INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2025, VOL. 71, NO. 4, PP. 1-10
Manuscript received July 20, 2025; revised September 2025. doi: 10.24425/ijet.2025.155468

Integrating Quantum AI, Gamification, and Adaptive Storytelling in educational augmented reality: a systematic review

A. Rahman

***Abstract*—The convergence of Quantum Artificial Intelligence (QAI) with known educational technologies like Augmented Reality (AR), Gamification, and Adaptive Storytelling (AS) offers revolutionary learning experiences. While AR, Gamification, and AS have been demonstrably shown to enhance learner engagement and comprehension, especially in higher education in the STEM, language, and health domains, integrating them into a comprehensive, adaptive system that QAI can optimize remains a significant challenge. Currently, QAI applications in education are largely conceptual. This systematic literature review, following PRISMA guidelines, analyzed 42 relevant studies from Scopus (2015–2025) selected from an initial 976 studies. The findings confirm the pedagogical benefits of integrating AR, Gamification, and AS. In contrast, QAI implementation is hampered by technical constraints, pedagogical integration difficulties, and a lack of validated evaluation methodologies. Recognizing the potential of QAI-optimized adaptive learning necessitates closing the gap between existing practices and future aspirations via focused research, comprehensive framework development, expanded educator abilities, and strong multidisciplinary cooperation.**

***Keywords*—Quantum artificial intelligence; augmented reality; gamification; storytelling; educational technology**

I. Introduction

THE dynamic development of digital technology has introduced some changes in many spheres of life such as education [1], [2]. Artificial intelligence (AI), augmented reality (AR), and quantum computing as new technologies have opened the horizons of learning and made it more interactive, immersive, and adaptive [3], [4], [5], [6]. Technology is no longer a tool, but it is also a component of making relevant and personalized learning environment. This has changed learning paradigm to student-oriented as opposed to teacher-oriented learning [7], [8], [9], [10]. The problem is how to facilitate the learning process of the so-called digital generation, or digital natives, who are fast, interactive and individualized [11], [12], [13]. To address these requirements, they are applying the methods of gamification and adaptive storytelling to make students more motivated and engaged [14], [15], [16], [17], [18]. When used together with augmented reality, these strategies enable the establishment of multisensory learning scenarios, which break the boundaries between the material and the real world [19], [20], [21]. Nevertheless, a huge amount of work needs to be done, especially series of building genuinely reactive systems that could react to individual behavior of each student in real-time [22], [23].

This is where Quantum Artificial Intelligence (Quantum AI) becomes one of the solutions of the highest importance. Quantum AI represents an interdisciplinary topic that integrates the capabilities of more advanced quantum computing with smart decision-making of the AI [24], [25]. Entanglement, quantum annealing, and superposition are the principles that allow these systems to have very high efficiency in their processing of very complex and large data structures than they are in conventional computers [26], [27], [28]. This technology can significantly change the way adaptive learning working in an academic setting. To give an example, Quantum AI can optimize narrative evolution of active story depending on the preferences, performance, and emotional and cognitive cues of the student. The resulting product is an actual personal, predictive, and contextual learning system, which can react to data complexities that traditional systems find not easy to tackle.

Although AR and gamification technologies are well established, the role of Quantum AI in integrated learning systems remains theoretical and shows significant literature gaps [18], [20], [29], [30]. Its implementation does face challenges such as the lack of a design framework and the limitations of current quantum infrastructure [31], but the rapid development of quantum technology globally encourages the importance of building a conceptual foundation [32]. Therefore, this study aims through a systematic literature review to map the trends, challenges, and potential integration between Quantum AI, AR, gamification, and adaptive storytelling, to provide a comprehensive theoretical and practical foundation for educational technology developers in the future.

To provide direction for this research, the following research questions have been formulated:

TABLE I
Research Questions

Identifier	Description
RQ1	In which countries have most studies conducted on this integration?
RQ2	How is the distribution of study types (e.g., empirical, conceptual, review) regarding this integration?

Author is with Warsaw University of Technology, Poland (e-mail: a.rahman.dokt@pw.edu.pl).

RQ3	What are the main subject areas or domains where this integration is most widely studied or applied?
RQ4	At which level of education is this integration most applied or studied?
RQ5	What are the benefits of integrating Quantum AI, AR, gamification, and adaptive storytelling in education?
RQ6	What are the main types of solutions, applications, or frameworks proposed or developed based on this integration?
RQ7	What are the main challenges in implementing this integrated technology approach in education?

II. BACKGROUND

A. Quantum Artificial Intelligence in Education

Quantum Artificial Intelligence (Quantum AI) integrates quantum computing principles with AI methodologies, leveraging phenomena such as superposition, entanglement, and quantum annealing to process complex data more efficiently than classical computing [24], [25], [26]. In the educational domain, Quantum AI has the potential to develop advanced adaptive learning systems [27], [28] by addressing challenges in learning personalization [33] and combinatorial optimization [34], which are particularly relevant for creating adaptive storytelling systems that are responsive to students' cognitive states. While promising as a future engine for adaptive content through Augmented Reality (AR) and gamification, its implementation is hampered by a gap between concept and realization due to limitations of quantum hardware [35] and the lack of pedagogical frameworks. Therefore, current research directions often involve hybrid approaches, such as simulating quantum algorithms on classical hardware [36], to bridge this gap [37].

B. Gamification in Education

Gamification in education is the application of game elements in non-game contexts to increase student motivation and engagement [38], by integrating components such as points and narratives [39], [40]. Research has demonstrated its effectiveness in increasing active participation and persistence [41] through instant feedback and its ability to create a state of flow [42], [43], [44]. With approaches varying from simple [45] to complex [46], [47], gamification has proven effective in a variety of fields [48], [49], [50], [51], [52]. While promising, critical analysis highlights inconsistencies in findings and the risk of over-gamification [53]. To address this and fill the gap in frameworks that consider individual differences [54], research is now moving towards adaptive gamification that integrates AI technology to dynamically adjust game elements [55], [56], with further potential through integration with Quantum AI and AR.

C. Adaptive Storytelling for Learning and Instruction

Adaptive storytelling is a learning approach that uses dynamic narratives that evolve based on learner interactions [57], [58] to create more engaging experiences [59], [60]. By providing emotive and contextual experiences, this approach has been shown to deepen understanding and engagement [61], [62], [63], and its potential is further enhanced by Generative AI [64]. The key enabling technology is AI, which is capable of dynamically adapting narratives based on real-time emotional analysis [65] and has been applied in fields such as history [66], psychology [67], and healthcare [68]. However, fundamental challenges remain in balancing narrative freedom with learning objectives [69], while research linking narrative features to learning outcomes is still limited [70]. Current research directions point to integration with AI for emotional analysis [71], implementation in Augmented Reality (AR) environments [72], and greater transformative potential when augmented by the computing capabilities of Quantum AI [73].

D. Augmented Reality in Educational Environments

Augmented Reality (AR) has become a transformative technology in education by integrating virtual elements into physical environments to create interactive learning experiences [74]. Research has identified its pedagogical benefits, including enhanced contextual learning, cognitive engagement, and knowledge retention [75], with implementations varying from marker-based to more flexible marker less [76]. Despite its significant benefits and potential in areas ranging from science visualization [77] to bringing historical events to life [78], critical reviews have revealed limitations, such as the lack of clear design guidelines [79], technical constraints, usability issues, and potential cognitive overload [80]. These limitations are rooted in more fundamental issues, reflected in key research gaps, such as static and poorly adaptive systems [81], limited integration with artificial intelligence technologies and suboptimal instructional design [82]. This highlights the need to integrate AR with gamification, adaptive storytelling, and Quantum AI to create more personalized and meaningful learning experiences.

III. METHODOLOGY

A. Research Design

To answer the research questions and achieve the stated objectives, a systematic literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [83], a method chosen for its rigorous standards and proven success in various fields, including education, to provide comprehensive insights [84], [85], [86]. To conduct a scientifically rigorous study, the Scopus database was used as the primary source to identify related documents through a comprehensive combination of search keywords, as Scopus is widely recognized as one of the largest scientific databases covering peer-reviewed literature from various fields, thus guaranteeing relevant and high-quality coverage for this interdisciplinary topic [87].

B. Systematic Literature Review Process

This systematic literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [83]. Data collection occurred in March 2025, exclusively utilizing the Scopus database, with the publication year range restricted to 2015–2025 to ensure literature relevance and currency. The initial Identification phase involved employing three primary search query combinations targeting titles, abstracts, and keywords (TITLE-ABS-KEY) to capture studies intersecting:

1) **Augmented Reality (AR) and Gamification in Education:**
(TITLE-ABS-KEY (("augmented reality" OR "AR") AND (gamif* OR "game element") AND (education OR learning OR teaching)))
2) **Quantum AI or Computing (including Quantum Annealing or Optimization) in Education:**
(TITLE-ABS-KEY (("quantum ai" OR "quantum computing") AND ("quantum annealing" OR "quantum optimization") AND (education OR learning OR teaching)))
3) **Gamification and Adaptive Storytelling (or Interactive Narrative) in Education:**
(TITLE-ABS-KEY ((gamif* OR "game element") AND ("adaptive storytelling" OR "interactive narrative") AND (education OR learning OR teaching)))

Of the initial 976 documents, a Screening phase with sequential filters for publication year (2015–2025), subject area, and document type left 114 articles for eligibility assessment. Eligibility assessment through full-text reading, which verified substantial integration of the targeted technology combinations and other inclusion criteria, then excluded 72 articles. Ultimately, 42 studies met all requirements and were included in the qualitative synthesis, as illustrated in the PRISMA flowchart in Fig. 1. These 42 studies were categorized into three main types: empirical studies (27 articles, ≈ 64.3%), proposal and prototype development papers (11 articles, ≈ 26.2%), and review or conceptual papers (4 articles, ≈ 9.5%).

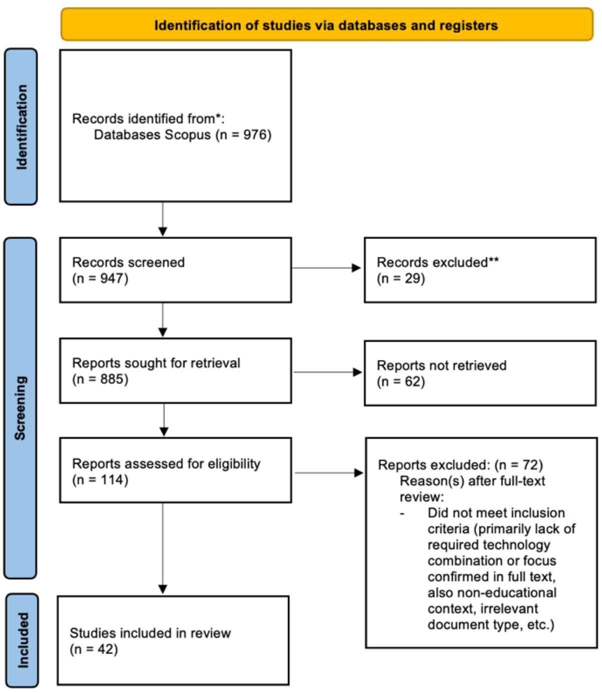

Fig. 1. Data collection and analysis – Prisma Method.

The review, conceptual, and theoretical papers (n=4) were analyzed in depth to identify their primary findings. For the proposal and prototype papers (n=11), their suggestions, guidelines, practices, focus areas, and findings were also examined and analyzed. The empirical studies (n=27) were analyzed and compared according to the following variables:

1) Country where the research was conducted.
2) Focus area/subject matter.
3) Educational level.
4) Technologies integrated.
5) Main research objective(s).
6) Design approach or methodology.
7) Main benefits of technology integration.
8) Findings related to the learning process.
9) Main challenges.

IV. Results

Qualitative analysis and synthesis [88] were conducted on the systematically extracted data from the selected studies in this literature review.

A. In which countries have most studies conducted on this integration?

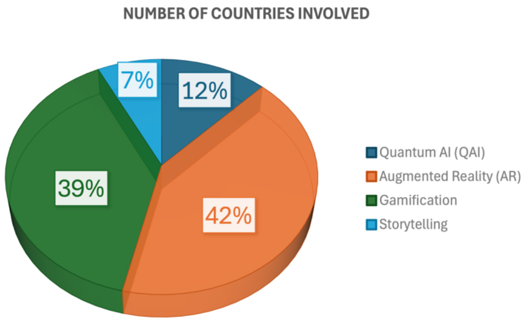

Fig. 2. Proportional Summary of Research Interest in Core Technologies

To understand the geographic distribution of research interest in the four core technologies, the detailed data in Table II and the proportional summary in Fig. 2 show that research on Augmented Reality and Gamification has the broadest geographic reach. These two technologies significantly dominate the global research landscape, representing approximately 42% and 39% of total country engagement, respectively, as confirmed by the participation of seventeen countries in the Augmented Reality study and sixteen countries in the Gamification study. In contrast, the other two technologies exhibit a narrower geographic focus: research on Quantum AI is concentrated in only five countries (China, India, Italy, the Netherlands, and the United States), representing approximately 12% of total engagement, while research activity related to Storytelling is even more limited, found in studies from only three countries (Canada, Greece, and Spain) and accounting for only 7% of overall country engagement. This pattern indicates that while Augmented Reality and Gamification have been widely accepted by the international research community, investigations into Quantum AI and Storytelling in integrated education contexts are still in the early stages of their geographic spread.

TABLE II
GEOGRAPHIC DISTRIBUTION OF STUDIES BY CORE TECHNOLOGY

Core Technology	Number of Countries Involved	Countries Conducting Studies	Related References
Augmented Reality (AR)	17	Brazil, Canada, China, Colombia, Finland, Greece, Hong Kong, India, Indonesia, Italy, Malaysia, Peru, Philippines, Portugal, Spain, Taiwan, Turkey	[98], [99], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127], [128], [129], [130]
Gamification	16	Brazil, Canada, China, Colombia, Finland, Greece, Hong Kong, India, Indonesia, Italy, Malaysia, Peru, Philippines, Portugal, Spain, Taiwan	[99], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [120], [121], [122], [123], [124], [126], [127], [128], [129], [130]
Quantum AI (QAI)	5	China, India, Italy, Netherlands, United States	[89], [90], [91], [92], [93], [94], [95], [96], [97]
Storytelling	3	Canada, Greece, Spain	[99], [106], [107], [114], [130]

B. How is the distribution of study types (e.g., empirical, conceptual, review) regarding this integration?

The data in Table III shows that the Experimental approach is the most dominant study type, comprising 13 studies, followed by Prototype Development Studies which are also common with 11 studies. A lower frequency is seen in Empirical Studies (n=5), while several other study types such as Systematic Reviews, Design-Based Research, and Case Studies are found in 3 studies each. The remainder includes Mixed Methods Studies (n=2), Survey Studies (n=1), and Concept Development Studies (n=1). This distribution indicates that research in technology integration is currently driven by experimental investigations of impact or effectiveness as well as concrete efforts in developing new applications or prototypes.

TABLE III
STUDY TYPE DISTRIBUTION

Study Type	Number of Studies
Experimental Research / Study	13
Prototype Development Study	11
Empirical Study	5
Systematic Review	3
Design-Based Research	3
Case Study	3
Mixed Methods Study	2
Survey Study	1
Concept Development Study	1

C. What are the main subject areas or domains where this integration is most widely studied or applied?

Based on Fig. 3, the distribution of the 42 studies analyzed shows a dominance in the domains of Computer Science, Quantum Technologies, and Related AI (9 studies), followed by general educational technology and platforms (7 studies). Other prominent areas are Language and Literacy Education (6 studies), as well as STEM Education, Health Education, and Humanities, each with 5 studies. Domains with a narrower focus include special education (2 studies), as well as vocational education, home-based education, and orientation learning, each with one study.

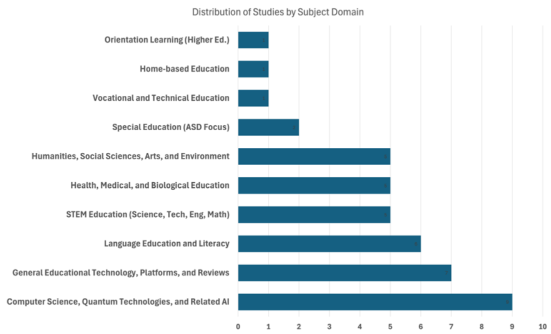

Fig. 3. Distribution of Studies by Subject Domain.

This distribution highlights the intense concentration on basic computing technologies and general research on technology platforms for education, alongside significant exploration across core educational subject areas such as language, STEM, health, and humanities in the reviewed literature.

D. At which level of education is this integration most applied or studied?

The data in Fig. 4 shows that Higher Education is the most dominant level studied, accounting for 29 studies. 7 studies focus on primary education, the next most common focus. 3 studies target secondary education. Significantly fewer studies focus on other levels. Only 1 study represents early childhood education, special education, and elementary to higher studies in this dataset.

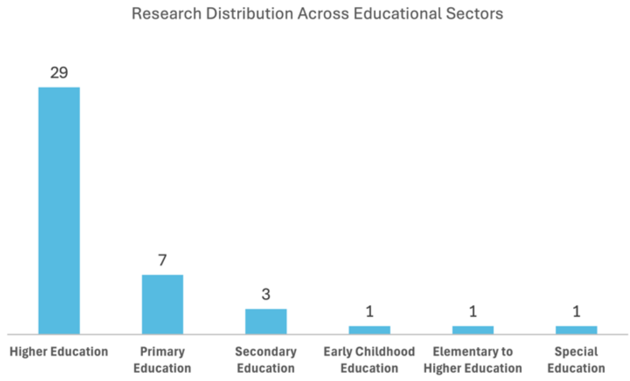

Fig. 4. Distribution of Studies by Education Level.

This distribution strongly indicates that research and implementation efforts related to technology integration have been heavily concentrated in the higher education sector, with significantly less exploration of elementary, secondary, or special education contexts.

E. What are the benefits of integrating Quantum AI, AR, gamification, and adaptive storytelling in education?

Table IV presents a synthesis of the key benefits from the 42 studies analyzed, with the most prominent and consistent finding being significant improvements in student engagement, motivation, and learning outcomes, including conceptual understanding and knowledge retention. Furthermore, the potential for personalized learning experiences through adaptive pathways and the development of 21st-century skills were also frequently identified as key findings, with these benefits ranging from immediate impacts on students to the potential for developing adaptive education systems in the future.

TABLE IV
BENEFITS OF INTEGRATING QUANTUM AI, AR, GAMIFICATION, AND STORYTELLING IN EDUCATION

Main Benefit Category	Description / Specific Examples	Supporting References
Increased Engagement, Motivation and Interest	Creates engaging, fun, interactive, and immersive experiences. Increases participation, interest, satisfaction, and positive attitudes or emotions. Fulfills Self Determination Theory needs.	[98], [99], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [113], [114], [115], [116], [117], [118], [119], [120], [121], [123], [124], [125], [127], [128], [129], [130]
Improved Learning Outcomes and Concept Understanding	Enhances conceptual understanding, knowledge retention, and academic performance. Facilitates visualization of abstract or complex concepts. Improves learning quality and effectiveness.	[101], [103], [104], [105], [106], [112], [113], [118], [119], [128]
21st Century Skills Development	Develops practical skills, problem solving, critical thinking, collaboration, creativity, communication skills including for students with ASD, and social media literacy. Fosters computational thinking.	[99], [101], [102], [104], [106], [109], [113], [115], [121], [129], [130]
Personalization and Adaptive Learning	Enables personalized experiences and adaptive pathways. Supports learning at one's own pace and self-guided learning, fostering student autonomy. Shows potential for learning optimization.	[94], [100], [106], [109], [110], [111], [112], [115], [121], [126], [128]
Enhanced Learning Accessibility and Flexibility	Offers flexible access, for instance through mobile devices. Assists learners with special needs, such as students with ASD. Provides user friendly tools suitable for various ages.	[100], [108], [111], [121], [125], [130]
Advanced Computing Potential (Quantum)	Demonstrates feasibility for AI and machine learning tasks such as Reinforcement Learning, Clustering, and Optimization. Offers potential for speedup or new capabilities for educational technology. Includes potential data security benefits.	[89], [90], [91], [92], [93], [94], [95], [97]
Educator Competency Development & Support	Develops teacher competencies like transmedia, digital, and creative skills. Facilitates the co design of relevant applications.	[99], [122]

F. What are the main types of solutions, applications, or frameworks proposed or developed based on this integration?

Fig. 5 summarizes the proportion of the main output focuses of the reviewed studies, showing that the development of Specific Applications based on Augmented Reality and Gamification (40%) and the development of Design Frameworks or Methodologies (29%) are the most dominant. Smaller proportions are dedicated to the proposal of quantum methods (17%), the provision of Recommendations or Reviews (12%), and the development of meta-learning models and Datasets (2%). This distribution underscores the strong current research orientation on the development of applied solutions and conceptual frameworks, followed by the exploration of quantum computing methods.

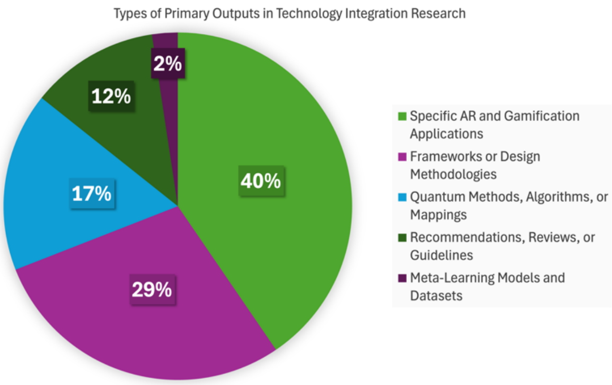

Fig. 5. Distribution of Primary Research Outputs

G. What are the main challenges in implementing this integrated technology approach in education?

To understand the distribution and relative emphasis of various challenges in implementing an integrated technology approach in education, we can refer to the detailed list of study references in Table V and Fig. 6 below.

TABLE V
CHALLENGES OF IMPLEMENTING AN INTEGRATED TECHNOLOGY APPROACH IN EDUCATION

Challenge	Study
Pedagogy and Instructional Design	[89], [91], [92], [93], [97], [99], [100], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [113], [114], [116], [117], [118], [119], [120], [121], [122], [124], [125], [127], [128], [130]
Technical and Infrastructure	[89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [100], [101], [102], [103], [104], [109], [112], [113], [114], [120], [124], [125], [126], [127], [128], [130]
Research and Evaluation	[89], [90], [91], [92], [93], [95], [96], [97], [99], [105], [106], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [121], [122], [123], [127], [129]
Teacher and Learner Factors	[98], [100], [101], [103], [104], [105], [107], [108], [109], [110], [111], [113], [114], [115], [116], [117], [118], [119], [121], [122], [124], [129]
Ethics and Accessibility	[94], [100], [111], [112], [116], [120]
Cost and Resources	[94], [100], [101], [108], [112]

The visual representation in Fig. 6 clearly shows that challenges related to Pedagogy and Instructional Design (27%) were the most prominent, followed by Technical and Infrastructure Issues (23%), Research and Evaluation (22%), and Teacher and Learner Factors (19%). These four categories collectively accounted for 91% of the total challenges reported, with this high frequency of mention supported by the large number of studies listed in Table V. In contrast, challenges related to Ethics and Accessibility (5%) and Cost and Resources (4%) were reported much less frequently, indicating that despite their importance, these issues are less recognized as major barriers by the research community within the reviewed literature.

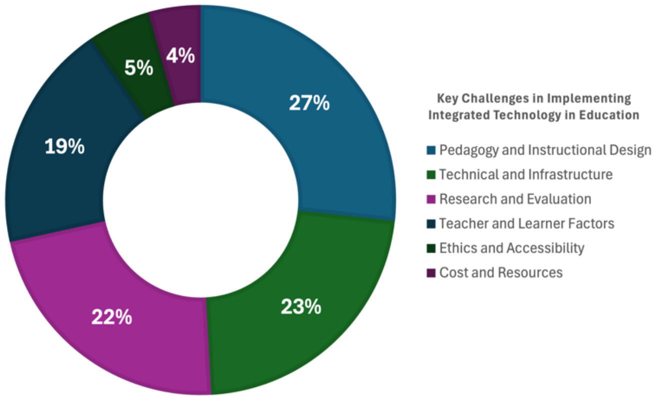

Fig. 6. Distribution of Reported Implementation Challenges by Category.

V. DISCUSSION

This study examines the integration of Quantum Artificial Intelligence (QAI), Augmented Reality (AR), Gamification, and Adaptive Storytelling (AS), revealing a dynamic field but with a large gap between theoretical potential (particularly QAI) and practical implementation. The integration of AR, Gamification, and AS has been shown to improve engagement and learning outcomes (Table IV), although the research has concentrated on Higher Education (Fig. 4) and specific domains (Fig. 3, Table II), thus limiting its generalizability. The realization of truly adaptive systems is hampered by the immaturity of QAI, with technical challenges such as hardware limitations and algorithmic complexity [89]-[97], [90], [91], [97], [131]. Furthermore, pedagogical challenges are also significant (Table V, Fig. 6), including instructional design needs, evaluation frameworks [93], [96], as well as ethical issues [94], [122] and under-reported accessibility (Fig. 6). Nevertheless, the theoretical potential of QAI for real-time optimization remains enormous [89], [94], and overcoming these obstacles requires continued interdisciplinary investment.

VI. LIMITATIONS

This systematic literature review (SLR) follows the consistent PRISMA methodology [83], but it is important to acknowledge the inevitable degree of subjectivity, such as in the definition of search terms and the specific query combinations used. Furthermore, while thematic analysis [88] and data synthesis were conducted systematically, the interpretation and categorization of findings still carry the potential for subjectivity in the analysis and reporting. The search period used, 2015 to 2025, was chosen to ensure the relevance of the literature, but this temporal scope naturally limits the review to that period and excludes publications outside that timeframe, while each search technique also has inherent limitations in a dynamic, interdisciplinary domain. Given the broad research objective of understanding the trends, challenges, and potential synergies of integrating these four technologies, in-depth analysis of each sub-combination could be the focus of a future SLR. Nonetheless, this broad scope allows the current study to map the overall landscape, highlight potential synergies, and articulate the key challenges associated with the complex effort to integrate these four technologies in an educational context, as discussed in the previous section, while also underscoring the promising potential of this integration for future education.

VII. Conclusion

This paper aims to offer insights into the state of multidisciplinary research on the integration of Quantum Artificial Intelligence, Augmented Reality, Gamification, and Adaptive Storytelling in educational settings, with valuable insights for educators and technology developers. The review highlights that the integration of Augmented Reality, Gamification, and Adaptive Storytelling offers significant benefits to the learning process, including increased student engagement and motivation, improved learning outcomes, the development of 21st-century skills, and opportunities for personalization and accessibility. To facilitate this integration, a common approach is the development of specific applications and the design of integrated frameworks, although exploration of Quantum AI methods is currently still conceptual. However, successful implementation depends not only on technical tools but also on crucial non-technical factors such as careful pedagogical design, addressing technical limitations (especially for Quantum AI), developing valid evaluation methods, and attention to readiness and acceptance by educators and students. Ultimately, the literature surveyed demonstrates a gap between established practices and the future potential of Quantum AI, and bridging this gap requires sustained interdisciplinary efforts, investment in basic research, deliberate pedagogical design, and thorough evaluation and ethical considerations to guide the transformative power of this technology.

VIII. Acknowledgment

The author would like to express his deepest gratitude to the editor, associate editors, and reviewers for their valuable comments and constructive suggestions, which have significantly improved the quality of this work.

References

[1] M. T. Matriano, "Balancing of Skills in the Digital Transformation of Education and Employability," SHS Web of Conferences, vol. 156, p. 08004, 2023, https://doi.org/10.1051/shsconf/202315608004

[2] I. L. Khalid, M. N. S. Abdullah, and H. Mohd Fadzil, "A Systematic Review: Digital Learning in STEM Education," Journal of Advanced Research in Applied Sciences and Engineering Technology, vol. 51, no. 1, pp. 98–115, Sep. 2024, https://doi.org/10.37934/araset.51.1.98115

[3] K. Rädel-Ablass et al., "Teaching opportunities for anamnesis interviews through AI based teaching role plays: a survey with online learning students from health study programs," BMC Med Educ, vol. 25, no. 1, p. 259, Dec. 2025, https://doi.org/10.1186/s12909-025-06756-0

[4] A. Coban, D. Dzsotjan, S. Küchemann, J. Durst, J. Kuhn, and C. Hoyer, "AI support meets AR visualization for Alice and Bob: personalized learning based on individual ChatGPT feedback in an AR quantum cryptography experiment for physics lab courses," EPJ Quantum Technol, vol. 12, no. 15, 2025, https://doi.org/10.1140/epjqt/s40507-025-00310-z

[5] Dr. R. Campbell, Dr. W. Diffie, and C. Robinson, "Advancements in Quantum Computing and AI May Impact PQC Migration Timelines," Feb. 2024, https://doi.org/10.20944/PREPRINTS202402.1299.V1

[6] X. Xiaoning, M. Md Yunus, and K. R. M. Rafiq, "Use of VR in Higher Education: A Systematic Review (2014-2023)," International Journal of Academic Research in Progressive Education and Development, vol. 13, no. 1, 2024, https://doi.org/10.6007/ijarped/v13-i1/20659

[7] S. Guizani, T. Mazhar, T. Shahzad, W. Ahmad, A. Bibi, and H. Hamam, "A systematic literature review to implement large language model in higher education: issues and solutions," Discover Education, vol. 4, no. 35, 2025, https://doi.org/10.1007/s44217-025-00424-7

[8] A. Tay, H. Huijser, S. Dart, and A. Cathcart, "Learning technology as contested terrain: Insights from teaching academics and learning designers in Australian higher education," Australasian Journal of Educational Technology, vol. 39, no. 1, pp. 56–70, 2023, https://doi.org/https://doi.org/10.14742/ajet.8179.

[9] A. W. T. Lo, "The educational affordances and challenges of generative AI in Global Englishes-oriented materials development and implementation: A critical ecological perspective," System, vol. 130, 2025, https://doi.org/10.1016/j.system.2025.103610

[10] Z. Mohammadi Zenouzagh, W. Admiraal, and N. Saab, "Learner autonomy, learner engagement and learner satisfaction in text-based and multimodal computer mediated writing environments," Educ Inf Technol (Dordr), vol. 28, no. 11, pp. 14283–14323, 2023, https://doi.org/10.1007/s10639-023-11615-w

[11] E. M. Manurung, Y. S. Purwadi, and I. B. Sugiharto, "Digital Learning Process: Challenges for Specific Creativity," The Electronic Journal of e-Learning, vol. 20, no. 2, pp. 112–119, 2022, [Online]. Available: www.ejel.org.

[12] H. Akram and A. H. Abdelrady, "Examining the role of ClassPoint tool in shaping EFL students' perceived E-learning experiences: A social cognitive theory perspective," Acta Psychol (Amst), vol. 254, 2025, https://doi.org/10.1016/j.actpsy.2025.104775

[13] H. Wiesel, "How to transfer knowledge to Generation Z," Safety of Nuclear Waste Disposal, vol. 2, pp. 237–238, 2023, https://doi.org/10.5194/sand-2-237-2023

[14] I. Întorsureanu, S. V. Oprea, A. Bâra, and D. Vespan, "Generative AI in Education: Perspectives Through an Academic Lens," Electronics (Switzerland), vol. 14, no. 5, 2025, https://doi.org/10.3390/electronics14051053

[15] W. Oliveira et al., "The effects of personalized gamification on students' flow experience, motivation, and enjoyment," Smart Learning Environments, vol. 9, no. 16, 2022, https://doi.org/10.1186/s40561-022-00194-x

[16] D. Sousa, A. Coelho, M. F. Torres, A. R. Garcia, and T. Rossini, "Adaptability and Procedural Content Generation for Educational Escape Rooms," in Proceedings of the 16th European Conference on Games Based Learning, 2022, pp. 766–773.

[17] F. Anderle, A. Cattoni, P. Venuti, and A. Pasqualotto, "Exploring the impact and acceptability of gamified tools to address educational needs in decoding and writing skills: A pilot study," Res Dev Disabil, vol. 160, pp. 1–14, 2025, https://doi.org/10.1016/j.ridd.2025.104967

[18] A. Pandian, S. B. Baboo, and L. J. Yi, "Digital storytelling: Engaging young people to communicate for digital media literacy," Jurnal Komunikasi: Malaysian Journal of Communication, vol. 36, no. 1, pp. 187–204, 2020, https://doi.org/10.17576/JKMJC-2020-3601-11

[19] S. Hadjistassou, S. Joannidou, P. Molina, P. Louca, and L. Papmehl-Dufay, "Developing augmented reality applications to promote digital storytelling: The cases of Choirokoitia and Sandby Borg," Education for Information, vol. 39, no. 2, pp. 187–201, 2023, https://doi.org/10.3233/efi-230030

[20] A. Predescu and M. Mocanu, "Gamification in Real-World Applications: Interactive Maps and Augmented Reality," in Level Up! Exploring Gamification's Impact on Research and Innovation, IntechOpen, 2024. https://doi.org/10.5772/intechopen.1004870

[21] N. H. Rahani, A. A. Bilong, and M. R. Mat Suruji, "Learning Logic Gates Using Augmented Reality," International Journal of Multimedia and Recent Innovation, vol. 2, no. 1, pp. 26–44, 2020, https://doi.org/10.36079/lamintang.ijmari-0201.81

[22] M. T. Alshammari, “Design and evaluation of an adaptive framework for virtual learning environments,” International Journal of Advanced and Applied Sciences, vol. 7, no. 5, pp. 39–51, 2020, https://doi.org/10.21833/ijaas.2020.05.006

[23] A. A. Munshi and A. Alhindi, “Big Data Platform for Educational Analytics,” IEEE Access, vol. 9, pp. 52883–52890, 2021, https://doi.org/10.1109/ACCESS.2021.3070737

[24] S. Wang, N. Wang, T. Ji, Y. Shi, and C. Wang, “Research Progress of Quantum Artificial Intelligence in Smart City,” Intelligent and Converged Networks, vol. 5, no. 2, pp. 116–133, 2024, https://doi.org/10.23919/ICN.2024.0009

[25] M. L. How and S. M. Cheah, “Forging the Future: Strategic Approaches to Quantum AI Integration for Industry Transformation,” AI (Switzerland), vol. 5, no. 1, pp. 290–323, 2024, https://doi.org/10.3390/ai5010015

[26] B. Wu, “Classical Computer, Quantum Computer, and the Gödel’s Theorem,” in Frank Wilczek, WORLD SCIENTIFIC, 2022, pp. 281–290. https://doi.org/10.1142/9789811251948_0021

[27] Y. Tao, “Quantum entanglement: Principles and research progress in quantum information processing,” Theoretical and Natural Science, vol. 30, pp. 263–274, 2024, https://doi.org/10.54254/2753-8818/30/20241130

[28] S. H. Sack and M. Serbyn, “Quantum annealing initialization of the quantum approximate optimization algorithm,” Quantum, vol. 5, Jul. 2021, https://doi.org/10.22331/Q-2021-07-01-491

[29] A. Gill et al., “Implementing Universal Design through augmented-reality game-based learning,” Computers & Education: X Reality, vol. 4, pp. 2–10, 2024, https://doi.org/10.1016/j.cexr.2024.100070

[30] S. Alneyadi and Y. Wardat, “Integrating ChatGPT in Grade 12 Quantum Theory Education: An Exploratory Study at Emirate School (UAE),” International Journal of Information and Education Technology, vol. 14, no. 3, pp. 398–410, 2024, https://doi.org/10.18178/ijiet.2024.14.3.2061

[31] T. S. Humble, A. McCaskey, D. I. Lyakh, M. Gowrishankar, A. Frisch, and T. Monz, “Quantum Computers for High-Performance Computing,” IEEE Micro, vol. 41, no. 5, pp. 15–23, 2021, https://doi.org/10.1109/MM.2021.3099140

[32] V. Hassija et al., “Present landscape of quantum computing,” IET Quantum Communication, vol. 1, no. 2, pp. 42–48, 2020, https://doi.org/10.1049/iet-qtc.2020.0027.

[33] Y. Zhou, C. C. Xu, M. Song, and Y. K. Wong, “Quantum-Powered Personalized Learning,” ArXiv, vol. abs/2408.15287, 2024, [Online]. Available: https://api.semanticscholar.org/CorpusID:271974483.

[34] S. Yarkoni, E. Raponi, T. Bäck, and S. Schmitt, “Quantum annealing for industry applications: introduction and review,” Reports on Progress in Physics, no. 10, 2022, https://doi.org/10.1088/1361-6633/ac8c54

[35] E. G. Rieffel et al., “Assessing and advancing the potential of quantum computing: A NASA case study,” Future Generation Computer Systems, vol. 160, pp. 598–618, 2024, https://doi.org/10.1016/j.future.2024.06.012

[36] S. Yamazaki, F. Uchida, K. Fujisawa, and N. Yoshida, “Quantum algorithm for collisionless Boltzmann simulation of self-gravitating systems,” Comput Fluids, vol. 288, 2025, https://doi.org/10.1016/j.compfluid.2024.106527

[37] A. Ajagekar and F. You, “Quantum computing and quantum artificial intelligence for renewable and sustainable energy: A emerging prospect towards climate neutrality,” Renewable and Sustainable Energy Reviews, vol. 165, 2022, https://doi.org/10.1016/j.rser.2022.112493

[38] H. Balalle, “Exploring student engagement in technology-based education in relation to gamification, online/distance learning, and other factors: A systematic literature review,” Social Sciences and Humanities Open, vol. 9, 2024, https://doi.org/10.1016/j.ssaho.2024.100870

[39] E. D. Mekler, F. Brühlmann, A. N. Tuch, and K. Opwis, “Towards understanding the effects of individual gamification elements on intrinsic motivation and performance,” Comput Human Behav, vol. 71, pp. 525–534, 2017, https://doi.org/10.1016/j.chb.2015.08.048

[40] M. Denden, A. Tlili, F. Essalmi, M. Jemni, N. S. Chen, and D. Burgos, “Effects of gender and personality differences on students’ perception of game design elements in educational gamification,” International Journal of Human Computer Studies, vol. 154, 2021, https://doi.org/10.1016/j.ijhcs.2021.102674

[41] B. Nguyen-Viet and B. Nguyen-Viet, “The synergy of immersion and basic psychological needs satisfaction: Exploring gamification’s impact on student engagement and learning outcomes,” Acta Psychol (Amst), vol. 252, 2025, https://doi.org/10.1016/j.actpsy.2024.104660

[42] H. Ogino and H. Matsuguma, “Effective Implementation of Feedback in Gamification Verifying the utility of feedback to induce behavior,” International Journal of Asia Digital Art and Design, vol. 28, no. 2, pp. 9–17, 2024.

[43] W. Oliveira, J. Hamari, and S. Isotani, “The Relationship between Users’ Behavior and Their Flow Experience in Gamified Systems,” Proc ACM Hum Comput Interact, vol. 7, 2023, https://doi.org/10.1145/3611032

[44] W. Oliveira, K. Tenório, J. Hamari, O. Pastushenko, and S. Isotani, “Predicting students’ flow experience through behavior data in gamified educational systems,” Smart Learning Environments, vol. 8, no. 1, 2021, https://doi.org/10.1186/s40561-021-00175-6

[45] J. Xu et al., “Psychological interventions of virtual gamification within academic intrinsic motivation: A systematic review,” J Affect Disord, vol. 293, pp. 444–465, 2021, https://doi.org/10.1016/j.jad.2021.06.070

[46] B. Yu and W. Wang, “Using digital storytelling to promote language learning, digital skills and digital collaboration among English pre-service teachers,” System, vol. 129, Apr. 2025, https://doi.org/10.1016/j.system.2024.103577

[47] D. Xu, J. Read, and J. Allen, “Exploring the Effects of Progression Mechanics in Competitive and Collaborative Gamified Learning,” in 17th European Conference on Games Based Learning, University of Twente, Enschede, Netherlands, 2023. Accessed: Apr. 07, 2025. [Online]. Available: https://clok.uclan.ac.uk/49163/.

[48] E. Boom-Cárcamo, L. Buelvas-Gutiérrez, L. Acosta-Oñate, and D. Boom-Cárcamo, “Gamification and problem-based learning (PBL): Development of creativity in the teaching-learning process of mathematics in university students,” Think Skills Creat, vol. 53, 2024, https://doi.org/10.1016/j.tsc.2024.101614

[49] M. Kalogiannakis, S. Papadakis, and A. I. Zourmpakis, “Gamification in science education. A systematic review of the literature,” Educ Sci (Basel), vol. 11, no. 1, pp. 1–36, 2021, https://doi.org/10.3390/educsci11010022

[50] D. Rawendy, Y. Ying, Y. Arifin, and K. Rosalin, “Design and Development Game Chinese Language Learning with Gamification and Using Mnemonic Method,” in Procedia Computer Science, Elsevier B.V., 2017, pp. 61–67. https://doi.org/10.1016/j.procs.2017.10.009

[51] E. Namaziandost, F. Çakmak, and P. Ashkani, “How do you feel? Unmasking ambiguity tolerance, learning adaptability, self-management, and learning outcomes in gamification vs. ludicization in foreign language learning,” Computers in Human Behavior Reports, vol. 18, May 2025, https://doi.org/10.1016/j.chbr.2025.100651

[52] P. Sanz-Angulo, J. Galindo-Melero, S. De-Diego-Poncela, and Ó. Martín, “Promoting soft skills in higher engineering education: Assessment of the impact of a teaching methodology based on flipped learning, cooperative work and gamification,” Educ Inf Technol (Dordr), 2025, https://doi.org/10.1007/s10639-025-13322-0

[53] E. Mårell-Olsson, “Teachers’ Perception of Gamification as a Teaching Design,” Interaction Design and Architecture(s), no. 53, pp. 70–100, 2022, https://doi.org/10.55612/s-5002-053-004

[54] A. C. G. Santos et al., “The relationship between user types and gamification designs,” User Model User-adapt Interact, vol. 31, pp. 907–940, 2021, https://doi.org/10.1007/s11257-021-09300-z

[55] A. I. Zourmpakis, M. Kalogiannakis, and S. Papadakis, “Adaptive Gamification in Science Education: An Analysis of the Impact of implementation and Adapted game Elements on Students’ Motivation,” Computers, vol. 12, no. 7, 2023, https://doi.org/10.3390/computers12070143

[56] G. P. Bharathi, I. Chandra, D. P. R. Sanagana, C. K. Tummalachervu, V. S. Rao, and S. Neelima, “AI-driven adaptive learning for enhancing business intelligence simulation games,” Entertain Comput, vol. 50, 2024, https://doi.org/10.1016/j.entcom.2024.100699

[57] B. Yousuf and O. Conlan, “Supporting Student Engagement Through Explorable Visual Narratives,” IEEE Transactions on Learning Technologies, vol. 11, no. 3, pp. 307–320, 2018, https://doi.org/10.1109/TLT.2017.2722416

[58] E. S. de Lima, B. Feijó, and A. L. Furtado, “Adaptive storytelling based on personality and preference modeling,” Entertain Comput, vol. 34, 2020, https://doi.org/10.1016/j.entcom.2020.100342

[59] C. Khundam and F. Noël, “Storytelling framework with adaptive interaction system for interactive content in virtual museum,” ECTI Transactions on Computer and Information Technology, vol. 15, no. 1, pp. 34–49, 2021, https://doi.org/10.37936/ecti-cit.2021151.239948

[60] J. Zhang and Y. Liu, "Exploration of Emotion Perception in Serious Interactive Digital Narrative," Comput Intell Neurosci, vol. 2022, 2022, https://doi.org/10.1155/2022/8160695

[61] V. Kumaran, J. Rowe, B. Mott, and J. Lester, "SceneCraft: Automating Interactive Narrative Scene Generation in Digital Games with Large Language Models," AIIDE, vol. 19, no. 1, pp. 86–96, 2022, https://doi.org/https://doi.org/10.1609/aiide.v19i1.27504.

[62] M. Bellini, "Interactive Digital Narratives as Complex Expressive Means," Front Virtual Real, vol. 3, 2022, https://doi.org/10.3389/frvir.2022.854960

[63] B. Gillespie, "Using Digital Storytelling and Game-Based Learning to Increase Student Engagement and Connect Theory with Practice," Teaching and Learning Inquiry, vol. 10, 2022, https://doi.org/10.20343/TEACHLEARNINQU.10.14

[64] H. Gerba, "Universal Narrative Model: an Author-centric Storytelling Framework for Generative AI," arXiv preprint arXiv:2503.04844, 2025, [Online]. Available: http://arxiv.org/abs/2503.04844.

[65] D. Neelima, D. H. Sudharshan, P. Priyanka, G. C. Naidu, H. Periyala, and T. Satvika, "A Smart Story Telling Model with Emotion-Based Enunciation," Journal of Nonlinear Analysis and Optimization, vol. 15, no. 1, 2024.

[66] L. Tong, R. W. Lindeman, H. Lukosch, R. Clifford, and H. Regenbrecht, "Applying Cinematic Virtual Reality with Adaptability to Indigenous Storytelling," Journal on Computing and Cultural Heritage, vol. 17, no. 2, pp. 1–25, 2024, https://doi.org/10.1145/3647996

[67] P. Paudyal et al., "Coproducing a culturally sensitive storytelling video intervention to improve psychosocial well-being: a multimethods participatory study with Nepalese migrant workers," BMJ Open, vol. 15, no. e086280, 2025, https://doi.org/10.1136/bmjopen-2024-086280

[68] C. Ingram, "Storytelling in Medical Education, Clinical Care, and Clinician Well-Being," Archives of Medicine and Health Sciences, vol. 9, no. 2, pp. 337–344, 2021, https://doi.org/10.4103/amhs.amhs_289_21

[69] M. Gaeta, V. Loia, G. R. Mangione, F. Orciuoli, P. Ritrovato, and S. Salerno, "A methodology and an authoring tool for creating Complex Learning Objects to support interactive storytelling," Comput Human Behav, vol. 31, no. 1, pp. 620–637, 2014, https://doi.org/10.1016/j.chb.2013.07.011

[70] E. Naul and M. Liu, "Why Story Matters: A Review of Narrative in Serious Games," Journal of Educational Computing Research, vol. 58, no. 3, pp. 687–707, 2020, https://doi.org/10.1177/0735633119859904

[71] L. E. Arenas-Deseano, J. M. Ramirez-Cortes, J. Rangel-Magdaleno, and I. Cruz-Vega, "Real-Time Multiplatform Emotion Classification Using CNN in a Fog Computing Environment," IEEE Access, vol. 12, pp. 139988–139997, 2024, https://doi.org/10.1109/ACCESS.2024.3450633

[72] A. Javanbakht, L. Hinchey, K. Gorski, A. Ballard, L. Ritchie, and A. Amirsadri, "Unreal that feels real: artificial intelligence-enhanced augmented reality for treating social and occupational dysfunction in post-traumatic stress disorder and anxiety disorders," Eur J Psychotraumatol, vol. 15, no. 1, 2024, https://doi.org/10.1080/20008066.2024.2418248

[73] E. D. Payares and J. C. Martinez-Santos, "Parallel Quantum Computation Approach for Quantum Deep Learning and Classical-Quantum Models," in Journal of Physics: Conference Series, IOP Publishing Ltd, 2021. https://doi.org/10.1088/1742-6596/2090/1/012171

[74] Dr. S. F, Mahesh, Indrani, and Laxmi, "Augmented Reality in Education," Int J Res Appl Sci Eng Technol, vol. 10, no. 9, pp. 1734–1739, 2022, https://doi.org/10.22214/ijraset.2022.46915

[75] P. Dhar, T. Rocks, R. M. Samarasinghe, G. Stephenson, and C. Smith, "Augmented reality in medical education: students' experiences and learning outcomes," Med Educ Online, vol. 26, no. 1, 2021, https://doi.org/10.1080/10872981.2021.1953953

[76] A. S. Tiwari and K. Kumar Bhagat, "Comparative Analysis of Augmented Reality in Engineering Drawing Course: Assessing Spatial Visualization and Cognitive Load with Marker-Based, Markerless, and Web-Based Approaches," Australasian Journal of Educational Technology, vol. 40, no. 6, pp. 19–36, 2024.

[77] M. Hincapie, C. Diaz, A. Valencia, M. Contero, and D. Güemes-Castorena, "Educational applications of augmented reality: A bibliometric study," Computers and Electrical Engineering, vol. 93, 2021, https://doi.org/10.1016/j.compeleceng.2021.107289

[78] D. Basumatary and R. Maity, "Effects of Augmented Reality in Primary Education: A Literature Review," Hum Behav Emerg Technol, vol. 2023, 2023, https://doi.org/10.1155/2023/4695759

[79] A. A. Ziden, A. A. A. Ziden, and A. E. Ifedayo, "Effectiveness of Augmented Reality (AR) on Students' Achievement and Motivation in Learning Science," Eurasia Journal of Mathematics, Science and Technology Education, vol. 18, no. 4, 2022, https://doi.org/10.29333/ejmste/11923

[80] X. Geng, "Enhancing Translation Education Through Augmented Reality (AR): An Empirical Analysis of Effectiveness and Engagement," International Journal of Web-Based Learning and Teaching Technologies, vol. 19, no. 1, 2024, https://doi.org/10.4018/IJWLTT.361651

[81] C. Papakostas, C. Troussas, A. Krouska, and C. Sgouropoulou, "Personalization of the Learning Path within an Augmented Reality Spatial Ability Training Application Based on Fuzzy Weights," Sensors, vol. 22, no. 18, 2022, https://doi.org/10.3390/s22187059

[82] A. Zouhri and M. El Mallahi, "Improving Teaching Using Artificial Intelligence and Augmented Reality," Journal of Automation, Mobile Robotics and Intelligent Systems, vol. 18, no. 2, pp. 57–61, 2024, https://doi.org/10.14313/jamris/2-2024/13

[83] M. J. Page et al., "PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews," The BMJ, vol. 372, 2021, https://doi.org/10.1136/bmj.n160

[84] M. L. Rethlefsen et al., "PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews," Journal of the Medical Library Association, vol. 109, no. 2, pp. 174–200, Jul. 2021, https://doi.org/10.5195/jmla.2021.962

[85] M. J. Page et al., "Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement," J Clin Epidemiol, vol. 134, pp. 103–112, 2021, https://doi.org/10.1016/j.jclinepi.2021.02.003

[86] S. R. M. Yusop, M. S. Rasul, R. M. Yasin, H. U. Hashim, and N. A. Jalaludin, "An Assessment Approaches and Learning Outcomes in Technical and Vocational Education: A Systematic Review Using PRISMA," Sustainability (Switzerland), vol. 14, no. 9, 2022, https://doi.org/10.3390/su14095225

[87] J. Zhu and W. Liu, "A tale of two databases: the use of Web of Science and Scopus in academic papers," Scientometrics, vol. 123, no. 1, pp. 321–335, 2020, https://doi.org/10.1007/s11192-020-03387-8

[88] M. Bearman and P. Dawson, "Qualitative synthesis and systematic review in health professions education," Med Educ, vol. 47, no. 3, 2013, https://doi.org/10.1111/medu.12092

[89] F. Neukart, D. Von Dollen, C. Seidel, and G. Compostella, "Quantum-Enhanced Reinforcement Learning for Finite-Episode Games with Discrete State Spaces," Front Phys, vol. 5, 2018, https://doi.org/10.3389/fphy.2017.00071

[90] B. Wang, X. Yang, and D. Zhang, "Research on Quantum Annealing Integer Factorization Based on Different Columns," Front Phys, vol. 10, 2022, https://doi.org/10.3389/fphy.2022.914578

[91] J. Schrock, A. J. McCaskey, K. E. Hamilton, N. Imam, and T. S. Humble, "Recall Performance for Content-Addressable Memory Using Adiabatic Quantum Optimization," Entropy, vol. 19, no. 9, 2017, https://doi.org/10.3390/e19090500

[92] F. Neukart, D. Von Dollen, and C. Seidel, "Quantum-Assisted Cluster Analysis on a Quantum Annealing Device," Front Phys, vol. 6, 2018, https://doi.org/10.3389/fphy.2018.00055

[93] N. M. P. Neumann, P. B. U. L. de Heer, and F. Phillipson, "Quantum reinforcement learning: Comparing quantum annealing and gate-based quantum computing with classical deep reinforcement learning," Quantum Inf Process, vol. 22, no. 125, 2023, https://doi.org/10.1007/s11128-023-03867-9

[94] B. Hanafi, M. Ali, and D. Singh, "Quantum algorithms for enhanced educational technologies," Discover Education, vol. 4, no. 8, 2025, https://doi.org/10.1007/s44217-025-00400-1

[95] T. L. Patti, O. Shehab, K. Najafi, and S. F. Yelin, "Markov chain Monte Carlo enhanced variational quantum algorithms," Quantum Sci Technol, vol. 8, no. 1, 2023, https://doi.org/10.1088/2058-9565/aca821

[96] R. Pellini and M. Ferrari Dacrema, "Analyzing the effectiveness of quantum annealing with meta-learning," Quantum Mach Intell, vol. 6, no. 48, 2024, https://doi.org/10.1007/s42484-024-00179-8

[97] X.-J. Yuan et al., "Quantum Support Vector Machines for Aerodynamic Classification," Intelligent Computing, vol. 2, 2023, https://doi.org/10.34133/icomputing.0057

[98] C. Volioti et al., "Using Augmented Reality in K-12 Education: An Indicative Platform for Teaching Physics," Information (Switzerland), vol. 13, no. 7, 2022, https://doi.org/10.3390/info13070336

[99] M. E. Del Moral-Pérez, N. López-Bouzas, and J. Castañeda-Fernández, "Transmedia skill derived from the process of converting films into educational games with augmented reality and artificial intelligence," Journal of New Approaches in Educational Research, vol. 13, no. 15, 2024, https://doi.org/10.1007/s44322-024-00015-8

[100] M. Asadullah, M. Yeasmin, A. F. Alam, A. Alsolami, N. Ahmad, and I. Atoum, "Towards a Sustainable Future: A Systematic Review of Mobile Learning and Studies in Higher Education," Sustainability (Switzerland), vol. 15, no. 17, 2023, https://doi.org/10.3390/su151712847

[101] D. P. Kaur, A. Kumar, R. Dutta, and S. Malhotra, "The Role of Interactive and Immersive Technologies in Higher Education: A Survey," Journal of Engineering Education Transformations, vol. 36, no. 2, pp. 79–86, 2022, https://doi.org/10.16920/jeet/2022/v36i2/22156

[102] D. E. Marcial, L. dela Peña, J. Montemayor, and J. Dy, "The Design of a Gamified Responsible Use of Social Media," Front Educ (Lausanne), vol. 6, 2021, https://doi.org/10.3389/feduc.2021.635278

[103] A. Lu, C. S. K. Wong, R. Y. H. Cheung, and T. S. W. Im, "Supporting Flipped and Gamified Learning With Augmented Reality in Higher Education," Front Educ (Lausanne), vol. 6, 2021, https://doi.org/10.3389/feduc.2021.623745

[104] B. Mei and S. Yang, "Nurturing environmental education at the tertiary education level in China: Can mobile augmented reality and gamification help?," Sustainability (Switzerland), vol. 11, no. 16, 2019, https://doi.org/10.3390/su11164292

[105] R. Z. Ramli, N. A. U. Marobi, and N. S. Ashaari, "Microorganisms: Integrating Augmented Reality and Gamification in a Learning Tool," International Journal of Advanced Computer Science and Applications, vol. 12, no. 6, 2021, [Online]. Available: www.ijacsa.thesai.org.

[106] P. E. Antoniou et al., "Medical Education Escape Room Aligned with Flipped Classroom and Powered by Mobile Augmented Reality," Electronics (Switzerland), vol. 13, no. 12, 2024, https://doi.org/10.3390/electronics13122367

[107] A. Kleftodimos, M. Moustaka, and A. Evagelou, "Location-Based Augmented Reality for Cultural Heritage Education: Creating Educational, Gamified Location-Based AR Applications for the Prehistoric Lake Settlement of Dispilio," Digital, vol. 3, no. 1, 2023, https://doi.org/10.3390/digital3010002

[108] S. H. Tanalol, D. N. M. Nizam, Z. H. A. Sani, A. Baharum, A. Tahir, and I. A. Zolkifly, "Jawi using multi-maker augmented reality," Bulletin of Electrical Engineering and Informatics, vol. 10, no. 5, 2021, https://doi.org/10.11591/eei.v10i5.2464

[109] G. Lampropoulos, E. Keramopoulos, K. Diamantaras, and G. Evangelidis, "Integrating Augmented Reality, Gamification, and Serious Games in Computer Science Education," Educ Sci (Basel), vol. 13, no. 6, 2023, https://doi.org/10.3390/educsci13060618

[110] O. Chamorro-Atalaya et al., "Inclusion of Metaverses in the Development of the Flipped Classroom in the University environment: Bibliometric Analysis of Indexed Scientific Production in SCOPUS," International Journal of Learning, Teaching and Educational Research, vol. 22, no. 10, 2023, https://doi.org/10.26803/ijlter.22.10.14

[111] N. Sharmin, A. K. Chow, D. Votta, and N. Maeda, "Implementing Augmented Reality to Facilitate the Learning of Oral Histology," Healthc Inform Res, vol. 28, no. 2, 2022, https://doi.org/10.4258/hir.2022.28.2.170

[112] R. Setiawan, U. Farisiyah, M. Z. Abidin, and W. Widiawanti, "Harnessing AI-based learning media in education: A meta-analysis of its effects on student achievement," Participatory Educational Research, vol. 12, no. 1, 2025, https://doi.org/10.17275/per.25.12.12.1

[113] S. N. Moral-Sánchez, M. a. T. Sánchez-Compaña, and I. Romero, "Geometry with a STEM and Gamification Approach: A Didactic Experience in Secondary Education," Mathematics, vol. 10, no. 18, 2022, https://doi.org/10.3390/math10183252

[114] B. Perry, "Gamified Mobile Collaborative Location-Based Language Learning," Front Educ (Lausanne), vol. 6, 2021, https://doi.org/10.3389/feduc.2021.689599

[115] D. Wang, M. N. M. Khambari, S. L. Wong, and A. B. Razali, "Exploring interest formation in english learning through xplorerafe+: A gamified ar mobile app," Sustainability (Switzerland), vol. 13, no. 22, 2021, https://doi.org/10.3390/su132212792

[116] M. F. R. Oliva, H. H. Ponce, B. A. García, and M. M. Martínez, "Emerging Methodologies and Technologies Applied to University Education," J Technol Sci Educ, vol. 14, no. 1, 2024, https://doi.org/10.3926/jotse.2643

[117] H. C. K. Lin, Y. H. Lin, T. H. Wang, L. K. Su, and Y. M. Huang, "Effects of Incorporating Augmented Reality into a Board Game for High School Students' Learning Motivation and Acceptance in Health Education," Sustainability (Switzerland), vol. 13, no. 6, 2021, https://doi.org/10.3390/su13063333

[118] H. C. K. Lin, Y. H. Lin, Y. M. Huang, T. H. Wang, and L. K. Su, "Effects of Incorporating AR into a Board Game on Learning Outcomes and Emotions in Health Education," Electronics (Switzerland), vol. 9, no. 11, 2020, https://doi.org/10.3390/electronics9111752

[119] M. Muskhir, A. Luthfi, H. Sidiq, and R. Fadillah, "Development of Augmented Reality Based Interactive Learning Media on Electric Motor Installation Subjects," International Journal on Informatics Visualization, vol. 8, no. 4, 2022, [Online]. Available: www.joiv.org/index.php/joiv.

[120] I. T. Monteiro et al., "Design and evaluation of a prototype of a children's educational application during and for the COVID-19 pandemic and beyond," Journal on Interactive Systems, vol. 13, no. 1, pp. 54–76, 2022, https://doi.org/10.5753/jis.2022.2004

[121] N. López-Bouzas, M. E. del Moral-Pérez, and J. Castañeda-Fernández, "Communicative competence in students with ASD: Interaction and immersion in a Gamified Augmented Environment," Educ Inf Technol (Dordr), vol. 29, pp. 13175–13199, 2024, https://doi.org/10.1007/s10639-023-12319-x

[122] H. Tobar-Muñoz, S. Baldiris, and R. Fabregat, "Co-Design of Augmented Reality Games for Learning with Teachers: A Methodological Approach," Technology, Knowledge and Learning, vol. 28, 2023, https://doi.org/10.1007/s10758-023-09643-z

[123] A. Voreopoulou, S. Mystakidis, and A. Tsinakos, "Augmented Reality Escape Classroom Game for Deep and Meaningful English Language Learning," Computers, vol. 13, no. 1, 2024, https://doi.org/10.3390/computers13010024

[124] S. Iacono, "Augmented Learning: Case Study of Gamified and Extended Reality Courses †," Engineering Proceedings, vol. 38, no. 1, 2023, https://doi.org/10.3390/engproc2023038013

[125] A. V Geetha and T. Mala, "AREL – Augmented Reality–based enriched learning experience," Acta IMEKO, vol. 11, no. 3, 2022, [Online]. Available: www.imeko.org.

[126] M. C. Costa, P. Santos, J. M. Patrício, and A. Manso, "An interactive information system that supports an augmented reality game in the context of game-based learning," Multimodal Technologies and Interaction, vol. 5, no. 12, 2021, https://doi.org/10.3390/mti5120082

[127] N. Nguyen, T. Muilu, A. Dirin, and A. Alamäki, "An interactive and augmented learning concept for orientation week in higher education," International Journal of Educational Technology in Higher Education, vol. 15, no. 35, 2018, https://doi.org/10.1186/s41239-018-0118-x

[128] H. Xu, D. Song, T. Yu, and A. Tavares, "An enjoyable learning experience in personalising learning based on knowledge management: A case study," Eurasia Journal of Mathematics, Science and Technology Education, vol. 13, no. 7, pp. 3001–3018, 2017, https://doi.org/10.12973/eurasia.2017.00702a

[129] D. Wang and M. N. M. Khambari, "An AR-based Gamified English Course in Vocational College through Interest-driven Approach," Universal Journal of Educational Research, vol. 8, no. 1A, pp. 132–137, 2020, https://doi.org/10.13189/ujer.2020.081317

[130] N. López-Bouzas and M. E. Del Moral Pérez, "A gamified environment supported by augmented reality for improving communicative competencies in students with ASD: design and validation," IJERI: International Journal of Educational Research and Innovation, no. 29, pp. 80–93, 2023, https://doi.org/10.46661/ijeri.6820

[131] T. M. Khan and A. Robles-Kelly, "Machine Learning: Quantum vs Classical," IEEE Access, vol. 8, pp. 219275–219294, 2020, https://doi.org/10.1109/ACCESS.2020.3041719