanuel, B., Zhao, S., Egala, S. B., Mammet, Y., & Godson, K. (2022) Highlights that social media enhances brand visibility, customer engagement, and direct communication with consumers and shows that companies using social media strategically can achieve better customer loyalty and increased business performance.
- Fagundes, L., Munaier, C. G., & Crescitelli, E. (2022) Shows that social media strengthens brand equity in B2B marketing by improving brand associations, perceived quality, and customer loyalty, ultimately enhancing business performance.
- Faisal, A., & Ekawanto, I. (2022) It shows that social media powerfully strengthens brand awareness, improves brand image, and increases purchase intention, making it an essential tool for business growth and adaptability.
- Grizane, T. & Jurgelane, I. (2017) Demonstrates that social media significantly influences business performance by enhancing customer engagement and brand visibility; however, it also highlights that many businesses fail to fully capitalize on these benefits due to inadequate strategic planning and evaluation of social media investments.
- Ibrahim, B. (2021) Shows that social media marketing activities, such as entertainment, interaction, and personalization, significantly strengthen brand loyalty and positively influence customer commitment.
- Khanal, A., Akhtaruzzaman, M., Kularatne, I.(2021) It encourages businesses to align their vision and values with environmentally friendly and employee-beneficial policies, thereby fostering responsible business practices.
- Kyriakou, C., Papaioannou, T., & Komodromos, M. (2023) Brands can gain consumer trust by addressing online criticism and being transparent about their values.
- Pöyry, E., & Laaksonen, S. (2022) Social media enables brands to engage in brand activism by promoting socio political causes, helping brands build loyalty with consumers who support those values.
- Radebe, S.S., Verkijika, S.F. & Neneh, B.N. (2024) Underscores the significant role of social media in enhancing small business performance. It highlights that social media usage positively influences firm performance by improving customer engagement, facilitating information sharing, and fostering stronger customer relationships.
- Rosário, A. T., & Dias, J. C. (2023) Data-driven marketing through social media allows for personalized marketing, enhances customer experience, and strengthens customer-brand relationships.
- Santos, A., Ortiz, A., Fronda, J., Galano, J., Savellano, J. (2024) Emphasizes the importance of regular postings, interactive content, and proposes an action plan including training programs, financial support, and technical assistance to optimize social media strategies.
- Shabbir, M. S., Ghazi, M. S., & Mehmood, A. R. (2016) Highlights the significant role of social media in transforming business practices for small entrepreneurs. The study concludes that social media platforms have become essential tools for small businesses, facilitating advertising, customer engagement, and business growth by leveraging wide

networks and encouraging customer feedback.

Sunte, J., & Jadhav, B. (2023) Highlights that views, likes, shares, downloads, and ratings on social media are crucial indicators of user engagement and brand popularity, helping businesses measure their digital reach and effectiveness.

Tumasjan, A. (2023) The research shows that social media serves as a powerful tool for business by enhancing marketing, driving innovation, supporting financial activities, and providing valuable data for decision-making. Its diverse roles make it essential for modern business success across multiple areas.

Yu, S., Abbas, J., Draghici, A., Negulescu, O. H., Ain, N. U. (2022) Influenced individuals' attitudes toward social media use, leading to increased engagement for business communication and marketing purposes.

Table 2. Table synthesis about the Challenges of Using Social Media for Business.

Author	Challenges of Using Social Media for Businesses
Akter, M. (2024)	Highlights that backlash on social media regarding a brand's sustainability efforts can significantly reduce pro-environmental consumers' purchase intentions, damaging the brand's image.
Broekemier, G., Chau, N. N., & Seshadri, S. (2015)	Note that small businesses often struggle with limited resources, lack of expertise, and difficulty measuring social media ROI, which can limit the effectiveness of their efforts.
Bushell, C. (2022)	Risks related to the misuse of social media by employees, fake news, bots spreading disinformation, and the impact of online reviews can harm brand reputation.
Demsar, V., Ferraro, C., Nguyen, J., & Sands, S. (2023)	Identifies that brand cancellation movements on social media can pose a significant threat to businesses, as they may face intense public scrutiny and backlash that could harm their reputation.
Emmanuel, B., Zhao, S., Egala, S. B., Mammet, Y., & Godson, K. (2022)	Points out that poorly managed social media can lead to customer dissatisfaction and harm a brand's reputation. Also, mentions the challenges of managing negative feedback and the difficulty of measuring the real impact on business performance.
Golzadeh, F., & Gharachorloo, N. (2021)	Identifies and prioritizes significant challenges in social media marketing such as high competition, difficulty in measuring ROI, content management issues, and rapid technological changes.
Kyriakou, C., Papaioannou, T., & Komodromos, M. (2023)	Brand cancellations can occur due to online criticism, where consumers take collective actions against brands, leading to potential long-term damage to brand reputation.
Odoom, R., Kosiba, J. P. B., & Odoom, P. T. (2024)	Brand hate, expressed through negative e-WOM, can be amplified on social media, leading to decreased patronage intentions and harm to brand reputation.
Pöyry, E., & Laaksonen, S. (2022)	Consumer backlash on social media can occur when brand activism conflicts with individual beliefs, leading to actions like boycotts, discrediting the brand, and even creative efforts to harm the brand (e.g., "trapping").
Rosário, A. T., & Dias, J. C.	Faces significant challenges, including consumer privacy concerns, data

(2023)	poisoning risks, information quality issues, and the need for significant organizational changes.
Santos, A. R., Ortiz, A. F., Fronda, J. G., Galano, J. A., & Savellano, J. N. (2024)	Small businesses face challenges such as limited financial resources and technical skills, which can hinder the effectiveness of their social media marketing efforts.
Sawy, A., & Bögenhold, D. (2022)	Shows that social media exposes micro-entrepreneurs to risks such as identity theft, reputation attacks, and privacy breaches, leading to stress and brand vulnerability.
Sunte, J., & Jadhav, B. (2023)	Mentions that reliance on surface-level metrics can sometimes mislead businesses about true consumer loyalty or purchasing intentions.

Table 3. Table synthesis about Strategies and Approaches in Social Media Marketing.

Author	Strategies and Approaches in Social Media Marketing
Broekemier, G., Chau, N. N., & Seshadri, S. (2015)	Suggests that small businesses should focus on relationship-building content, consistent posting, and selecting platforms that align best with their customer base to maximize their social media marketing effectiveness.
Bushell, C. (2022)	Brands should implement strategies to protect their reputation, such as training employees on appropriate social media behavior, monitoring online reviews, and combating disinformation.
Dalangin, J. J., McArthur, J. M. B., Salvador, J. B., & Bismonte, A. (2021)	Brands should collaborate with influencers who are perceived as honest and trustworthy, as these traits significantly influence consumer purchase intentions.
Emmanuel, B., Zhao, S., Egala, S. B., Mammet, Y., & Godson, K. (2022)	Emphasizes the need for businesses to use targeted content, influencer collaborations, and customer relationship management strategies via social media platforms to maximize performance.
Koay, K. Y., Teoh, K. W., & Soh, P. C. H. (2021)	Influence online impulse buying, with the credibility of influencers—particularly their attractiveness and trustworthiness—serving as key mediators in this relationship. This underscores the importance of selecting credible influencers to enhance the effectiveness of social media marketing strategies.
Kyriakou, C., Papaioannou, T., & Komodromos, M. (2023)	Brands should proactively manage online criticism by developing strategies for handling cancel culture, such as clear communication and maintaining a genuine brand identity aligned with consumer values.
Li, F., Larimo, J., & Leonidou, L. C. (2020) Zhakubayev, A., & Taibi, D. (2023)	Provides a comprehensive framework defining and categorizing social media marketing strategies, identifying strategic components like content creation, community engagement, and monitoring as critical for achieving marketing goals.
Odoom, R., Kosiba, J. P. B., & Odoom, P. T. (2024)	Brands can leverage social media influencers to repair brand sentiment and enhance consumer relationships by aligning influencer content with the brand's values and consumer expectations.
Santos, A. R., Ortiz, A. F., Fronda, J. G., Galano, J. A., & Savellano, J. N. (2024)	The authors recommend strategies like regular postings, interactive content, and the development of an action plan that includes training programs, financial support, resource provision, ROI measurement tools, continuous learning, and technical support to optimize social media marketing for small businesses.

Xu, T. (2020)

Facilitating direct communication with consumers, fostering brand awareness, and influencing purchasing decisions. It also highlights concerns regarding privacy issues and the need for businesses to navigate these challenges effectively to maintain consumer trust.

DISCUSSION

The Advantages of Social Media in Business Marketing

In modern day business marketing, social media has emerged and became a pivotal tool. It offers numerous advantages that improve marketing approaches which naturally leads to increased customer engagement. As stated in Table 1, the same literature as reviewed has continued to highlight the prowess of social media in enhancing brand visibility and in undertaking effective cultivation of customer relationships, which are matters that are bound to have an overall impact on the performance of the business. In the fast-growing presence of online stores, companies need to change their practices to ensure they continue reaching mass clientele. This is where social media venues come in with their sharp ability to deliver. An increased brand awareness is one of its most outstanding merits. The companies are able to advertise their products and services using a reachable and cost effective promotional monopoly which attracts a target audience. According to Almazrouei et al. (2020), social media plays a positive role in the performance of businesses since it helps to increase brand recognition that directly links to the increase in sales and customer loyalty. Along the same lines, Emmanuel et al. (2022) draw our attention to the fact that effective social media can boost the visibility of brands and make them interact directly with consumers, therefore, establishing stronger relationships with the audience. This wide coverage is of essence to a corporation and a small business that wants to cut through in the competitive world. Also, Bushell (2022) has a similar point to make about social media as it has the potential to

associate brands with every global entity, and the exposure level that it has is undoubtedly second to none.

As it expands, it is also part of another huge potential of social media, a higher level of engagement with customers. Social media is a real-time communication platform allowing brands to communicate with consumers in real time and build closer relationships. As Ibrahim (2021) notes, the use of social media marketing in terms of entertainment, personalization, and interactive content significantly contributes to the enhancement of brand loyalty and positive effects on the commitment of customers. Similarly, Grizane and Jurgelane (2017) underscore the critical role of social media in engaging customers and enhancing a business's overall performance and brand recognition. On the same note, Radebe et al. (2024) also observe that social media enhances firm performance through improving the relationships between customers and firms, augmenting customer orientation, and promoting customer co-creation, and, consequently, customer co-creation intensifies the effects of the relationships between the customers and the firms on the overall performance.

Social media forms a tool to enhance and strengthen a customer relationship hence playing a critical role in influencing business performance and sales as it is an effective tool of communication and promotion regardless of the size of the business. This is reinforced by Cartwright et al. (2021) and Santos et al. (2024), who finds that social media is revolutionizing business performance, particularly in B2B marketing and small business sectors by serving as a strategic tool for sales facilitation, integrated communication, and employee engagement, thereby enhancing business performance and competitiveness. Also, a study by Shabbir et al. (2016) highlights social media's vital role in transforming small entrepreneurs' business practices by offering cost-effective advertising and customer engagement, leading to viable business growth.

Another notable advantage of social media marketing is the use of influencer marketing and social proof which are powerful drivers in influencing consumer behavior in today's era dominated by social influencers. Dalangin et al. (2021) emphasizes how social media influencers effectively contribute to higher purchase intentions by establishing trust, credibility, and relatability with their audience or followers. Compared to conventional advertising, influencers are considered to be the new brand ambassadors, and their recommendations and reviews are perceived to be more genuine. Sunte and Jadhav (2023) goes further to explain the importance of measurements such as views, likes, shares, downloads, and ratings of social media as important metrics through which users gain more insight into monitoring the level of attractiveness and engagement on a particular brand owned by a business and how the digital reach of that business can be measured.

In addition, social media affects the creation and strengthening of the brand to an immense degree. There is no doubt that the modern economy has enabled firms to finally create a stable and engaging brand personality that will speak to their customers through certain content and narration. As Fagundes et al. (2022) remark, social media serve not only to enhance brand equity in the case of the business-to-business (B2B) marketing but also to promote the customer loyalty and perceived quality. Such an improvement is critical in such domains where trustworthiness and sustainability of relationships are the art of success in the long run. In a similar context, Rosario and Dias (2023) point out that data-driven strategies arise as a significant factor that helps to increase personalization and enhance the overall customer experience, which, subsequently, strengthens customer-brand relationships. Armed with these capabilities and advanced social media analytics technologies, corporate entities can serve personalized content that will appeal to the individual consumer's interest. This, in its turn, increases the chances of engagement and conversion to the maximum.

The other emerging benefit is that the brands have the chance of undertaking social responsibility and advocacy. Akter (2024) and Khanal et al. (2021) stated that social media offers the possibility to promote its sustainability initiative and the socially responsible practice to businesses. These are not the only activities that lead to an appealing brand image but also create confidences and commitments of socially conscious consumers. As consumers gradually learn to align their buying strategies with their values, a brand that openly shares its ethical promises is usually more likely to invite an increased interest and backing.

Other platforms that have encouraged consumer involvement in the marketing process are TikTok, Instagram, and Facebook. In those marketing campaigns, the consumers go out of their way to market their brand in other areas including user-generated content (UGC). The model aids in the development of an emotional bond between the consumers and the brands. According to Demsar et al. (2023), evidence from these feedback loops suggests that businesses can often reset market expectations rapidly by adjusting accordingly to their expectations, values, and habits. That is why adaptability, derived from the interactivity of social media sites, has become one of the core functions of brand relevance over time.

Although numerous benefits are discussed and referenced, the real-world outcomes of social media marketing can be challenging to quantify. According to Dolega et al. (2021), using digital channels to engage your customers or increase traffic can generate attention for a brand and lead to increased demand for products. While digital engagement generally increases web visibility, it is not always the best way to convert that interest into increased sales. As such, engagement on social media platforms can only have limited value if businesses do not have a complementary offline/backend campaign (such as customer support, a streamlined checkout process, and high-quality product delivery).

As it can be seen, the benefits of social media in business marketing are multidimensional and are well known in many industries and business sizes. The majority of the studied literature is consistent in pointing out the capacity of social media to increase brand awareness, facilitate direct contact with consumers, and facilitate strategic communication that builds customer relationships. In terms of interactive content, influencer collaborations, or data-driven personalization, the synthesis demonstrates how social media can have a significant contribution to the overall business performance. Overall, the literature supports the idea that social media is no longer an optional marketing tool in business. It has become a core, strategic element of business marketing whose effective use is advantageous to the business in terms of branding, communication, and long-term customer engagement.

The Challenges of Using Social Media for Business

As presented in Table 2, while social media offers numerous advantages in business marketing, it also introduces businesses to significant challenges and risks. Being an extensive platform that taps into a wide-reaching audience, one significant issue it poses is the risk to brand reputation. For example, a promotional post that does not sit right with most of the audience or something that does not align with the consumer values can ignite a viral outrage that can damage the brand's reputation over a single post. As Kyriakou et al. (2023) and Demsar et al. (2023) point out, social media can easily intensify brand cancellation due to online criticism, where consumers take collective actions against brands that can potentially cause long-term damage to brand reputation. Controversial campaigns or perceived misalignments with consumer values often fuel public backlashes. Akter (2024) echoes this sentiment, emphasizing that a backlash on brand's sustainability efforts can significantly deter

the purchase intentions of pro-environmental consumers which then naturally affects the brand's image.

Moreover, the potential for backlash inherently challenges handling negative feedback. Emmanuel et al. (2022) state that poorly managed social media can lead to customer dissatisfaction and harm a brand's reputation. Odoom et al. (2024) also focus on the brand hate conveyed via the electronic word-of-mouth that diffuses quicker online (e-WOM) resulting in reduced patronage intentions and damage to a brand name. Such incidents demonstrate the speed at which the internet mood can go, pushing brands to control their material and how it is perceived and acted upon by users.

There are also some operational and strategic issues facing small to medium enterprises (SMEs) regarding social media marketing. A typical challenge SMEs face is the inability to afford resources and technological knowledge to thrive in such online platforms. Broekemier et al. (2015) state that not all small businesses can allocate enough time, resources, and expertise to ensure that social media is present regularly and effectively. This leads to posting less frequently, poorly structured content, and irregular interaction. Such activities can diminish the impact of a brand in online communities. Besides, Golzadeh and Gharachorloo (2021) mention such difficulties as strong competition, the inability to control social media content, and fast-growing technological changes. The speed at which these changes occur, both in the platform's algorithms and what is shared or consumed by users, requires quickness and current knowledge that most companies cannot afford.

Another complex challenge businesses face is measuring social media campaigns' return on investment (ROI). These metrics of likes, shares, and comments in posts might provide a sense of engagement, but do not translate to sales growth, customer retention, or brand loyalty, all of which are concrete business outcomes. This, in turn, criticizes the

companies to prove their investments in social media or which strategy works. Rosário and Dias (2023) also note that to maximize the benefits of using data-driven social media marketing, the organizations in question will have to invest in making the structural and analytical changes. Some companies can gain many benefits by using analytics information. However, most companies can not turn insight into action, and without the right tool and proper knowledge concerning the statistical methods, even required growth is postponed, and optimization possibilities are ignored. This is to indicate that as much as social media offers strong marketing capabilities it has tangible operation costs which can jeopardize business effort unless handled with precaution and expertise.

The other standing crisis in businesses' adoption of social media is the heightening of privacy, security, and ethical risks, besides reputation management and resource drawbacks. With digital marketing getting more data-driven, there is a tendency to use consumer data collection and analysis to personalize content and target ads. These dependencies, however, bring outstanding consumer privacy issues. According to Rosário and Dias (2023), organizations are required to handle the threats of data poisoning, degraded information integrity, and ethical considerations of data use on personal data. Unethical use of consumer data or poor handling of the same may not only kill brand trust, but also lead to legal problems based on laws dealing with data protection such as the General Data Protection Regulation or GDPR. The risks are even more crucial for micro-entrepreneurs and small businesses. According to Sawy and Bögenhold (2022), these businesses are especially prone to identity robbery, privacy, and internet reputation attacks, which seriously disturb their reputation and may undermine their continued viability.

The fact that social media environments are fast-paced and, at times, unregulated compounds these privacy and security concerns. Bushell (2022) stresses that fake news,

misinformation, and disinformation created by bots can misrepresent brand messages and consumer perception to affect the validity of the marketing campaign. Meanwhile, Pöyry and Laaksonen (2022) state that brand activism or messaging that contradicts the latter's personal beliefs might result in consumer backlash through boycotting the brand, publicly criticizing it, or purposefully sabotaging it. Ethical integrity, in this regard, is necessary. Companies must have a transparent data policy, ensure authentic and culturally sensitive content, and train personnel about responsible online behavior. Proactive defense measures will play a pivotal role in developing and maintaining consumer trust in an internet environment where reputational harm can happen instantly and in front of public audiences.

Over-dependence on influencers and content creators is another primary concern. Although influencer marketing has proved to be a way to create engagement and brand awareness, it comes with its traps. The seeds of collaborations are dysfunctional when the people deemed to be the influencers are caught in the middle of the controversy or when their values fail to align with the brand. The key to influencing the consumer purchase intent positively, as Dalangin et al. (2021) and Koay et al. (2021) explain, depends on influencer credibility, honesty, and trustworthiness. When clients believe something is false or is falsely advertisement-oriented, the company name can be spoiled rather significantly. This suggests the relevance of enforcing strict verification procedures by businesses and aligning content in outputs by influencers and overall messages of the brands. Odoom et al. (2024) also indicate that there must be congruence between the content by the influencer and what consumers expect to develop longstanding relationships, while avoiding reputation loss.

Globally, marketing on social media also creates language sensitivity and cultural issues. Something that works effectively in one market may be misinterpreted by the other about different cultural norms and values. Zhakubayev and Taibi (2023) indicate that the lack

of cultural sensitivity might result in adverse consumer reactions, harshening a brand's reputation in foreign markets. Hence, companies must use effective localization techniques and cultural audits to adapt content accordingly. These demand time and specialist skills that many organizations, particularly smaller ones, lack. Broekemier et al. (2015) posit that small enterprises can fail to cope with these subtleties due to limited human resources and marketing might, further enhancing the threats of miscommunication and cross-cultural backfire.

Strategies and Approaches in Social Media Marketing

As presented in Table 3, the rapid growth of technology and its advancement has led to the development of social media as the most efficient tool for marketing and for businesses to connect with their consumers effectively and efficiently. Nowadays, social media platforms such as Facebook, Instagram, and TikTok are used globally, making advertising easier. Businesses seek to improve their products on these platforms to enhance the brand's visibility and trust among consumers. The quoted literature aids in understanding the different techniques adopted for social media marketing focusing on influencer marketing, brand promotion through content creation, interpersonal communication, and image upkeep.

One of the key trends of contemporary social media marketing is to make use of influencers strategically. The study by Koay et al. (2021) reveals that influencer attractiveness and trustworthiness, specifically influencer credibility, influence impulse buying significantly. This implies that companies should also work and be keen when engaging influencers who do not deceive when representing their brand name. On the same note, Odoom et al. (2024) also claim that as long as the provided contents by the influencers align with the brands and consumer expectations, then the individual is resourceful in the

development of consumer relationship and also in the betterment of general attitude towards the brand. The importance given to perceived honesty and trustworthiness in influencers can be similarly echoed by Dalangin et al. (2021) since it is a factor that has profound implications on consumers' purchase intentions. In addition to influencer marketing, direct attention and personal communication are essential to social media marketing. As Xu (2020) explains, social media gives businesses a direct connection with consumers, allows brand awareness to be created, and influences buying considerations. Such a means of communication supports better relations with consumers; however, it also raises the issue of data privacy. Companies must ensure that there is a balance between personalized marketing and the responsible use of data so that their consumers remain trustworthy. Emmanuel et al. (2022) point out that specific content, influencer collaboration, and customer relationship management are the most significant strategies to optimize performance across social media platforms.

Strategic planning and content creation are part and parcel of success in social media marketing. Li et al. (2020), and Zhakubayev and Taibi (2023) provide a systematic nature of SMM, where content development, community building, and monitoring are defined as the key to reaching the marketing purpose. Production of quality, consistent and interactive content enables a brand to create engagement and stay relevant. Also, a small business will be of more benefit to post regularly or synchronize the use of the platform with audience activity, as proposed by Broekemier et al. (2015). Another important SMM strategy is controlling brand reputation, which may occur when online criticism and misinformation occur. Kyriakou et al. (2023) highlight the necessity of proactive approaches to address cancel culture and criticism. This also involves a clear and steady brand image that echoes the changing needs of the consumers. Bushell (2022) augments this perception by suggesting that

brands track the online reviews of their products and services and train their workforce to ensure they know how to conduct themselves on social media, and also take measures to reverse any disinformation, which are key practices in the current high-paced and rather volatile computer world. Measuring the effectiveness of social media marketing is necessary for optimizing the strategies and guaranteeing a high return on investment. Engagement metrics and advanced analytics are being used by the businesses to monitor their performance and to get insights about the consumer behavior. Future social media marketing is also determined by such emerging technologies as AI, augmented reality, and virtual influencers; thus, we must be ready to keep adapting to a rapidly transforming digital world.

However, with the help of social media marketing, it is possible to record the backlash practically in real-time, so crisis communication becomes immediate and strategic. In the current environment, even the smallest blunders can be catastrophic to a brand's reputation and consumer trust. As Kyriakou et al. (2023) note, the proliferation of cancel culture incites brands and businesses to adopt proactive and transparent communication policies in response to public scrutiny. Being responsive, open, and accepting of faults, along with taking responsibility and showing empathy, lessens the negative impact on the organization's reputation while potentially increasing customer loyalty. This is more effective than strategically managing backlash, reinforcing that mitigating defection through public authentic engagement does more good than the anticipated adverse consequences from silence.

Picking up from the previous point, reputation management entails monitoring digital feedback, anticipating crises, and training personnel on acceptable social media protocols. According to Bushnell (2022), brands need to take active steps to prevent disinformation,

control employees' digital behavior, and resolve issues in real time. Such activities enable fuel credibility while strengthening it against changing online conditions.

In addition to reactive tactics, some businesses proactively seek to advocate for social issues aligned with their brand values as part of social brand activism. Such approaches resonate deeply with younger consumers who are values-oriented and seek validation and moral obligation from brands. Pöyry and Laaksonen (2022) assert that when brands try to align their corporate messaging and activities, it can foster loyalty, but only if the attempts are genuine. Brand Activism is quite risky despite the opportunities. According to Akter (2024), performative activism, in other words, visibly supporting without making any significant internal efforts, may cause skepticism and even opposition even among environmentally or socially oriented audiences. To add credence to this, it can be stated that to maintain credibility and transparency, Khanal et al. (2021) maintain that credibility and transparency require that a letter in response to a frequently asked question should include a direct answer with sufficient justification. This helps reinforce the claim that uniformity of ethics, as opposed to mere propagandized piety, became vital in efficient social media branding.

Data measurement tools are important in communication at a brand level as well as managing a crisis. Real-time analytics using sites like Meta Business Suite, Hoot suite and Google analytics help companies monitor consumer habits, their level of engagements and the performance of content. With these platforms, the metrics including but not limited to impressions, click-through rates, conversions, and bounce rate can be metrics that are essential in refining marketing approaches and assessing the return on investment (Rosário & Dias, 2023). By determining the material that initially appeals to the target group, the

businesses will be able to change the campaigns to meet the target audience and make any promotional or value-oriented message reach its mark.

These tools are particularly important to small and medium enterprises (SMEs) since they work under tight marketing budgets. According to Santos et al. (2024), SMEs can take advantage of systematic strategies that have continuous monitoring, technical training, and financing strategies to ensure they make the best out of their investment in social media. Such situations make it important to know what and why favorable and genuinely contribute to digital competitiveness, positive customer engagement, and reaffirming brand positioning in the online platforms.

CONCLUSION

Based on the findings, it is concluded that social media has become a popular and valuable tool in business marketing, since it facilitates cost-effective brand exposure, direct contact with customers, and communication at a one-to-one level, and this has played a key role in customer loyalty as well as business performance. Although it has its advantages, social media has its challenges in the form of reputation risk, resource constraints, data privacy, and measurement of ROI that businesses should embrace ethical, strategic, and technically flexible strategies to thrive. Influencer relationships, customized content, brand activism, real-time connection, and analytics-based approach help businesses enhance brand awareness and consumer engagement, focusing on authenticity, consistency, and flexibility in fast-paced digital environments.

What comes out now is the necessity of businesses, particularly SMEs, to have a governance framework to facilitate responsible digital marketing. Social media strategies have to be informed by technological upskilling, data ethics, and cultural awareness to achieve a balance between visibility and resilience. In economics, sustainable investment in

analytics and content management is essential. Socially, encouraging genuine relationships can create trust. In contrast, environmentally and ethically, brands should be able to prove that their values and behaviors are congruent to ensure that they do not risk their reputation with hyper-aware audiences today.

Moreover, constant assessment and revision are keys to long-term success in social media. Businesses need to be adaptive and continually review the success of their content, user engagement rates, and character of ethical considerations because platforms shift and user expectations do not stand still. With the use of feedback loops and the incorporation of cross-functional expertise, one can improve innovation as well as accountability. In the case of SMEs, cooperation with digital experts or collaboration with influencers who share the same brand values is a way to increase reach without sacrificing authenticity. In the end, strategic agility along with the strong adherence to the principles of transparency and the communications that can be characterized as purpose-driven are going to allow the business to find its way through the comfortable digital terrain and ensure a lasting relationship with the ever more demanding customers.

REFERENCES

- Akter, M. (2024). *The impact of social media backlash toward a brand's sustainability initiatives on pro-environmental consumers' purchase intentions* (Master's thesis, Trent University, Peterborough, Ontario, Canada). Trent University.
- Almazrouei, F. A., Alshurideh, M., Al Kurdi, B., & Salloum, S. A. (2021). Social media impact on business: A systematic review. In A. E. Hassanien, A. Slowik, V. Snášel, H. El-Deeb, & F. M. Tolba (Eds.), *Proceedings of the International Conference on Advanced Intelligent Systems and Informatics 2020 (AISI 2020)* (Advances in Intelligent Systems and Computing, Vol. 1261). Springer. https://doi.org/10.1007/978-3-030-58669-0_62
- Broekemier, G., Chau, N. N., & Seshadri, S. (2015). Social media practices among small business-to-business enterprises. *Small Business Institute Journal*, 11(1), 37–48.
- Bushell, C. (2022, April 1). Brand risks in the era of social media. *SSRN*. <https://doi.org/10.2139/ssrn.4080009>

- Cartwright, S., Liu, H., & Raddats, C. (2021). Strategic use of social media within business-to-business (B2B) marketing: A systematic literature review. *Industrial Marketing Management*, 97, 35–58. <https://doi.org/10.1016/j.indmarman.2021.06.005>
- Castillo, R. A., Jaramillo, C. Z., & Sy, L. (2022). The effectiveness of social media influencers in the cosmetic and skincare industry to the purchase intention of the generation Z Filipinos. *Journal of Business and Management Studies*, 4(2), 180–191. <https://doi.org/10.32996/jbms.2022.4.2.14>
- Dalangin, J. J. G., McArthur, J. M. B., Salvador, J. B. M., & Bismonte, A. B. (2021). The impact of social media influencers purchase intention in the Philippines. *Jurnal Studi Komunikasi*, 5(3), 551–568. <https://ejournal.unitomo.ac.id/index.php/jsk/article/view/4399>
- Demsar, V., Ferraro, C., Nguyen, J., & Sands, S. (2023). Calling for cancellation: Understanding how markets are shaped to realign with prevailing societal values. *Journal of Macromarketing*, 43(3), 000–000. <https://doi.org/10.1177/02761467231168874>
- Dolega, L., Rowe, F., & Branagan, E. (2021). Going digital? The impact of social media marketing on retail website traffic, orders and sales. *Journal of Retailing and Consumer Services*, 60, 102501. <https://doi.org/10.1016/j.jretconser.2021.102501>
- Dwivedi, Y. K., Ismagilova, E., Rana, N. P., & Raman, R. (2021). Social media adoption, usage and impact in business-to-business (B2B) context: A state-of-the-art literature review. *Information Systems Frontiers*, 25(3), 971–993. <https://doi.org/10.1007/s10796-021-10106-y>
- Emmanuel, B., Zhao, S., Egala, S. B., Mammet, Y., & Godson, K. (2022). Social media and its connection to business performance—A literature review. *American Journal of Industrial and Business Management*, 12(05), 877–893. <https://doi.org/10.4236/ajibm.2022.125045>
- Fagundes, L., Munaier, C. G., & Crescitelli, E. (2022). The influence of social media and brand equity on business-to-business marketing. *Revista De Gestão*, 30(3), 299–313. <https://doi.org/10.1108/rege-07-2021-0114>
- Faisal, A., & Ekawanto, I. (2022). The role of social media marketing in increasing brand awareness, brand image and purchase intention. *Indonesian Management and Accounting Research*, 20(2), 185–208. <https://doi.org/10.25105/imar.v20i2.12554>
- Golzadeh, F., & Gharachorloo, N. (2021). Analyzing and prioritizing the social media marketing challenges. *International Journal of Innovation in Marketing Elements*, 1(1), 18–24. <https://doi.org/10.59615/ijime.1.1.18>
- Grizane, T., & Jurgelane, I. (2017). Social media impact on business evaluation. *Procedia Computer Science*, 104, 190–196. <https://doi.org/10.1016/j.procs.2017.01.103>

- Ibrahim, B. (2021). Social media marketing activities and brand loyalty: A meta-analysis examination. *Journal of Promotion Management*, 28(1), 60–90. <https://doi.org/10.1080/10496491.2021.1955080>
- Khanal, A., Akhtaruzzaman, M., & Kularatne, I. (2021). The influence of social media on stakeholder engagement and the corporate social responsibility of small businesses. *Corporate Social Responsibility and Environmental Management*, 28(6), 1921–1929. <https://doi.org/10.1002/csr.2169>
- Koay, K. Y., Teoh, K. W., & Soh, P. C.-H. (2021). Instagram influencer marketing: Perceived social media marketing activities and online impulse buying. *First Monday*, 26(9). <https://doi.org/10.5210/fm.v26i9.11598>
- Kyriakou, C., Papaioannou, T., & Komodromos, M. (2023). Online criticism and cancel culture in digital marketing: A case study of audience perceptions of brand cancellation. *International Journal of Technology Enhanced Learning*, 15(4), 412–427. <https://doi.org/10.1504/ijtel.2023.133788>
- Li, F., Larimo, J., & Leonidou, L. C. (2020). Social media marketing strategy: Definition, conceptualization, taxonomy, validation, and future agenda. *Journal of the Academy of Marketing Science*, 49(1), 51–70. <https://doi.org/10.1007/s11747-020-00733-3>
- Mason, A. N., Narcum, J., & Mason, K. (2021). Social media marketing gains importance after COVID-19. *Cogent Business & Management*, 8(1), 1870797. <https://doi.org/10.1080/23311975.2020.1870797>
- Odoom, R., Kosiba, J. P. B., & Odoom, P. T. (2024). Brand hate experiences and the role of social media influencers in altering consumer emotions. *Journal of Brand Management*, 31(5), 529–542. <https://doi.org/10.1057/s41262-024-00356-x>
- Pöyry, E., & Laaksonen, S. (2022). Opposing brand activism: Triggers and strategies of consumers' antibrand actions. *European Journal of Marketing*, 56(13), 261–284. <https://doi.org/10.1108/ejm-12-2020-0901>
- Radebe, S. S., Verkijika, S. F., & Neneh, B. N. (2024). Social media use and performance of small businesses: A customer-centric perspective. *Baltic Journal of Management*, 19(1), 69–84. <https://doi.org/10.1108/BJM-01-2023-0044>
- Rosário, A. T., & Dias, J. C. (2023). How has data-driven marketing evolved: Challenges and opportunities with emerging technologies. *International Journal of Information Management Data Insights*, 3(2), 100203. <https://doi.org/10.1016/j.jjime.2023.100203>
- Santos, A. R., Ortiz, A. F., Fronda, J. G., Galano, J. A., & Savellano, J. N. (2024). Effective approaches to enhance social media marketing for Philippine small enterprises. *International Review of Management and Marketing*, 14(5), 205–215. <https://doi.org/10.32479/irmm.16773>

- Sawy, A., & Bögenhold, D. (2022). Dark, darker, social media: Dark side experiences, identity protection, and preventive strategies of micro entrepreneurs on social media. *Journal of Research in Marketing and Entrepreneurship*, 25(2), 223–252. <https://doi.org/10.1108/jrme-02-2022-0017>
- Shabbir, M. S., Ghazi, M. S., & Mehmood, A. R. (2016). Impact of social media applications on small business entrepreneurs. *Arabian Journal of Business and Management Review*, 6(3), Article 203. <https://doi.org/10.4172/2223-5833.1000203>
- Sunte, J., & Jadhav, B. (2022). The views, likes, share, downloads, ratings of social media network. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 8(4), 203–210. <https://doi.org/10.32628/CSEIT228424>
- Tumasjan, A. (2023). The many faces of social media in business and economics research: Taking stock of the literature and looking into the future. *Journal of Economic Surveys*, 38(2), 389–426. <https://doi.org/10.1111/joes.12570>
- Xu, T. (2020). The impact of social media on business marketing and consumer shopping. *International Journal of Literature and Arts*, 8(5), 272–276. <https://doi.org/10.11648/j.ijla.20200805.12>

Literature Review on AI-Enhanced Augmented Reality for Real-Time Language Translation in Multicultural Classrooms

Abstract

The rise of multicultural classrooms presents significant language barriers, which AI-enhanced Augmented Reality (AR) aims to address through real-time translation. This study investigates the extent to which AI-powered AR systems can provide contextually accurate language translation to improve communication and learning outcomes. It is a synthesis of available research on effectiveness of the technology, implementation strategies and impact the technology is having. The 20 peer-reviewed articles published since 2020 and until 2025 were retrieved via databases such as IEEE Xplore and Google Scholar using methods of a characterised systematic literature review to examine essential factors, utility and scholarly influence. The establishment of findings indicates that the technology is highly effective in terms of communicational experiences, involvement, results of learning, but the level of its effectiveness depends on a range of factors. They are the precision of Speech-to-Speech translation engines especially in noisy-explosive surroundings and sophistication of AI algorithms in personalizing. Cohesive interoperability this requires the use of intuitive user interfaces that are not cognitively demanding and technically advanced scalable architectures. Research has been shown to positively affect reading comprehension and knowledge retention and to be able to encourage inclusivity. The implications show that there is high need in technological developments of ASR accuracy and strategies of pedagogy which have to incorporate such tools. Its further evolution should be user-centric in nature and handle ethical issues of data privacy and bias of algorithms to ensure fair deployment.

Keywords: Augmented Reality, Artificial Intelligence, Real-Time Translation, Multicultural Education, Educational Technology

INTRODUCTION

Recently, augmented reality (AR) coupled with artificial intelligence (AI) in the area of educational contexts has been gaining traction. It is the side-product of the necessity to bridge the language divides in multi-cultural classrooms, which become more and more common and encourage communication and learning when there is a diversity of culture and languages to bridge. Meas et al. (2020) and Wedyan et al. (2022) have reported the ability of such AI-driven AR tools to provide a real-time translation service to facilitate interactive learning and encourage an open atmosphere of the classroom. However, there exist numerous uncertainties surrounding the most productive incorporation of these technologies within our current educational frameworks. There have existed many previous studies covering the development of translation algorithms or user interface design, while the lacking aspect is in

the depiction of how these elements translate into better academic outcomes. There are other controversies over whether the digital tools can repeatedly capture contextual nuances during language exchange as well as the inherent limitations in machine learning models inhibit their effectiveness (Zhao & Wang, 2024). Furthermore, there are incongruities in empirical findings (e.g., varying accounts of usability and translation accuracy) that render a review of literature that reflects conflicting trends, methodological deficiencies, and uncharacterized aspects of language learning by means of AI enhanced AR imperative (Ebadi & Ashrafabadi, 2022). Through this background, the opportunities and the hurdles that need to be addressed for the application of AI enhanced AR tools to aid real time linguistic translation for multicultural education are laid.

It shows that existing work does not fully address the clear problem posed by the challenges in adopting AI enhanced AR for language translation as has been proved by what follows. While it appears that such systems enhance engagement and academic performance among students, there are no such guarantees with respect to consistency of their operation as well as integration with traditional teaching methods. There are a few studies that show that while the interface of these systems is user friendly, having high cognitive load and the occasional inaccurate translations in the context specific translations prevents them from gaining wider adoption (Xia et al., 2024; Zhao & Wang, 2024). Moreover, studies report mixed outcomes of these tools that indicate possible inconsistencies of their performance in faring well in improving language acquisition, but not necessarily learning outcomes across varying educational settings (Wedyan et al., 2022). This raises a sense of urgency to further investigate these conflicting results not only to validate the technology's utility in practical classroom situations but also to improve the underlying algorithms as well as the usability rules for making the best use of the technology. The problem to be researched, in essence, is

how AI enhanced AR systems can be optimized to offer real-time accurate language translation while at the same time marrying the enhanced communication with the existing educational practice through seamless integration so that any benefits accrued from the enhanced communication are tangible and academic.

Therefore, this paper investigates to what degree AI boosted AR systems can provide contextually accurate language translation for effective communication and learning in transnational education, paving the way for the suggestions of how to improve teaching practices and AR tool design in a digital world (Kot & Nykyporets, 2024). In addition to that the goal of this study is to investigate the use of AI for real time language translation in multicultural classroom settings using AR. The purpose of this study is to explore and synthesize the current state of the AI in AR for real time language translation in multicultural classroom settings. The activity of this research consists of a wide literature review that critically evaluates peer-reviewed articles in the last 5 years that deal with design in user interface, translation accuracy and academic performance. The paper will therefore look at the following factors in order to investigate it such as cognitive load on a user interface, adaptability of translation algorithms to different linguistic contexts, and measured effect on student learning outcomes. This review has not only helped contribute to studies on these dimensions; it also has been a good starting point of building superior AR based language translation systems because it addresses the gaps created by past studies.

THE REVIEW

The Design

The present study follows a critical literature review approach; it can be viewed as a systematic method of carrying out and reporting a review based on well-developed procedures of conducting a literature review and reporting it (Labadze et al., 2023). The intended purpose is to

determine, study, and present a synthesis and review of the available literature on how and why to use the AI-Enhanced Augmented Reality to support Real-Time Language Translation in a Multicultural Classroom in its entirety. This formal procedure guarantees profound and impartial analysis of the available academic writing. The review will be defined by the research objectives that will be established depending on the preplated research question, carefully searching the literature and finding relevant studies according to established criteria, reviewing the main piece of information concerning the objectives, and citing the results with a coherent picture of the present body of knowledge and recognizing the patterns as well as noting the areas of research gaps.

Research Objectives

This literature review seeks to address the central research question: To what extent can AI-enhanced augmented reality systems deliver real-time, contextually accurate language translation to improve communication and learning outcomes in multicultural classrooms? To achieve this, the review focuses on three specific objectives. (1) It aims to determine the key elements that affect how effectively AI-powered augmented reality tools provide instant language translation in diverse classroom settings. (2) It seeks to investigate how seamlessly these tools can be incorporated and utilized in educational environments, with particular emphasis on interface usability and student interaction. (3) The review also intends to measure the impact of AI-driven AR solutions in fostering clearer communication and improving academic performance among students from various cultural backgrounds.

Retrieving and Selecting Pertinent Literature

A systematic search for relevant literature was conducted using reputable academic databases pertinent to Computer Science, Information Technology, Engineering, and Education. Key databases included Google Scholar and IEEE Xplore, following the activity guidelines. To ensure comprehensive coverage, searches may also incorporate databases such as the ACM Digital Library and Scopus, known for their extensive collections in related fields. Relevant studies were identified

using keywords including “Augmented Reality, Artificial Intelligence “ and “Real Time Translation on Multicultural Classroom”.

Synthesizing the Literature

The selected pertinent literature was published from the year 2020-2025. The total articles are 20, which met the criteria for the review and were selected from the studies, extracting data from each article and examining the main study findings combined in Table 1-3.

Table 1. Synthesis of Key Elements in AI-AR Instant Language Translation Effectiveness.

Authors	Key elements in AI-AR Instant Language Translation Effectiveness
AlGerafi, M. A. M. et al. (2023)	Evaluation of AR/VR, motivation, learning outcomes, engagement, retention, skill acquisition, immersive/interactive learning, distance ed, student attitudes, challenges.
Anazia et al. (2024)	Describes a web-based platform for real-time speech-to-text translation between English and Yoruba for students. Aims to address communication barriers and need for language accessibility. Uses ASP.Net/C# stack, SQL Server database, and Google Cloud Translation API. Focuses on system architecture, workflow, algorithms, and user interface.
Avila-Garzon, C. et al. (2021)	Bibliometric analysis (1995-2020), research trends, growth, key countries/authors/sources, keywords, co-citation networks, emerging topics.
Bezzaoucha, I. (2024)	AR's impact on interpreting practices, interpreter training, ethical considerations (privacy, accuracy, human roles), AR functionalities.
Dhawan (2022)	Describes Speech-to-Speech (S2ST) translation as a system to bridge linguistic divides. Details the 3-stage process (ASR, MT, TTS). Outlines history, applications (travel, lectures), current international efforts, essential system features, and significant challenges (spontaneous speech, delay, context, noise, unwritten languages, data scarcity, standardization, usability, copyright).
Ebadi & Ashrafabadi (2022)	Investigated Augmented Reality's (AR) impact on EFL learners' reading comprehension and attitudes (mixed-methods). Focused on upper-intermediate learners in Iran. Examined cognitive load, motivation, interactivity, background knowledge.
Fountoulakis, M. S. (2024)	Investigates AI algorithm accuracy, cultural sensitivity of datasets, and personalization capabilities as crucial factors for effective language learning and intercultural understanding.
Garzón, J. (2021)	History/evolution of AR in education (3 generations), trends, benefits (learning gains, motivation, enjoyment), challenges (access, usability, pedagogy), AI integration.
Geng, X. (2024)	AR in translation education, student engagement, motivation, accuracy (across genres), translation speed/efficiency, contextual comprehension.
Karacan, C. G., & Akoğlu, K. (2021)	AR as an educational tool (foreign language), learning theories, pedagogies, teacher/student perspectives, infrastructure, types of AR apps.
Kot & Nykyporets (2024)	Explores the integration and effectiveness of AI (adaptive learning systems, NLP tools) in tertiary English education. Focuses on personalizing the learning experience to improve language proficiency and communicative competence. Addresses impact on acquisition rates, communication skills, ethical considerations (privacy, bias), and accessibility.
Likith et al. (2024)	Addresses comprehension challenges in diverse classrooms (language barriers, cognitive/hearing impairments). Proposes a real-time audio transcription system leveraging mobile tech. Aims to enhance inclusivity, comprehension, engagement, and participation. Evaluates accuracy, latency, usability, and practical implementation challenges. Uses STT, NLP, and mobile technology concepts.
Özyurt, S. (2024)	AI's potential in medical English learning, role of English & cultural competence in healthcare, AI personalization, simulation, terminology/nuance teaching, ethical concerns

	(privacy, bias, access).
Southwell et al. (2022)	Investigates feasibility of using commercial ASRs (Google, Rev.ai, Watson) for transcribing middle-school student collaborative talk in noisy classrooms. Analyzes Word Error Rates (WER), error patterns (deletion, substitution, insertion), and impact of ASR errors on downstream NLP tasks (topic words, semantic distance, CPS skill classification).
Svoboda & Knihová (2025)	Investigates integration of Metaverse technologies (VR, AR) and AI tools in education. Explores AI-enhanced tools, digital & AI competencies. Literature review covers VR, AR, Metaverse, AI roles. Identifies trends via comparative document analysis (Innovating Pedagogy Reports 2019-2024). Examines educator readiness, challenges (cost, tech requirements, training), and perspectives on AI integration, online collaboration, digital app use. Highlights key evolving AI-driven pedagogies.
Vakkalanka (2024)	Examines implementation and effectiveness of AI-enhanced Mixed Reality (MR) systems across diverse educational settings (n=245) using mixed methods. Focuses on learning outcomes, engagement, skill development. Identifies key success factors (adaptive algorithms, real-time feedback, immersive visualization) and challenges (infrastructure, pedagogy, access). Includes longitudinal data (2 years) and proposes an implementation framework.
Vargas et al. (2024)	Systematic literature review (60 articles) connecting Situated Learning (SL: learning via participation in authentic contexts/communities of practice) with Artificial Intelligence (AI) in Education 4.0. Analyzes SL concepts over time, identifies barriers (traditional school/pedagogy, teacher training) and implementation challenges. Explores AI's potential to enhance SL.
Wedyan et al. (2022)	Explores factors affecting AR integration in language education, including visual augmentation, cognitive load, and contextual relevance of digital content.
Xia et al. (2024)	It finds critical factors like adaptive learning algorithms and possible content adjustments to suit heterogeneous needs of the linguistic and cultural affiliation.
Zhao & Wang (2024)	Identifies the challenges of the traditional way of translation teaching and shows how AR technology could solve problems like the low engagement and poor resource use.

Table 2. Synthesis of AI-AR Tool Integration, Usability, and Student Interaction in Educational Settings.

Authors	Tool Integration, Usability, and Student Interaction in Educational Settings
AlGerafi, M. A. M. et al. (2023)	Enhancing learning (K-12, higher ed, STEM, training), simulations, interactive experiences, virtual classrooms, distance learning, medical ed, fostering collaboration.
Anazia et al. (2024)	Users interact via web browser, providing input via microphone (speech) or keyboard (text) in English/Yoruba. Backend uses ASP.Net/C#. Optional ASR -> Text cleaning/tokenization -> Translation via Google API (encoder/decoder/attention) -> Post-processing (detokenization/normalization) -> Text output and optional Text-to-Speech synthesis. System designed using Object-Oriented Methodology (OOM).
Avila-Garzon, C. et al. (2021)	Documents AR's use across educational research; identifies study patterns (mobile learning, game-based learning keywords).
Bezzaoucha, I. (2024)	Overlaying digital translations/visual aids, AR-based simulations for training, remote interpreting platforms, enhancing communication/comprehension.
Dhawan (2022)	S2ST systems take speech input in a source language and produce speech output in a target language using Automatic Speech Recognition (ASR), Machine Translation (MT), and Text-to-Speech (TTS) synthesis. Systems rely on language-specific tech, parallel corpora, and speech unit databases.
Ebadi & Ashrafabadi (2022)	Used AR apps (CXOCARD, ROAR) on smartphones ("Reader Buddy" project) to provide visual/audio supplements (videos, sounds, translations, example sentences) linked to triggers in reading texts for pre-, during-, and post-reading activities.
Fountoulakis, M. S. (2024)	User surveys and interviews towards estimating the usability of AI tools (in this case, Duolingo and ChatGPT) focusing on the interface design, perceived usefulness, and how could they be integrated into current curricula.
Garzón, J. (2021)	Enriching educational contexts, teaching anatomy, mobile AR, smartglasses for accessibility, WebAR, AI-powered personalization.

Geng, X. (2024) Simulating authentic translation environments, contextual learning, overlaying texts/information, providing interactive scenarios, real-time feedback.

Karacan, C. G., & Akoğlu, K. (2021) Language learning activities (all skills), vocabulary development, providing multimedia scaffolding, creating contextual AR experiences.

Kot & Nykyporets (2024) AI platforms analyze learner data (pace, proficiency, style) to customize content. NLP-driven conversational agents provide interactive practice (speaking/writing) with immediate feedback. Adaptive algorithms adjust difficulty based on performance. Enables scalable, personalized learning experiences.

Likith et al. (2024) Implemented a system using Raspberry Pi (audio capture/processing/hosting), microphone, PyAudio (streaming over local network), Python Flask (backend), Deepgram API (real-time transcription), and a web interface (HTML/CSS/JS) for display. Students access live transcriptions on their devices via a URL when connected to the same local network/router.

Özyurt, S. (2024) Personalized/adaptive language learning platforms, simulating medical scenarios, teaching medical terminology & cultural nuances, complementing human instruction.

Southwell et al. (2022) Collected audio of small group work (dyads-tetrads) using tabletop mics in STEM classrooms. Human transcribed utterances. Compared ASR transcripts to human transcripts using WER and error analysis. Assessed ASR utility by measuring distance between human- and ASR-based results on downstream NLP tasks (Topic, BLEU, Semantic, CPS).

Svoboda & Knihová (2025) Mixed-methods study: Comparative document analysis of Innovating Pedagogy Reports (2019-2024) to define evolving pedagogies (e.g., AI-enhanced learning, immersive learning, intelligent textbooks). Quantitative survey (n=93 Czech educators/students) on frequency of online collaboration, digital educational application use, and AI competency. Qualitative analysis of open-ended survey questions on challenges. Chi-Square tests used to analyze relationships between collaboration/app use and AI competency.

Vakkalanka (2024) Analyzes systems integrating AI (adaptive algorithms, real-time performance analysis, content scaffolding, difficulty adjustment) with MR (immersive virtual environments, AR overlays, simulations, virtual labs) to personalize learning, provide immediate, contextually relevant feedback, and enable collaboration.

Vargas et al. (2024) Proposes using AI tools (adaptive systems, intelligent tutors/coaches, immersive simulations, data analytics) to overcome traditional barriers to SL (passive learning, lack of context, fixed outcomes). AI enables personalization, interactivity, real-world connections, competency-based assessment, and data-driven teacher support within SL frameworks. AI augments SL.

Wedyan et al. (2022) It describes the digital information overlay on the real-world environments with an emphasis on providing a user friendly design aspects that reduce anxiety and increases engagement.

Xia et al. (2024) Describes reports on a well designed system with high usability that uses the Technology Acceptance Model (TAM) to guarantee ease of use, and student continuous engagement.

Zhao & Wang (2024) It gives details of an interactive AR platform with an intuitive interface for accessing multimedia teaching resources, increasing student involvement and practical skills.

Table 3. Synthesis of AI-AR Impact on Cross-Cultural Communication and Academic Performance.

Authors	Impact on Cross-Cultural Communication and Academic Performance
AlGerafi, M. A. M. et al. (2023)	Shows AR/VR can improve engagement, motivation, outcomes; facilitates understanding complex concepts; poses challenges (cost, access, cognitive load, cybersickness); requires sound pedagogy and design.
Anazia et al. (2024)	Provides an intuitive, secured platform enabling real-time translation between English and Yoruba, effectively bridging communication gaps for students. Leverages powerful external APIs (Google Translate). Aims to improve accuracy, reliability, and user experience in S-to-T systems. Contributes to accessibility and inclusivity.
Avila-Garzon, C. et al. (2021)	Documented significant growth in AR education research; identified key contributors, core keywords ('AR', 'VR', 'mobile learning'), and emerging topics (game-based learning, HoloLens, medical ed).
Bezzaoucha, I. (2024)	Demonstrates potential to revolutionize interpreting, enhance efficiency/accuracy, expand access, necessitate professional development, and raises ethical concerns.

- Dhawan (2022) S2ST is crucial for global business/exchange but faces major hurdles. Accuracy and naturalness decrease with spontaneous, complex, or noisy speech. Requires vast data resources. Future requires more sophisticated models, larger aligned corpora, better end-to-end performance, and standardization.
- Ebadi & Ashrafabadi (2022) AR group showed significantly higher reading comprehension improvement vs. control group. Students reported positive attitudes: enjoyed AR, preferred it to traditional methods, felt it provided good background knowledge, created an interactive environment, lowered cognitive load, increased interest and motivation.
- Fountoulakis, M. S. (2024) Qualitative analysis of the levels of proficiency tests for both language skills and cultural outcomes. Education on who to help and how, and oversight by authorities, but positive student outcomes.
- Garzón, J. (2021) Shows positive impact (learning gains, motivation); Mobile AR increased access; highlights future trends (smartglasses, WebAR, AI) and pending issues.
- Geng, X. (2024) Found marked improvements in translation speed/efficiency, enhanced accuracy (esp. technical/medical), greater contextual comprehension, increased engagement/motivation, reduced cognitive load.
- Karacan, C. G., & Akoğlu, K. (2021) Shows benefits (motivation, interaction, retention, visualization, learning outcomes), reduces cognitive load, increases engagement, but notes AR is not ready for total integration.
- Kot & Nykyporets (2024) Findings indicate AI significantly accelerates language learning compared to traditional methods. NLP tools effectively foster real-world communicative abilities (fluency, cultural understanding). Concludes AI can transform language education (more personalized, engaging, inclusive) but requires careful attention to ethics, accessibility, and ongoing research.
- Likith et al. (2024) Successfully transcribed lectures in real-time with ~3-second lag (generally acceptable). Transcriptions were accurate and reliable, significantly aiding comprehension, especially for students facing language/hearing barriers. Facilitated active engagement and participation, fostering a dynamic learning environment. High user satisfaction reported. Network instability caused occasional increased lag/disruptions for some users, highlighting the need for robust infrastructure. Overall, demonstrated significant potential for inclusivity.
- Özyurt, S. (2024) Aims to improve medical professionals' English proficiency & cultural competence, enhance patient care in diverse settings, address language barriers, requires careful ethical implementation.
- Southwell et al. (2022) Commercial ASRs had very high WER (.84-.95), mainly deletions (high precision, low recall). Google transcribed most utterances but had more substitutions. Errors mainly at utterance level (stable across speakers/recordings). Despite high WER, ASR retained meaningful info for downstream NLP (esp. semantic/discourse levels). Suggests imperfect ASR is usable for specific applications.
- Svoboda & Knihová (2025) Metaverse and AI boost student engagement and knowledge retention. Key challenges are high costs and technical requirements. Educator AI competency varies widely; higher competency linked to frequent use of cloud-based collaboration and digital tools for professional development. Highlights the need for targeted training to improve educator AI competency. Underscores the critical role of AI and Metaverse in enhancing learning experiences and shaping future education towards more personalized, engaging, and effective outcomes.
- Vakkalanka (2024) Statistically significant improvement in learning outcomes (overall grade +18.3%, STEM +23.7%, practical assessments +27.9%) compared to traditional methods. Showed sustained improvements in engagement (e.g., active participation +38.7%) and knowledge retention (72.4% vs 41.8% after 6 months). Enhanced skill development (e.g., technical proficiency +31.2%, critical thinking +24.8%) and pedagogical benefits (comprehension, motivation).
- Vargas et al. (2024) AI presents tangible solutions to overcome persistent barriers to SL implementation. Integrating AI thoughtfully can enhance contextualization, social knowledge construction, and real-world connections. AI + SL are complementary, demanding a reimagining of education towards empowered agents, co-construction, and participatory simulations. Human guidance remains essential for ethical grounding. Offers insights for policy, practice, and research on integrating AI and SL.
- Wedyan et al. (2022) It demonstrated that AR can enhance reading proficiency and vocabulary acquisition, and subsequently, enhance academic outcome and outcome in language learning EFL.

Xia et al. (2024)	There are empirical studies which had demonstrated that the system improves language proficiency and intercultural competence tremendously, and thus increasingly proving that it is effective in real world educational environments.
Zhao & Wang (2024)	Results from empirical studies suggest that the AR-based platform is superior, as the translation proficiency, reading comprehension and grammar analysis are superior than traditional methods.

DISCUSSION

The Key Elements in AI-AR Instant Language Translation Effectiveness.

As presented in Table 1, the practical implementation and educational applicability of the AI-driven Augmented Reality (AR) technology in providing the immediate language translation in the heterogeneous spaces of multicultural classrooms depend upon a most complex interrelation of a range of key factors. These factors range between the technologies on which the translation engines and AI algorithms are based, the details of the integration of AR, the important requirements of the system speed and real-time operation, and the general aspects of the learning setting, interests of participants. These aspects are thoroughly important to comprehend when considering the development of systems that are not only technologically advanced but also actually helpful to ensure fair and successful education across the linguistic divide.

Core Translation Technologies and AI Algorithmic Sophistication

Directly at the center of such innovative learning tools sits the prowess and advancement of translation technologies to empower them and the AI systems behind them. The success of instant language translation directly relies on the performance of the Speech-to-Speech (S2ST) systems that, as Dhawan (2022) explains, constitute a rather complicated technological chain where Automatic Speech Recognition (ASR) is used to process a human voice, Machine Translation (MT) processes the input to translate it to another language, and Text-to-Speech (TTS) synthesis produces the translatable version in a voice format. Dhawan (2022) additionally suggests that such S2ST systems usually use complex neural network

designs, among encoder-decoder models with an attention mechanism, specifically intended to address cross-linguistic comprehension and multilingual speech generation nuances that are significant to multicultural educational discourse. Such systems require technical implementation with massive training on domain specific corpora which ideally can contain multicultural classroom interactions, highly different educational vocabulary in various languages and pedagogical languages structures which are highly different than general conversational corpora.

These S2ST capabilities have been realized practically in a number of research works. Anazia et al. (2024) report the creation of an HTML web-based application that provides real-time speech-to-text English to Yoruba translation and the use of technology stack comprising of ASP.Net/ C #, SQL Server as the database, and Google Cloud translation API. This brings out the current trend of incorporating custom commercial APIs concerning the core translation capabilities. In the same way, Likith et al. (2024) exhibit a real-time audio transcription system, which is based on mobile technology, with Speech-to-Text (STT) and Natural Language Processing (NLP) functions implemented in it and operated by the Deepgram API of the corresponding transcription meaning. These are some of the exemplifications of the architectural complexity in developing systems capable of real-time translation.

However, a significant and persistent challenge within this domain is the accuracy and reliability of the ASR component, especially in the uncontrolled acoustic environments of typical multicultural classrooms. These environments are often characterized by spontaneous speech patterns, varying levels of background noise, diverse accents, and overlapping conversations. Dhawan (2022) explicitly points out the difficulties S2ST systems face with spontaneous speech and noisy conditions. This is empirically supported by Southwell et al.

(2022), whose investigation into the feasibility of using commercial ASRs (like Google, Rev.ai, Watson) for transcribing middle-school student collaborative talk in noisy classrooms revealed high Word Error Rates (WER). Southwell et al. (2022) further detail the types of errors, such as deletions and substitutions, which can profoundly impact the intelligibility of the transcribed text and, consequently, the accuracy of the downstream MT process. Such errors can lead to misunderstandings and undermine the very purpose of the translation tool.

Beyond the foundational ASR-MT-TTS pipeline, the sophistication of the AI algorithms governing the entire process is paramount. Fountoulakis (2024) underscores that AI algorithms must not only strive for high translation accuracy but also be designed to handle cultural sensitivities embedded within datasets and enable a significant degree of personalization for individual learners. This need for personalization is echoed by Xia et al. (2024), who identify adaptive learning algorithms and the capacity for content adjustments as critical factors to cater to the heterogeneous linguistic and cultural needs of students in diverse classrooms. Kot and Nykyporets (2024) also stress the importance of using AI and NLP tools to make the process of learning personal, achieving better results in overall language proficiencies and communicative competence. The system architecture underlying the system, as proposed by Anazia et al. (2024) in their audit of system architecture, workflow, and user interface, needs to be capable of handling such complicated AI-driven systems so that they work efficiently and with reliability throughout the collection of input to the delivery of the translated output. This involves the effective flow of data, error management and distribution of resources.

Augmented Reality Integration and Experiential Functionalities

The addition of Augmented Reality (AR) adds a new dimension of essential features that influence seriously the experience of the user and pedagogical capacity of such

translation tools. Responding to real-world classroom environment with digital knowledge is the main role of AR, which constitutes the overlay of digital data, both translations and supporting visual source, on the reality perceived by the user. Bezzaoucha (2024) refers to the influence of AR on the interpreting process and the features of AR, among which a digital overlay of translations and visual support, as well as the ability to make communication more instantaneous and rooted in context, are noted. Wedyan et al. (2022) also state the importance of using visual augmentation in AR-based language learning. The possibilities enabled by this are rather tremendous, as students can be exposed to not merely audio or text outputs of translations, but rather more composite and engulfing effects. By way of example, the visual appearance of translated text might be anchored to the speaker or additional visual devices (e.g. to provide a grammatical connotation or cultural appreciation) may be added to the translation.

Zhao and Wang (2024) suggest that the AR technology has the potential to solve the problem of low engagement among students and resource inefficient use in traditional teaching by providing much more engaging and stimulating learning experiences. It is emerging through the development of AR in education, as observed by Garzon (2021), to be more integrated into AI so as to provide such rich learning backgrounds. The author also records the history and development of AR in education through three generations, which leads to the fact that the educational context is becoming more sophisticated and integrated (Garzon, 2021). To make AR work as something more than a selling point, i.e., a gimmick or fodder of the moment, a high level of detail should be put into the implementation of the visual augmentation and situational applicability of the displayed digital information. As the article by Wedyan et al. (2022) emphasizes, the digital material should be pertinent to the instructional activity and be formulated in the manner that does not undermine but improves

the learning goals. The AR used also affects the extent to which information can be smoothly and contextually included (e.g. marker-based, markerless, SLAM-based). More advanced spatial perception and positioning of augmented information, without predetermined markers is possible, such as through SLAM (Simultaneous Localization and Mapping) technologies, which are more appropriate when working in dynamic classroom setting.

System Performance, Real-Time Capabilities, and Scalability

The effectiveness and feasibility of using AI-augmented AR translation systems lie greatly upon their system performance, in which real-time processing plays a very huge role. According to Geng (2024), the translation speed, efficiency in translations, and accuracy are essential in different genres of discourse people usually come across during the educational process. In a live classroom, it is important to have minimal latency and give translations so that the interaction and natural quality of conversing does not get lost out. According to Likith et al. (2024), the lag of their system that provides real-time transcription of audio messages is about 3 seconds, which is considered, as the researchers claim, to be generally acceptable. However, even lags of this duration can disrupt conversational turn-taking and impose cognitive burdens if too frequent or inconsistent. Striving for near-instantaneous translation is a key design goal.

The challenge lies in achieving this real-time performance while processing complex audio inputs, executing sophisticated AI translation algorithms, and rendering AR overlays, all potentially for multiple users simultaneously in a multicultural classroom. This requires optimized algorithms, efficient data handling, and potentially powerful local processing capabilities or robust, low-latency connections to cloud-based services. Furthermore, the system must maintain consistent accuracy across different "genres" of classroom

communication, which could range from formal lectures and presentations to informal group discussions and one-on-one interactions (Geng, 2024). The linguistic characteristics of these genres can vary significantly, posing different challenges for ASR and MT components. Ensuring scalability is also a critical element; the system architecture must be able to support a growing number of users, languages, and an increasing volume of data without degradation in performance. This involves considerations for load balancing, efficient database management (as suggested by Anazia et al.'s (2024) use of SQL Server), and potentially microservices-based architectures that allow individual components to be scaled independently.

Educational Context, User-Centric Factors, and Ethical Imperatives

Beyond the purely technological aspects, several elements rooted in the educational context and user-centric factors profoundly influence the effectiveness of these tools. A primary concern is managing the cognitive load imposed on students. While AR can present information in engaging ways, poorly designed interfaces or overwhelming amounts of augmented information can increase extraneous cognitive load, hindering rather than helping learning. AlGerafi et al. (2023) and Ebadi & Ashrafabadi (2022) both acknowledge cognitive load as a challenge in AR/VR educational contexts. Thus, interface design must be intuitive, minimizing the mental effort required to use the tool itself, allowing students to focus on the translated content and the learning task.

To achieve cognitive load addressing in real-time AR translation scenarios, one will need more than intuitive interface design itself, one will need more careful and pedagogical approach, which will have to be enacted into classroom practice. The possibility of cognitive overload is increased when students are multitasking in terms of listening to spoken instructions, reading AR-overlaid translations, and reading subject material. To alleviate this,

teachers may adopt a staged introduction approach: instead of enabling all the AR translation features at once, teachers can enable one feature at a time such as beginning with text overlay translation features only before the full functionality is enabled. Teachers can also create structured periods of AR-off during the lesson where students put aside their AR-enabled devices and solidify their understanding by discussion or written reflection, which has reduced sustained cognitive demand. Karacan and Akooglu (2021) support this postulate by pointing out that AR is not ready yet to be fully and completely integrated, which reaffirms the importance of blended rather than totally immersive AR deployment. Moreover, the output of the translation should be designed in such a way that it only shows up when it is specifically relevant, i.e. when it is triggered by certain vocabulary or key phrases, as opposed to running continuously, which would mean that students would be constantly divided between looking at the augmented layer and the primary instructional material.

Fostering positive student attitudes towards the technology is also crucial for adoption and effective use (AlGerafi et al., 2023). If students find the tool cumbersome, inaccurate, or unhelpful, they are unlikely to engage with it meaningfully. Ebadi & Ashrafabadi (2022) found that students in their AR group reported positive attitudes, enjoyed AR, and preferred it to traditional methods, which contributed to its effectiveness. Incorporating teacher and student perspectives throughout the design, development, and implementation phases is essential to ensure the tool meets actual user needs and integrates well with existing pedagogical practices (Karacan & Akoğlu, 2021). This includes understanding teachers' comfort levels with technology and providing adequate training and support.

Infrastructural limitations present another significant hurdle. The successful implementation also demands sufficient Wi-Fi connection, competent gadgets among students (smartphones, tablets, or dedicated brain-AR devices), not to mention specially

assigned technical assistance (Karacan & Akoğlu, 2021). The digital divide in the sense that not every student has an equal access to these resources should be taken into account carefully in order not to introduce additional inequalities.

Finally, the most important thing is the ethical imperatives of these technologies. Both studies by Bezzaoucha (2024) and by Özyurt (2024) are questionable in ethics. Data privacy concern is a significant challenge: such systems will handle and possibly store linguistic or student interactions data. Strong policies and technical mitigation are necessary to verify that data is kept safe, anonymized where possible, and work with regulations such as GDPR or FERPA. The other serious issue is algorithmic bias. The problem is that AI models (such as ASR ones and the MT) are trained with large-scale data, and in case such data are biased regarding particular accents, dialects, or cultural expressions, these models will not work or even reinforce such negative stereotypes of the groups. The consistent problem lies in the fairness and equity of algorithmic performance in different linguistic and cultural backgrounds. Students with disabilities should also have equal accessibility and the primary design principle should be to enable as many students to access the AR interfaces and translated content without difficulties; the interfaces should be perceivable, operable, understandable, and robust to all students. Thorough considerations of these factors are deemed not only a technical issue but, first and foremost, the key to responsible and successful employment of AI-enhanced AR translation facilities in the multicultural education sphere. Such tools need to lead to a comprehensive development by weighing the prospects of technological advances against the robustness of a well-premised pedagogical approach, the needs of the user and absolute ethical considerations.

The AI-AR Tool Integration, Usability, and Student Interaction in Educational Settings.

As presented in Table 2, the integration and proper use of AI-supported Augmented Reality (AR) translation devices into the vibrant and multi-ethnic weft of learning environments, specifically, multicultural classrooms, are a complex matter. The success is pivotal to the establishment of enhanced interface usability, the development of solid and flexible forms of educational incorporation and use, utilization of AI-based personalization and adaptive learning opportunities, successful technical integration and system development, and proactive facilitation of the student interaction and collaboration. These related factors require in-depth scrutiny to determine how these advanced technologies could become more than potential advancements into the field of education and become truly transformative educational resources.

Interface Usability and Design for Adoption: The Gateway to Engagement

Interface usability proves to be the key to effective adoption and use of any educational technology, and consideration of the complexity level, the use of AI-enhanced AR translation is no exception. The user interface (UI) design and general user experience (UX) should be very clear, user friendly, and intuitive, to reduce the level of cognitive load and foster interest. The superiority of user-friendly design features that make the presentation of digital information in real-world environments less anxiety-causing and more involving is emphasized by Wedyan et al. (2022) explicitly. It is especially relevant in diverse multicultural classrooms whose students might be more or less technologically literate and comfortable. Complexity may be so great that it starts to act as a drawback itself: the main objective of the interface to communicate and to learn will be lost. Xia et al. (2024) also emphasize this with the help of referencing to the Technology Acceptance Model (TAM), according to which the perceived ease of use and perceived usefulness are the major drivers of technology adoption. In the case of AI-based AR systems, it implies that students and

teachers need to be able to easily work with the system and consider that the system can be of any help with language barriers and, overall, make the learning experience more engaging.

There has been practical consideration on interface design in literature. The system of the English- to Yoruba translation offered by Anazia et al. (2024) is characterized by the authors, who consider it as a system in which users communicate using a web browser with which they are very familiar to operate and offer speech input with the help of a microphone or traditional textual one, using a keyboard. Selecting a web browser as a main interface will additionally help to reduce the barrier to entry as the platform is available to the audience in a broad range and is well known by the audience. The fact that they have employed Object-Oriented Methodology (OOM) in designing the systems is also an indication of a direction, which tends to lay much emphasis on modularity and ease of understanding, which end-users would be able to easily handle. Another crucial aspect of teaching in the AR environment is the creation of interactive AR platforms that will have easy-to-use interfaces, which is stressed upon by Zhao & Wang (2024) as, by doing so, the access to the multimedia teaching materials will become easy, and the participation of students and their practical knowledge will be higher. It means that the AR interface itself will be not only a displaying anti-translation, but may also allow accessing the additional educational information in convenient navigation way. In the assessment on the use of AI tools (international language apps) such as Duolingo and ChatGPT, Fountoulakis (2024) concentrates on interface design and perceived usefulness as two key design parameters that would determine the manner of the integration of those tools in existing curricula. This makes the point made earlier, namely that even the strongest AI functions lose their power when the interface is characterised by a steep learning process of when it makes the experience feel clunky. The design must therefore be iterative,

incorporating user feedback from diverse student and teacher populations to refine usability and ensure cultural appropriateness in interface elements (e.g., icons, layout, color schemes).

To ensure that the use of technology in the management of an AR-translated multicultural classroom does not become a distraction, it is imperative that teachers adopt clear, structured facilitation strategies at the very outset. An efficient solution is the creation of clear classroom AR guidelines - agreed-upon rules about when devices are raised, when translation functions are turned on, and when attention is redirected to the teacher or a peer speaker. As an example, when a teacher is attempting to explain some content to a whole-classroom, they may ask students to put away their AR devices and rely on verbal comprehension, enabling them to activate translation tools only in the context of independent reading or a small group discussion where the language barrier between peers is the most acute. This is similar to the organized technology use policies already established in most digital classes and avoids the AR layer competing with, instead of aiding in, instructional delivery. Wedyan et al. (2022) support this by noting that the digital overlays should be designed to reduce, rather than increase, anxiety, which in practice means that the teachers also need to take an active role in normalizing the technology so that students who rely on it do not feel singled out. A buddy system that matches students with different language backgrounds with those without a language background can also help in integrating the use of translation tools as part of natural collaborative activity as opposed to positioning the use of translation tools as remedial support. Fountoulakis (2024) agrees with this by stating that the perceived usefulness is one of the primary factors of technology adoption, that is, the ability of teachers to visibly model and affirm the purpose of the technology to establish it as a legitimate and unremarkable part of the classroom environment rather than a novelty or a distraction.

Modes of Educational Incorporation and Application: Versatility in Practice

The versatility of AI-enhanced AR translation tools allows for a wide spectrum of modes of educational incorporation and application, catering to different learning objectives, subject areas, and pedagogical approaches. AlGerafi et al. (2023) provide a broad overview, noting that AR/VR technologies can enhance learning across K-12, higher education, and STEM fields by providing simulations, fostering interactive experiences, creating virtual classrooms, supporting distance learning, and even aiding medical education. In the context of language translation, this versatility means the tools can be integrated into various classroom activities. Garzón (2021) also speaks to the broad utility of AR in enriching educational contexts, from teaching anatomy to enabling mobile AR and smart glasses for accessibility, all of which can benefit from real-time translation.

More specific applications are detailed by other researchers. Ebadi & Ashrafabadi (2022) describe the "Reader Buddy" project, where AR apps (CXOCARD, ROAR) on smartphones provide visual and audio supplements—such as videos, sounds, translations, and example sentences—linked to triggers in reading texts. This exemplifies how AR can augment traditional learning materials, providing instant linguistic support during pre-, during-, and post-reading activities. Bezzaoucha (2024) discusses the application of AR in overlaying digital translations or visual aids in real-time communication scenarios and even using AR-based simulations for interpreter training, which directly leverages the translation capabilities for skill development. Vakkalanka (2024) explores AI-enhanced Mixed Reality (MR) systems, which can offer immersive virtual environments, AR overlays, simulations, and virtual labs, all potentially enhanced by integrated translation to support diverse learners. Karacan & Akoğlu (2021) emphasize the role of AR in specific language learning activities, vocabulary development, providing multimedia scaffolding, and creating contextual AR

experiences. As an example, it would be possible to use an AR application to show translations of objects within the room where the lessons take place, so that vocabulary learning in a new language can go on, or to offer translated subtitles to a live lecture or a discussion. The decision on the mode of application will be based on the targeted learning objectives, the maturity level of students and resources available as far as technological infrastructure is concerned.

AI-Driven Personalization and Adaptive Learning: Tailoring the Experience

One of the transformative possibilities of these tools is their ability to be personalized and adapt with sophisticated Artificial intelligence technologies so that learning can be individualized to the unique needs of the students in multicultural environments. Kot & Nykyporets (2024) discuss the differences with the help of which AI platforms may analyze the data of the learners, including learning pace, the level of language proficiency, and some learning preferences to individualize the delivery of content. Their work provides an overview of NLP-based conversational agents offering interactive practice in both speaking and writing with immediate feedback and adapts the tasks difficulty based on current student performance due to adaptive algorithms. Such individualization is hard to reach in ordinary classes, particularly when there is linguistic variation involved. A similar option is targeted by Özyurt (2024), as well, specifically related to special practice, such as medical English, whose terminology can be taught by simulating scenarios and using AI.

According to Vargas et al. (2024), the adaptive systems and intelligent tutor/coaches are part of AI tools that will allow overcoming the traditional impediments to Situated Learning (SL) by allowing personalization, interactivity, and connectivity to the real world by consuming the passive learning and lack of context. Vakkalanka (2024) also focuses on the kind of personalization that can be attained by AI incorporated into MR with the use of

adaptive algorithms, real-time performance analysis, scaffolding content and difficulty-level adjustment. The effect of such dynamic adaptation is that the challenge and support is provided to the student, not matter what their point of origin is. In the case of translation to a language, it may imply the system simulates the simplicity of translated words or phrases depending on the proficiency level of the user, or gives more elaborated explanations on some language characteristics should a user be not capable of tackling them. This flexible nature is essential to the success of the translation tool in that it cannot merely serve as a vessel of information but be a facilitator of language use and understanding.

Technical Integration and System Architecture: Ensuring Robustness and Scalability

The technical integration into the educational landscapes with such tools is also critically dependent on easy integration of functionality and the structural scalable architecture of the taught system. The respective technology should be able to fit the challenging tasks of real-time translation and AR rendering in a reliable manner. Likith et al. (2024) give a good example of a system run on Raspberry Pi to capture, process and host audio a microphone as input, pyAudio to stream over a local lan, Python Falk as the backend, Deepgram API as real time transcription, and a Web interface (html/css/js) to display the result. This depicts a popular trend of using off-the-subsidary equipment, freely available programs, and business Application Programming Interfaces to assemble workmanship structures. The architecture of a different English/Yoruba translation platform is characterized by Anazia et al. (2024) that applies an ASP.Net / C# back-end, SQL Server database, and uses Google Cloud Translation API. These diverse examples show there isn't a one-size-fits-all architecture, but common themes emerge, such as reliance on cloud-based APIs for core AI functionalities (Dhawan, 2022).

Beyond the individual components, the overall architecture must support scalability to accommodate a growing number of users and increasing data loads. It must also ensure interoperability with existing school IT infrastructure, such as Learning Management Systems (LMS) and student information systems, potentially through standardized APIs like LTI (Learning Tools Interoperability). The system must be resilient to network fluctuations, especially if relying on cloud services, and provide mechanisms for offline functionality or graceful degradation of service where possible. Security is also a critical architectural consideration, ensuring that student data is protected and that the system is not vulnerable to cyber threats. The deployment model (e.g., cloud-based, on-premise, hybrid) will also influence technical integration challenges and costs.

Enhancing Student Interaction and Collaboration: Fostering Communicative Competence

A key objective for incorporating these tools is to enhance student interaction and collaboration, particularly in linguistically diverse classrooms where communication barriers can hinder peer learning and social integration. Svoboda & Knihová (2025), in their exploration of Metaverse and AI tools, highlight the potential for fostering online collaboration and improving digital educational application use. AI-enhanced translation can act as a bridge, allowing students who speak different languages to communicate more effectively during group projects, discussions, and collaborative problem-solving activities. Southwell et al. (2022) discuss the use of ASR to transcribe and analyze small group collaborative talk in STEM classrooms. While their focus was on the feasibility and challenges of ASR in this context, it points to the potential for these technologies to not only facilitate but also provide insights into student interactions, which could then be used to improve pedagogical strategies for collaboration.

Wedyan et al. (2022) believe that augmented-reality (AR) classrooms require designing digital overlay, where it is necessary to make animation that can reduce anxiety and increase interest- two prerequisites to effective interaction of students with one another. As long as the translation gadget is nonobtrusive and makes proper semantic reproduction, it can be made an instrument of elevating the confidence of students in their course participation. Further, Xia et al. (2024) postulates the creation of adaptive learning algorithms and content modification based on heterogeneous linguistic needs as a smoother ability to interact with the student. In case a learner experiences troubles in understanding a contribution of a peer, the system may provide simplified translation or some more explanations. Through the dismantling of linguistic boundaries, these tools create environments of inclusiveness and participation where each student, regardless of his or her cultural and linguistic background, is appreciated and able to bring his or her own individuality into the learning process and thus help deepen the overall experience

To ensure that AR translation tools are as unobtrusive in practice as possible, it is essential that the teachers play an active facilitation role as opposed to just letting the students manage their use of the devices on their own. An effective plan would be that teachers assign rotating discussion roles when having students work in groups, i.e., have one student per group be the designated translation monitor, whose role is to signal when the AR tool is being overutilized or when the tool is producing incorrect outputs, rather than everyone in the group handling both content engagement and device interaction simultaneously. This role rotation also develops digital literacy, critical evaluation skills in addition to language learning. Teachers can also avoid distraction by establishing clear limits of tasks - such as telling students to use AR translation only during the listening part of a peer presentation and to set devices aside during their own speaking turn so that the technology assists with

understanding, but does not replace the communicative act that creates the real language competence. Likith et al. (2024) mention that even a 3-second lag in transcription can disrupt natural conversation flow, which means that even teachers have to teach students to pause in conversational flow in order to allow the system to catch up and integrate it as a taught conversational skill, instead of considering it a technological failure.

To sum up, the effective integration and use of AI-intensified AR translation tools requires an approach that is comprehensive and thorough, both in terms of interface usability, the opportunities of various modes of application, the use of AI to personalize the solutions, technology stack support, and the optimization of the student engagement. It is under the close consideration of such interconnected dimensions that educators and developers can only dream of achieving the maximum potential that lies in these technologies to change multicultural learning environment.

The AI-AR Impact on Cross-Cultural Communication and Academic Performance.

As presented in Table 3, the complex effects of the use of AI-driven Augmented Reality (AR) solutions to enhance clearer communication and academic performance among students representing different cultures cannot be assessed with reference to a single value and a specific time frame as there is a great potential of the techniques discussed to bring immense benefits as well as high levels of complexities and challenges. Conclusions in the literature indicate concrete benefits in terms of clarity and understanding of communication, direct benefits to learning outcomes and student engagement, significant potential to encourage inclusivity and meet learning disparities, and also state the ongoing problems, drawbacks and essential ethical issues that should be constrained to achieve complete and equal potential of these technologies in multicultural education.

Enhancing Communication Clarity and Comprehension: Bridging Linguistic Divides

The ability of AI-driven AR solutions to help considerably boost the clarity of communication and its understanding in linguistically diverse classrooms comprises one of the most direct and strong contributions of such a solution to education. Such tools serve as an effective communicating channel in that they help bridge the gap between communication in real-time or near real-time language translation. In their manuscript on the speech-to-text translation platform between English and Yoruba students, Anazia et al. (2024) are outright trying to deal with the topic of communication barriers, access to language, and to consequentially create a more inclusive environment, where students will be able to both understand and be understood despite their native language. This added accessibility is essential in active participation and good access to educational content. This is empirically argued by Likith et al. (2024) who argue that in their real-time audio transcription system, there was a huge contribution to the facilitation of understanding, to a higher extent of understanding, with many students who have language or hearing barriers. These tools give such students some advantage by enabling active participation using available transcriptions that are readily accessible.

The effect on reading comprehension, which is essential for academic achievement, is very significant. In a mixed-methods study, Ebadi & Ashrafabadi (2022) examined how AR affected the attitudes and reading comprehension of EFL students. Their results were convincing: the AR group outperformed the control group in terms of reading comprehension development. Students in the AR group also expressed favorable attitudes, said they liked the AR experience, said they preferred it to traditional techniques, and that it created an interactive atmosphere and gave strong foundation knowledge. This implies that AR, when combined with linguistic assistance or translation, improves the reading learning process

overall in addition to making literature more accessible. Focusing on augmented reality (AR) in translation education, Geng (2024) also discovered that students utilizing AR tools had significantly improved translation speed and efficiency, increased accuracy (particularly for technical and medical texts), and improved contextual comprehension. This suggests that AR can assist students in understanding the context and subtleties of translated content in addition to its literal meaning. Corroborating these findings, Zhao & Wang (2024) reported that empirical studies suggest AR-based platforms are superior to traditional methods in developing translation proficiency, reading comprehension, and even grammar analysis skills. The potential to revolutionize interpreting practices by enhancing efficiency and accuracy, as discussed by Bezzaoucha (2024), also underscores the fundamental role these technologies can play in making communication clearer and more effective across language barriers.

Elevating Learning Outcomes and Student Engagement: Transforming the Educational Experience

Beyond clearer communication, AI-driven AR solutions demonstrate a strong potential to positively elevate learning outcomes and significantly boost student engagement. AlGerafi et al. (2023), in their comprehensive evaluation of AR/VR in education, conclude that these technologies can improve engagement, motivation, and learning outcomes, particularly by facilitating the understanding of complex concepts. When language barriers are reduced through translation, students are better able to engage with core subject matter, leading to improved academic performance. Garzón (2021), in an overview of twenty-five years of AR in education, similarly highlights the positive impact of AR on learning gains and motivation, noting that mobile AR, in particular, has increased access. Karacan & Akoğlu (2021) further elaborate on the benefits, showing that AR can enhance motivation, interaction, knowledge retention, visualization, and overall learning outcomes. They attribute

this, in part, to AR's ability to make abstract concepts more concrete and learning more interactive.

Vakkalanka (2024), in a systematic analysis of AI-enhanced Mixed Reality (MR) in education involving 245 users, reports statistically significant improvements in learning outcomes. Specifically, students using these systems showed an overall grade improvement of +18.3%, STEM subject improvement of +23.7%, and practical assessment improvement of +27.9% compared to traditional methods. Crucially, these gains persisted, as did improved information retention (72.4% vs. 41.8% after 6 months) and engagement (e.g., active involvement +38.7%). Strong evidence for the long-term educational advantages of properly deployed AI-enhanced immersive technologies is shown by this longitudinal research. In particular, Wedyan et al. (2022) showed how AR might improve vocabulary and reading comprehension in EFL contexts, which in turn improves academic results in language learning. According to empirical research referenced by Xia et al. (2024), its Cross-Cultural Intelligent Language Learning System (CILS) significantly enhances language proficiency and intercultural competency, demonstrating its efficacy in authentic learning settings. Additionally, Svoboda and Knihová (2025), who investigate the integration of Metaverse and AI tools, emphasize how important they are for increasing student engagement, improving information retention, and influencing future educational trends toward more individualized, interesting, and successful results.

Promoting Inclusivity and Addressing Learning Disparities

A profoundly important impact of AI-driven AR solutions lies in their capacity to promote inclusivity and address learning disparities that often exist in multicultural classrooms. Vargas et al. (2024), drawing insights from Situated Learning literature, argue that AI presents tangible solutions to overcome persistent barriers to SL implementation. By

thoughtfully integrating AI, educators can enhance contextualization, support social knowledge construction, and forge stronger real-world connections for all learners. When combined with real-time translation, AI-enhanced AR can create learning environments where students' linguistic backgrounds are no longer significant impediments to participation or success. Özyurt (2024) aims to improve medical professionals' English proficiency and cultural competence through AI-assisted learning, directly addressing language barriers to enhance patient care in diverse settings, a principle that translates directly to educational contexts where clear understanding is paramount.

Kot and Nykyporets (2024) found that AI significantly accelerates language learning compared to traditional methods. Their research indicates that NLP tools effectively foster real-world communicative abilities, including fluency and cultural understanding, and conclude that AI can transform language education by making it more personalized, engaging, and inclusive. This inclusive aspect is crucial; by providing on-demand translation and linguistic support, these tools can level the playing field, allowing students who are not yet proficient in the language of instruction to access the curriculum and participate more fully in classroom activities. The successful real-time transcription of lectures reported by Likith et al. (2024), despite occasional network instability issues, demonstrates significant potential for inclusivity, especially for students with language barriers or hearing impairments. While challenges like robust infrastructure are noted, the overall impact is a move towards more equitable access to information and participation.

Challenges, Limitations, and Ethical Considerations: Navigating the Path Forward

Despite the overwhelmingly positive potential, the impact of AI-driven AR solutions is tempered by a range of challenges, limitations, and critical ethical considerations that demand careful navigation. Notably, while several studies indicate that AR can reduce

cognitive load (Ebadi & Ashrafabadi, 2022; Karacan & Akoğlu, 2021; Geng, 2024), this benefit is not consistently observed across all contexts. AlGerafi et al. (2023) identify cognitive load as a potential challenge alongside the significant practical issues of cost, access to technology, and even cybersickness. These factors can limit the widespread and equitable deployment of these tools. In real-time translation situations, in particular, the cognitive load is compounded as the students have to simultaneously process the original spoken or written content, monitor the AR-overlaid translation, evaluate its accuracy, and work with the underlying subject matter - four simultaneous cognitive tasks that can easily surpass the limits of working memory. To deal with this, both technological and pedagogical solutions need to be provided: on the technological side, the AR system should be designed in such a way that it not only displays the translation but also does so in a visually unobtrusive location within the field of view of the student, with font sizes and contrast levels that can be read on the periphery, without having to focus the eye on the message. On the pedagogical part, the teacher should expressly pre-teach important words in both languages before lessons where AR translation will be used and the load of novelty on the translation tool will be reduced and the students will use the translation tool as a confirmation rather than a primary comprehension tool. This pre-teaching technique directly lowers the cognitive load imposed on the AR system by minimizing the number of strange terms which must be processed in real time, making the translation layer additional instead of necessary to basic comprehension.

The accuracy of the core translation technologies, particularly S2ST systems, remains a concern. Dhawan (2022) points out that accuracy and naturalness decrease significantly with spontaneous, complex, or noisy speech, and that current systems require vast data resources and more sophisticated models for improvement. This is echoed by Southwell et al.

(2022), whose study on commercial ASRs in noisy classrooms found very high Word Error Rates (.84-.95), mainly due to deletions. While they suggest that even imperfect ASR can retain meaningful information for downstream NLP tasks, the high error rate highlights the gap still to be bridged for truly seamless real-time translation in challenging acoustic environments.

Practical implementation is further complicated by high costs and demanding technical requirements, as noted by Svoboda & Knihová (2025). They also highlight that educator AI competency varies widely, with higher competency often linked to more frequent use of cloud-based collaboration and digital tools for professional development. This emphasizes how important it is to provide educators with specialized training in order to enhance their AI competency and guarantee the successful pedagogical integration of these tools. It is crucial to take ethics into account. Vargas et al. (2024), Özyurt (2024), and Kot & Nykyporets (2024) all stress the importance of paying close attention to ethics. This includes ongoing efforts to mitigate algorithmic bias in translation models (which can reinforce stereotypes or perform poorly for underrepresented linguistic groups), ensuring equitable access to these technologies to prevent the digital divide from growing, and implementing strong data privacy measures to protect sensitive student linguistic data. Vargas et al. (2024) emphasize that human direction is still necessary for ethical grounding and making sure that technology supports educational objectives rather than dictates them. Maximizing the advantages and reducing the risks of these potent new tools in multicultural education requires constant research, careful assessment of their effects in many circumstances, and a dedication to responsible innovation. The way forward necessitates a well-rounded viewpoint that actively addresses the underlying challenges while also celebrating the potential.

CONCLUSION

The summary of results demonstrates that AI-enhanced AR translation tools positively impact academic performance, student participation in multicultural classrooms, and communication clarity. They are no longer merely theoretical. But there are major practical obstacles that limit its potential. The conclusion is that merely implementing the technology is not enough. In order to close the gap between the technology's potential and its equitable, practical use, it is imperative that the fundamental problems of accuracy, usability, and pedagogical integration be addressed.

This study has a wide range of consequences. More reliable AI models trained on a variety of domain-specific data are clearly needed technologically to address bias and accuracy concerns. Economically and socially, the high expense and infrastructure needs provide major obstacles to fair access, which could exacerbate the digital divide if not handled properly. The absence of uniform ethical standards for algorithmic fairness and data privacy in educational contexts is a serious weakness from the standpoint of governance.

Going forward, user-centered refinement must replace proof-of-concept as the primary developmental priority. This entails building training curricula to increase educator AI proficiency, defining explicit guidelines for moral application, and constructing adaptive systems that tailor the educational process. Thus, in an iterative design process, developers should work closely with instructors and a variety of student populations. Institutions of higher learning should make the required investments in professional growth and infrastructure, and legislators should set up explicit ethical guidelines to direct responsible innovation in this exciting area.

REFERENCES

- AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education. *Electronics*, 12(18), 3953. <https://doi.org/10.3390/electronics12183953>
- Anazia, E. K., Eti, E. F., Ovili, P. H., & Ogbimi, O. F. (2024). Speech-to-text: A secured real-time language translation platform for students. *FUDMA Journal of Sciences (FJS)*, 8(6), 329–338. <https://doi.org/10.33003/fjs-2024-0806-2890>
- Avila-Garzon, C., Bacca-Acosta, J., Kinshuk, Duarte, J., & Betancourt, J. (2021). Augmented reality in education: An overview of twenty-five years of research. *Contemporary Educational Technology*, 13(3), ep302. <https://doi.org/10.30935/cedtech/10865>
- Bezzaoucha, I. (2024). Augmented reality revolutionizing language services: An in-depth exploration. *International Journal of English Learning and Applied Linguistics (IJELAL)*, 4(2), 163–172. <http://dx.doi.org/10.21111/ijelal.v4i2.12024>
- Dhawan, S. (2022). Speech to speech translation: challenges and future. *International Journal of Computer Applications Technology and Research*, 11(03), 36–55. <https://doi.org/10.7753/IJCATR1103.1001>
- Ebadi, S., & Ashrafabadi, F. (2022). An exploration into the impact of augmented reality on EFL learners' reading comprehension. *Education and Information Technologies*, 27, 9745–9765. <https://doi.org/10.1007/s10639-022-11021-8>
- Fountoulakis, M. S. (2024). Evaluating the impact of AI tools on language proficiency and intercultural communication in second language education. *International Journal of Second and Foreign Language Education*, 3(1), 12–26. <https://doi.org/10.33422/ijfsfle.v3i1.768>
- Garzón, J. (2021). An overview of twenty-five years of augmented reality in education. *Multimodal Technologies and Interaction*, 5(7), 37. <https://doi.org/10.3390/mti5070037>
- Geng, X. (2024). Enhancing translation education through augmented reality (AR): An empirical analysis of effectiveness and engagement. *International Journal of Web-Based Learning and Teaching Technologies*, 19(1), 1–22. <https://doi.org/10.4018/IJWLTT.361651>
- Karacan, C. G., & Akoğlu, K. (2021). Educational augmented reality technology for language learning and teaching: A comprehensive review. *Shanlax International Journal of Education*, 9(2), 68–79. <https://doi.org/10.34293/education.v9i2.3715>
- Kot, S., & Nykyporets, S. (2024). Utilization of artificial intelligence in enhancing english language proficiency in tertiary education. In *Science and Education in the Third Millennium: Information Technology, Education, Law, Psychology, Social Sphere, Management* (pp. 244–268). <https://doi.org/10.5281/zenodo.11279390>

- Likith, P., Sahana, N. D., Puneeth, P., Niranthar, M., & Aruna, M. G. (2024). Implementation of real-time audio-to-text conversion and processing for seamless transformation in classroom environment. *International Journal of Innovative Science and Research Technology*, 9(9), 2328–2332. <https://doi.org/10.38124/ijisrt/IJISRT24SEP1335>
- Özyurt, S. (2024). AI-assisted English language learning for cross-cultural medical education in multilingual settings. *Experimental and Applied Medical Science*, 5(2), 83–92. <https://doi.org/10.46871/eams.1464830>
- Southwell, R., Pugh, S., Perkoff, E. M., Clevenger, C., Bush, J. B., Lieber, R., Ward, W., Foltz, P., & D’Mello, S. (2022). Challenges and feasibility of automatic speech recognition for modeling student collaborative discourse in classrooms. In A. Mitrovic & N. Bosch (Eds.), *Proceedings of the 15th International Conference on Educational Data Mining* (pp. 302–315). International Educational Data Mining Society. <https://doi.org/10.5281/zenodo.6853109>
- Svoboda, P., & Knihová, L. (2025). Exploring the future of education: Integrating metaverse and AI tools to enhance learning experiences. *TEM Journal*, 14(1), 631–643. <https://doi.org/10.18421/TEM141-56>
- Vakkalanka, S. (2024). AI-enhanced mixed reality in education: A systematic analysis of immersive learning technologies and student development outcomes. *International Journal of Research in Computer Applications and Information Technology (IJRCAIT)*, 7(2), 1252-1264. <https://doi.org/10.5281/zenodo.14169846>
- Vargas, E. G., Chiappe, A., & Durand, J. (2024). Reshaping education in the era of artificial intelligence: insights from Situated Learning related literature. *Journal of Social Studies Education Research*, 15(2), 1–28.
- Wedyan, M., Falah, J., Elshaweesh, O., Alfalah, S. F. M., & Alazab, M. (2022). Augmented reality-based english language learning: Importance and state of the art. *Electronics*, 11(2692). <https://doi.org/10.3390/electronics11172692>
- Xia, Y., Shin, S.-Y., & Kim, J.-C. (2024). Cross-cultural intelligent language learning system (CILS): Leveraging AI to facilitate language learning strategies in cross-cultural communication. *Applied Sciences*, 14, 5651. <https://doi.org/10.3390/app14135651>
- Zhao, Y., & Wang, Q. (2024). Applying augmented reality multimedia technology to construct a platform for translation and teaching system. *Heliyon*, 10, e28700. <https://doi.org/10.1016/j.heliyon.2024.e28700>

CONCLUSION

The six chapters included in this volume all point to one and only one thing, namely, the coming of artificial intelligence and the related technologies in the fields of education, business, and society are not a far-off event but a simple disruption. It is already in progress and it is fundamentally redefining what individuals, institutions and regulators should expect of these tools in order to protect human dignity and capture actual value of these tools.

In each of the chapters, the literature narrates a similar story of tension. Within the hyper-personalized realm, AI systems have shown a phenomenal ability to differentiate digital experiences at scale that no human team could be able to replicate - however, the same machine that makes recommendations feel naturally relevant also creates large-scale data ecosystems that are challenging to audit, govern, or secure. Privacy-by-design principle turns out to be the most promising solution of the field, yet it is much more of a hope than a reality. Regulation frameworks like GDPR and CCPA, despite their ambitious aims, remain behind the adaptive pace of AI-driven personalization and leave consumers in a discomposure state where their informed consent is oftentimes nominal at best.

Another form of structurally parallel tension is seen in gamification in computing and IT education. The intuition that game mechanics can be used to rejuvenate student interest in areas where the learning curve is steep and the attrition rate is high is supported by the evidence. However, the same review literature warns that greater activity does not necessarily result in deeper knowledge and that culture, motivation and design issues all interact in a way that may not be completely predicted by any single framework. Gamification is not a button that can be flipped by educators but a practice that needs to be tested, context sensitive, and continuously measured.

The chapter about immediate formulation and quality of the ChatGPT response, in its turn, carries its own didactic message: that the role of the human in the collaboration between humans and the AI is not passive, at all. The question asked will influence what an AI system can respond with, and the literature on prompt engineering is growing, suggesting that organizations and individuals that invest in that skill will draw meaningfully better responses out of the same underlying technology. It is an opportunity and equity issue, as the capability to use AI is not an issue of access to the tool itself.

The case study on managed expectations is presented in virtual reality and traditional online learning. The engagement and retention potential of VR has legitimate potential, but the expense, infrastructure, and pedagogical skills needed to effectively implement it are significant obstacles, especially to institutions in under-resource settings. Business social media, in its turn, shows how the tools created with connection in mind can also be used to increase brand reach and expose organizations to reputational, ethical, and regulatory risk in a way that outpaces governance.

Lastly, the investigation of AI-enhanced augmented reality to serve in real-time language translation in multi-cultural classrooms leads to one of possibly the most humanizing applications examined in this volume. When in place intelligently, these systems do not simply provide a technological overlay to a lesson delivered in a language that the student has not yet mastered with fluency. The empirical benefits of the controlled studies are large, but the chapter is also refreshingly candid about the ongoing realities of acoustic accuracy, cognitive load, data privacy and the digital divide that may turn a tool to inclusion into a tool to perpetuate inequity.

What is made evident by the volume as a whole is that the most consequential choices made regarding AI and the emergent digital technology are not necessarily chiefly technical.

They are choices concerning values: about who is benefited, who bears the risk, who is accountable, who is willing to move promptly between demonstration of the possibility to a just, sustainable practice at work. The scholars in the above discussion have made the challenging task of integrating evidence in cross-disciplinary and cross-situational settings. The more difficult task, of translating that evidence into policy, pedagogy and governance, now falls to those practitioners, regulators and educators who will decide what this technology moment will eventually become.

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