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Integrating Augmented Reality Technology in the Internet of Things Learning: A Systematic Review

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ABSTRACT

The Augmented Reality (AR) technology incorporation with regard to the Internet of Things (IoT) possesses the potential to revolutionize learning experiences by providing immersive and interactive educational environments. This systematic review assesses and expands the current body of research pertaining to the integration of AR technology in IoT learning environments. The review addresses the lack of comprehensive understanding regarding the integration of AR technology in IoT learning environments. By identifying key themes, methodologies, potential, and challenges with this integration, the review offers perceptions regarding the current state of knowledge and bridges the gap in existing research. The systematic review analysis follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) technique with respect to systematic literature reviews. Literature from two databases, namely Web of Science (WoS) as well as Scopus, was extracted and examined using specific keywords related to IoT, AR, including learning. After the search, a total of n=25 primary data were finally identified and analysed using a synthesis approach. Three main themes emerged from the analysis: (1) technology integration in education, (2) learning through AR and IoT, and (3) potential and challenges. The systematic review's results emphasize the various approaches and techniques utilized in integrating AR technology into IoT learning environments. The review also identifies gaps in the existing literature and suggests future research directions to explore further the possibilities and challenges associated with AR and IoT in education. By embracing AR and IoT, educational institutions may produce immersive and dynamic learning environments that enhance students for the technology-driven world and promote critical thinking and practical skills. Ultimately, the review provides valuable insights for educators, researchers, and policymakers, helping them make informed decisions regarding the adoption and implementation of AR and IoT in educational settings.

Keywords:
Augmented reality; Internet of Things; Learning

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1. Introduction

The rapid advancements in technology have transformed how we learn, work, and live. One such transformative trend is the integration of Augmented Reality (AR) technology in various domains, including education. With its ability to overlay virtual objects onto the real world, AR has opened new avenues for immersive and interactive learning experiences. In parallel, we now engage with the physical world in a completely new way thanks to the Internet of Things (IoT), a powerful network of linked objects that gather and share data. The pace of rapid IoT adoption will lead to rising demand for expertise to help companies in specific industries that incorporate IoT technology taken from the previous studies [1]. The IoT, as well as AR convergence, has created a synergy that holds great potential for educational applications. The integration of AR technology with the IoT (AR-IoT) can enhance learning experiences by providing real-time data, contextual information, and interactive visualizations taken from the previous studies [2]. AR-IoT learning environments assist in reducing the knowledge gap between applications and theory, offering students hands-on experiences and promoting active engagement.

1.1 Augmented Reality

AR is an encouraging new technology with significant potential for use in the field of education today. Despite gaining increasing attention recently, computer science and educational technology experts continue to define "AR" variously. The situation when users may view a blend of virtual objects and the actual environment in real-time was described by the technology's developers taken from the previous studies as AR [3]. Unlike a fully immersive virtual environment where users cannot see the real-world surroundings, AR, from other perspectives, enables users to perceive the real-world environment together with generated virtual objects. Therefore, AR is considered an enhancement to the real world rather than replacing it with a new environment.

AR essentially has been defined as overlaying digital content on top of a user's physical reality that provides additional information to the user, and allows for interaction between the virtual content and reality are taken from the previous studies [4]. Therefore, to understand the concept of AR, the widely accepted and referenced definition by the majority of researchers to date is the "Milgram Reality-Virtuality Continuum" visualization (see Figure 1), which was introduced by taken from the previous studies [3].

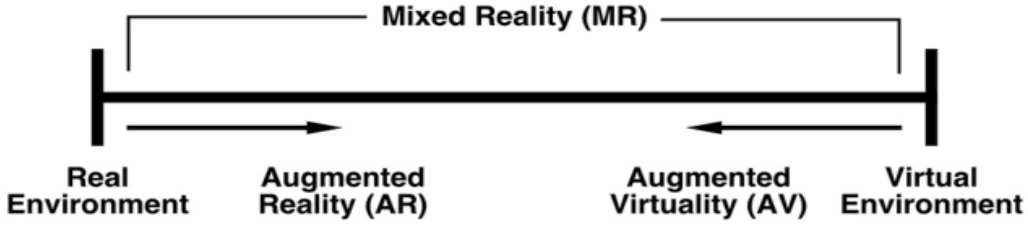

Fig. 1. Milgram Reality-Virtuality Continuum are taken from the previous studies [3]

Engineering, geography, chemistry, mathematics, history, languages, and other topics are all studied using AR technology. Additionally, AR has the potential to develop into a significant enabling technology for environmental education taken from the previous studies [5]. Therefore, it will be advantageous to establish AR applications and use them in education taken from the previous studies [6].

1.2 IoT in Education

The IoT resembles the concept where everyday gadgets as well as devices in our daily lives, may connect to the Internet and be controlled via mobile applications on smartphones, computers, or other Internet-connected devices. In this interconnected ecosystem, these devices collect data, study user decisions, can be supervised remotely, receive updates, as well as rely on internet connectivity to communicate and operate effectively are taken from the previous studies [7,8]. The integration of IoT in education has led to smart education. This entails facilitating education with smart technologies like Big Data, IoT, and Cloud Computing. As a result, educational institutions have transformed into smart learning environments where innovative hardware, software, network, and storage concepts are seamlessly integrated to create interactive and engaging educational atmospheres for all taken from the previous studies [9]. IoT-based learning systems for assessment, learning, as well as smart teaching develop a remote-accessible learning environment, enabling knowledge dissemination anytime and anywhere. This leads to several benefits, including improved interaction through sharing educational content, increased flexibility with remote access to knowledge, enhanced thinking abilities through collaboration among learners and institutions, and various other advantages that will increase the efficiency and the productivity to the user taken from the previous studies [10]. As a result, IoT in education transforms every aspect of the educational process, such as education itself, institutions, classrooms, teaching, learning, and assessment, into smart entities, as shown in Figure 2 taken from the previous studies [11].

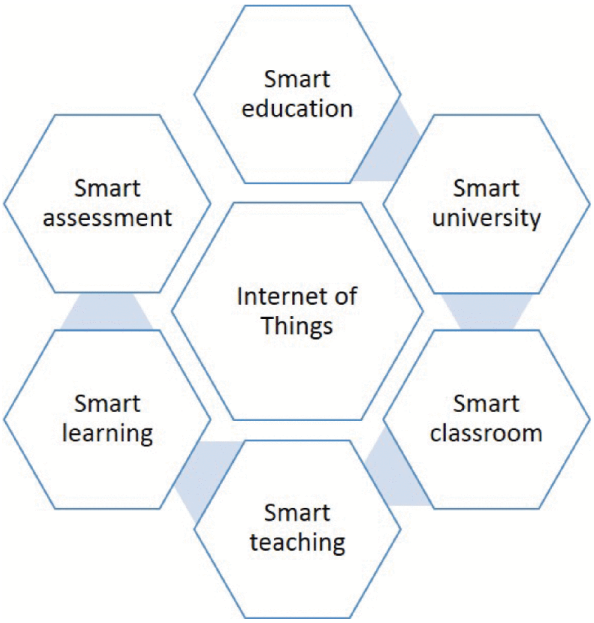

Fig. 2. Smart education environment are taken from the previous studies [11]

This systematic review analyses and expands the current body of research on integrating AR technology in IoT learning environments. By comprehensively examining the literature, this review seeks to identify the key themes, methodologies, potential, and challenges with integrating AR into IoT-based educational settings. However, despite the growing interest in this area, significant research gaps remain, particularly in understanding the long-term impact of AR-IoT integration on student learning outcomes, the scalability of these technologies in diverse educational contexts, and the development of effective pedagogical frameworks. This review offers valuable insights into the current state of knowledge in this emerging field through a systematic and rigorous analysis. By

shedding light on the existing body of knowledge, identifying research gaps, and exploring the possibilities and challenges of integrating AR technology into IoT learning, this systematic review contributes to advancing educational practices. It informs educators, researchers, and policymakers in making informed decisions regarding adopting and implementing AR-IoT in education.

2. Materials and Methods

This section focuses on the need for a comprehensive analysis of incorporating AR with IoT learning. The subsequent section explains the research methodology employed to address the formulated Research Questions (RQs). The review is structured into three main sections:

i. technology integration in education
ii. learning through AR and IoT
iii. potential and challenges.

The primary objective is to explore both the possibilities and challenges associated with the incorporation of IoT and AR in education. To accomplish this, we performed a systematic review as well as synthesis regarding relevant scientific literature, choosing and analysing important AR-IoT research. Finally, the section outlines potential actions to address the identified issues and suggests future research directions for scholars.

To conduct this analysis, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach is employed. It is a well-known standard for performing Systematic Literature Reviews (SLRs). It provides guidelines for assessing and reviewing rigor as well as accuracy pertaining to a review with relevant and essential details. Moreover, PRISMA emphasizes including randomized studies evaluation surveys, which are crucial factors in systematic analysis reports applicable to various study types are taken from the previous studies (Figure 3) [12,13].

Two key databases, Web of Science (WoS) and Scopus, were utilized for assessing the research methodology, given their robust nature. The section offers a brief description of the four important sub-sections that were employed in the study process: identification, screening, eligibility, and exclusion, as well as data abstraction.

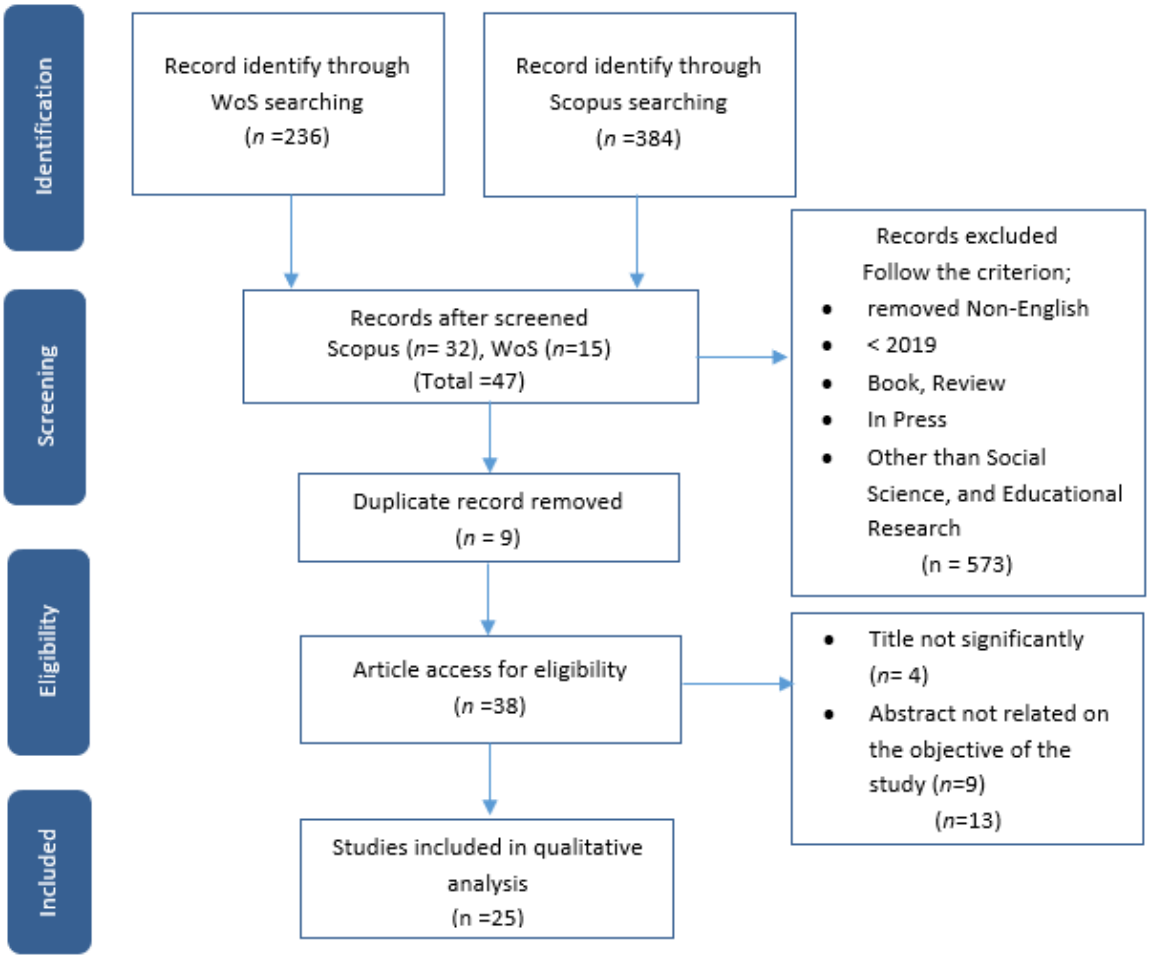

Fig. 3. Flow diagram of article selection are taken from the previous studies [12,13]

2.1 Identification

The study investigated associated study resources concerning the topic of integrating AR in IoT learning throughout the identification phase. The terms "augmented reality," "internet of things," and "learning" were employed. Finding these keywords was the initial stage, followed by a search for terms that were comparable in thesauri, dictionaries, and earlier studies. The WoS and Scopus databases' search strings were made once the relevant terms had been identified. Consequently, the study was able to retrieve 620 publications from the databases during the first stage of the advanced searching process (see Table 1).

Table 1
The search string used for the systematic review process

Databases	Keywords
Web of Science	"Augmented Reality" AND "Internet of Things" AND "Learning" (All Fields) and 2020 or 2021 or 2022 or 2023 or 2024 (Publication Years) and Proceeding Paper or Article (Document Types) and Education Educational Research (Research Areas) and English (Languages)
Scopus	TITLE-ABS-KEY ("augmented reality" AND "internet of things" AND "learning") AND PUBYEAR > 2019 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SUBJAREA, "soci")) AND (LIMIT-TO (PUBSTAGE, "final"))

2.2 Screening

During the second phase, 620 articles were examined based on several exclusion and inclusion criteria established by the researchers. Here, the first criterion was literature, which is the primary source of practical information. Publications in the form of books, book series, meta-synthesis, meta-analyses, reviews, systematic reviews, as well as chapters were excluded from the current study. The review focused only on papers written in English, and subject areas were limited to social science and educational research. The schedule was chosen for five years (2020-2024), with only the final stage publication included. In total, 573 publications were excluded based on particular parameters in Table 2. In this phase also, duplicated papers should be excluded. From 47 articles, nine articles were omitted for duplicated articles.

Table 2
Inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Literature type	Journal (Article), Proceeding	Book, Review
Language	English	Non-English
Subject Area	Social Science, Educational Research	Besides Social Science, Educational Research / Others
Timeline	2020 – 2024	< 2020
Publication Stage	Final	In Press

2.3 Eligibility

A total of 38 articles were generated for the third stage of screening, and their titles and primary findings were all carefully examined to make sure they met the criteria for inclusion and were appropriate to the current study's objectives. According to empirical data, 15 reports (n=15) were excluded since their titles were insignificant or their abstracts had nothing to do with the study's goal. Correspondingly, only 25 items were finally made available for evaluation.

2.4 Data Abstraction and Analysis

In this study, a range of research designs (mixed method, qualitative, and quantitative) was examined and synthesized using an integrative analysis as one of the assessment strategies. The competent study's objective was to determine appropriate topics and subtopics. Data collecting was the initial phase of the theme's development. Figure 3 demonstrates how the authors thoroughly examined a collection of 25 articles for assertions or material pertinent to the subjects of the current investigation. The authors then assessed recent noteworthy works on learning with AR and the IoT. Investigations are being conducted on both the research findings and methods employed in all studies. Subsequently, the author worked with other co-authors to establish themes based on the data in the context of this study. Throughout the data analysis process, a log was kept to note any analyses, perspectives, inquiries, or other ideas that could be significant to the data interpretation. The authors analysed the findings for any differences in the theme design procedure. It is important to note that authors discuss any differences in the concepts among themselves, if any. Consequently, final adjustments were made to the themes created to guarantee consistency. Two experts, one with expertise in higher education and the other in AR, conducted the analytical selection to ascertain the

validity of the issues. By defining the domain, the expert review process ensures that each subtheme is clear, significant, and appropriate.

3. Result and Finding

Data extraction was performed to support knowledge representation taken from the previous studies [14]. Then will meet the established criteria. Data extraction has filtered the data from this study's instruments according to the pre-defined categories. Among the categories specified in this study are technology integration, learning through AR and IoT, and potential and challenges. These categories were also synthesized to provide a clearer overview for generating meaningful comparisons taken from the previous studies [13].

A total of 25 articles were selected after going through several screening processes. The study found that six articles were sourced from the WoS database, while 19 were from Scopus. Among these articles, five were published in 2020, 7 in 2021, 3 in 2022, 4 in 2023 and 6 in 2024. The study also classified the articles based on themes according to the outlined research objectives. The results revealed that articles discussed technology integration in education, learning through AR and IoT, and potential and challenges (Table 3).

Table 3
The research article findings are based on the proposed search criterion

No	Authors	Title	Publication Year	Method
1	Ramli and Hashim [15]	Interactive AR Textbook Application For 3M Orang Asli Students in Primary School	2024	The study focused on developing an Interactive Augmented Reality (AR) textbook to help Orang Asli students in Perak, Malaysia, learn Malay vowels (a, e, è, i, o, u). Sixty-two first-year students tested the AR textbook, which aimed to make learning more engaging and effective. The results showed that students who used the AR textbook were more motivated and performed better in learning the vowels compared to traditional methods. Experts also found the AR tool to be user-friendly and easy to learn from. This study highlights the potential of AR technology to improve literacy and enhance learning experiences in education.
2	Hanafi *et al.,* [16]	IoT-Enabled GPS Tracking System for Monitoring the Safety Concerns of School Students	2024	The study focuses on developing an Internet of Things (IoT) GPS tracking system designed to help parents ensure their children's safety during school commutes. The system is for kids aged 4 to 10 and uses an Arduino Uno device placed in the child's school bag. Parents can track their child's real-time location through a mobile app, and the system can monitor multiple children at once. If the device stays in one place for too long, the system sends an alert to the parents, indicating a possible problem. The main goal is to give parents peace of mind by allowing them to quickly respond to any safety concerns during their children's journeys to and from school.

3	Hishamuddin *et al.,* [17]	Empowering Leaders: A Work in Progress on Promoting Leadership Roles in Online Learning through Project-Based Learning (PBL)	2024	This study examines the shift to online learning and the critical role of project-based learning (PBL) in developing leadership skills among student teachers. As education increasingly moves to virtual platforms, it's essential for student teachers to build leadership abilities that will help them navigate the complexities of digital teaching. This includes mastering digital pedagogy, which involves not only using technology for instruction but also effectively engaging students online. The article highlights ongoing efforts, strategies, and best practices for integrating PBL to foster leadership in the online learning environment, helping student teachers learn how to create active, inquiry-based learning experiences for their future classrooms.
4	Sidhu *et al.,* [18]	Awareness and Readiness of Malaysian Generation Z Students towards the Fourth Industrial Revolution (IR4.0)	2024	The study focused on assessing the awareness and readiness of Malaysian Generation Z students for Fourth Industrial Revolution (IR4.0) technologies. A total of 920 students aged 16 to 26 from public and private educational institutions across Malaysia participated. The findings revealed that students had low awareness and readiness for IR4.0 technologies such as AI, automation, and IoT. This highlights the urgent need for educational institutions and industries to collaborate in promoting IR4.0 awareness and integrating these technologies into education. The results are crucial for shaping strategies to better prepare students for the challenges and opportunities of IR4.0.
5	Chi *et al.,* [19]	A Systematic Review on Multidisciplinary Technological Approaches in Higher Education	2024	The study explored the impact of multidisciplinary technological approaches in higher education, addressing a gap in the literature regarding their effectiveness. Using the PRISMA guidelines and analysing studies from Scopus and Web of Science over the last decade, the review focused on 19 selected articles. The findings highlighted five key themes: sustainability, student employability, complex thinking, pre-service teacher training, and teaching innovation. These themes underscore the benefits of multidisciplinary methods in enhancing the quality of higher education. The review offers valuable insights for educators, policymakers, and researchers, guiding the adoption of these approaches in higher learning environments.

6	Yusof *et al.,* [20]	A Proposed Integration Model of Project Based Learning and Simulation to Improve the Learning Quality	2024	The study aimed to address the challenge of developing effective learning models in higher education by proposing a project-based learning and simulation model. The 4-D model design—define, design, develop, and disseminate was used to create and analyse the model. The results indicated that the proposed model was highly valid in terms of its rationale, supporting theory, syntax description, implementation, and support platforms. Additionally, there was a statistically significant improvement in students' skills, as shown by the increase in their pre-test and post-test scores. This suggests that the project-based learning and simulation model effectively enhances the quality of learning in higher education.
7	Brahimi and Hala [21]	Mapping the Scientific Landscape of Metaverse Using VOSviewer and Bibliometrix	2023	This study performed a comprehensive bibliometric analysis with respect to Metaverse research utilizing Bibliometrix and VOSviewer on the Scopus database. The analysis uncovered important trends and popular topics in the field, such as Virtual Reality (VR), AR, the IoT, as well as blockchain. Additionally, it suggested possible study topics with a particular emphasis on privacy, security, and education in the Metaverse. The study also revealed gaps in the body of knowledge that may be investigated in future research. Overall, the study offers relevant insights into the current state of Metaverse research and points towards promising avenues for further exploration.
8	Chen [22]	Interactive piano training using augmented reality and the Internet of Things	2023	The study concentrated on how students' musical literacy and piano proficiency were affected by an AR and IoT-aided piano instruction system. Note that 100 students from the Zhejiang Tourism College in China participated in the study and were split into control and experimental groups. The experimental group, using the AR and IoT system called HoloKeys, showed significantly better piano learning results than the control group. This indicates the positive potential of utilizing IoT and AR with regard to piano training. The findings are useful for designing modern piano training courses and can be applied to enhance learning in various other fields too.

9	Lin *et al.,* [23]	Developing an Integrated Teaching Module for the Topic of Smart Industry in the Museum	2023	This research aimed to improve innovative technology teaching in primary education in Taiwan. They developed an integrated teaching module for smart industry topics using a 5-step design procedure. The module included various teaching methods like an e-book, AR game, board game, and maker education aids. Students from engineering and non-engineering backgrounds participated, and the results showed positive learning outcomes. The module proved useful for science popularization and learning of technological issues.
10	Stojanović *et al.,* [24]	Empowering learning process in secondary education using pervasive technologies	2023	This paper introduces a new approach to using IoT and mobile technologies in secondary education. They developed a mobile app with AR that allows students to solve assignments in a smart classroom using QR codes, sensors, and actuators. The study evaluated the system with students in Serbia and found that using IoT and mobile technologies improved students' knowledge, and they were interested in using these technologies in their education.
11	Fomunyam [25]	The Itinerant Curriculum as a Key to Responsiveness in the Era of the Fourth Industrial Revolution in Nigerian Higher Education	2022	The Fourth Industrial Revolution (4IR) combines digital, physical, and biological elements, leading to advancements like Artificial Intelligence (AI), AR, IoT, as well as robotics. However, Nigeria's educational practices are not adequately preparing its citizens for this technological era due to the limited improvement in the higher education curriculum. To address this, this theoretical paper suggests the itinerant curriculum as an alternative approach to enhance curriculum responsiveness in Nigeria. The study explores how the itinerant curriculum might accomplish responsiveness in the 4IR period in terms of economic, cultural, disciplinary, and learning aspects. Overall, the itinerant curriculum is considered a valuable tool to improve Nigerian higher education and its curriculum's adaptability to the evolving technological landscape.
12	Gkotsiopoulos and Christos [2]	Augmented Reality and Internet of Things Trends in Education	2022	The usage of AR technologies is growing in popularity as a result of their increased accessibility and stability. AR improves access to appropriate data when combined with the affordability of devices like smartphones and tablets. Similarly, IoT technologies, being pervasive, are leading to a smarter interconnected world. Many industries have successfully adopted AR as well as IoT technologies, but their implementation in education is still at an early stage. This paper proposes using IoT and AR technologies to teach concepts required in the 'Informatics Applications' course for senior high schools in Greece.

13	Petrović *et al.,* [26]	Designing an extended smart classroom: An approach to game-based learning for IoT	2022	In a smart classroom integrating cutting-edge technologies like online, mobile, IoT, and AR, this article describes a game-based learning model. The educational game evaluated students' knowledge of IoT and was integrated into the e-learning platform Moodle. The results showed positive impacts on learning, suggesting that educational games can enhance formal learning models.
14	Patra [27]	Disruptive Innovative Library Services @ International Nalanda University: Present and Future Roadmaps	2021	The application of cutting-edge technology at the international Nalanda University in Rajgir, Bihar, India, is the main topic of this essay. Infrastructure, Collection Development, Emerging Tools and Technologies, Research Support Service, and Other Socially Responsible Activities are the five categories into which the university's services are divided. The numerous "Emerging Tools and Technologies" used to interact with people, such as Integrated AR, AI, and VR, are specifically highlighted in the report. These technologies are crucial in enhancing the university's services and user experience.
15	Liao and Chun [5]	Effectiveness of integrating AR and IoT technologies into environmental education for elementary school students	2021	This study focused on the harmful impact of suspended particles, a primary component of outdoor air pollution, on human health. It aimed to raise awareness among children about environmental pollution and ways to protect themselves. To achieve this, the researchers developed two learning aids: the IoT as well as AR for environmental education. The experiment involved 90 students, with a total duration of 120 minutes. The results indicated that both AR and IoT approaches significantly improved students' knowledge of air pollution. Furthermore, no substantial difference in learning satisfaction between the two groups using VR and IoT learning methods.
16	Liccardo *et al.,* [28]	Augmented Reality Laboratory for Instrumentation and Measurements Online Course	2021	Due to the pandemic, students faced difficulties with laboratory activities while studying from home. To address this, the article describes the development of a remote laboratory in AR. This technology allows students to replicate instruments on their devices and interact with real workstations using IoT protocols. It offers a solution to continue practical learning despite the limitations caused by the pandemic.
17	Raad [29]	A Modular Wearable Technology and IoT Educational Building System Using Brain and Muscular Signals	2021	This paper establishes a modular educational building system with respect to teaching wearable technology, VR, AR, and the IoT. The system includes mechanical, electrical, electronic, as well as optical components that can be connected to create smart wearables and IoT devices. These devices can respond to various inputs, like voice commands, temperature, gestures, and even brain and muscular waves, making learning about emerging technologies fun and interactive.

18	Aki Tamashiro [30]	How do we teach Emerging Technologies in K-9 Education?	2021	This project explores how design fiction and constructionist approaches can help 14–16-year-old students understand the societal implications of emerging technologies like IoT, AR, and Machine Learning (ML). It aims to create new school learning experiences to encourage critical thinking and hands-on learning. The early results show that combining constructionism and design fiction effectively supports students' understanding of technology's impact on society while deepening their knowledge of technology fundamentals.
19	Onime *et al.,* [31]	A reclassification of markers for mixed reality environments	2021	This paper proposes a new classification of markers with respect to mixed reality environments, which can also be applied to 3D modelling as well as robot navigation systems. The classifications are smart markers, active, virtual, augmented, blended, and abstract. The study demonstrates examples from various laboratories. The reclassification provides a more nuanced understanding of markers and their applications in mixed-reality environments. It allows for improved definitions of simple marker and markerless mixed reality environments, as well as support for more complex features, such as advanced interactivity and co-location of objects. The research highlights the potential benefits in the entertainment, business, and health sectors.
20	Huk [32]	From Education 1.0 to Education 4.0 – Challenges for the Contemporary School	2021	The article discusses the impact of digital media on education and the need for schools to prepare students for the rapidly changing world. It introduces the concept of Education 4.0, which focuses on comprehensive human development. The article traces the changes in education from Education 1.0 to Education 3.0 concerning evolving digital media. It then describes Education 4.0 and its components, for example, AR, Big Data Analytics, Cloud Computing, as well as the IoT. For modern schools, integrating these elements into the teaching and learning process is challenging. The article concludes with practical considerations from a primary school headmaster who is also an academic staff member.
21	Cîmpanu *et al.,* [33]	Virtual learning environments for never-ending learning: A survey	2020	The proposed study presents a comparison of virtual learning environments and summarises the state-of-the-art virtual labs for science, technology, and engineering.

22	Calderón and Rubén [34]	Machines for Industry 4.0 in Higher Education	2020	The paper discusses Industry 4.0, which involves converging digital technologies to create valuable products and services. However, current academic programs often lack teaching IoT, AR, and Additive Manufacturing (AM) technologies, leading to a gap in engineering skills required by the job market. The study presents two case studies where IoT, AR, and AM are integrated into mechatronics laboratories, focusing on an extruder machine and an automotive transmission gearbox. Through hands-on activities and free resources, students can develop competencies in these technologies straightforwardly and cost-effectively. This approach bridges the gap between academic knowledge and industry demands in Industry 4.0.
23	Bryceson [35]	Developing and using disruptive technologies in agricultural education	2020	This paper explores how different technologies are positively disrupting agricultural education at the University of Queensland (UQ), Australia. It focuses on systems as well as tools developed, tested, and implemented to create engaging and interactive learning experiences for students. Some of these technologies include AR simulations for blended learning, drone technology for agricultural management, as well as IoT multisensory mesh networks with data dashboards for biophysical monitoring. These technologies have been utilized in teaching at UQ from the year 2018 to 2020.
24	Zambri and Kamaruzaman [36]	The integration of augmented reality (AR) in learning environment	2020	Amid the uncertainty of the Covid-19 pandemic, the education sector is adapting its teaching methods to meet students' needs. The Ministry of Education in Malaysia recommends Open Distance Learning (ODL), an e-learning method, for schools under its jurisdiction. With the advancement of the IoT as well as technology integration, learning has become more accessible. This study explores students' engagement and motivation toward AR as part of their learning experience. The findings indicate positive learning outcomes, as AR effectively presents abstract knowledge in a more understandable context. AR's unique feature makes it a valuable educational tool, creating exciting and captivating learning environments that boost student motivation and interest in real-life scenarios.
25	Oprea [37]	Integration of robotics projects in the pre-university educational environment	2020	This study prepares students for future jobs like smart home developers and AR architects by teaching IoT, Robotics, and AI. It presents two projects using Arduino: a line-follower robot and an obstacle-avoiding robot. The results show the effectiveness of STEM education compared to traditional methods. Published in 2020 by the National Defence University.

3. Discussions

3.1 Technology Integration in Education

The first theme explores the role of technology integration in education. The findings related to technology integration in education show that various cutting-edge technologies, for example, IoT, AR, VR, AI, as well as Robotics, have the potential to transform the learning experience are taken from the previous studies [15,17-20,37]. These technologies offer interactive, immersive, and hands-on learning opportunities, bridging the gap between practical application and theoretical knowledge are taken from the previous studies [16,28,29]. They enable adaptive and individualized learning experiences, catering to the unique needs of students are taken from the previous studies [30,32]. Additionally, technology integration in education has positive impacts on learning outcomes as well as student engagement taken from the previous studies [35]. The benefits of technology integration, such as enhanced learning experiences, improved understanding of complex concepts, and increased student motivation, offer promising prospects for the future of education are taken from the previous studies [23,24,33,36]. The studies emphasize the importance of preparing teachers for the digital era and leveraging technology to create dynamic and effective learning environments are taken from the previous studies [5,18]. The case study conducted by Bryceson explores the current technologies integrated into agricultural education at the University of Queensland (UQ), Australia. This examination is conducted with a perspective that interprets these technologies as a positive force of 'disruption.' The study details the development, testing, and implementation of various tools and systems aimed at actively engaging students and fostering an interactive and educational experience. This commitment reflects UQ's dedication to remaining at the forefront of educational technology, ensuring the provision of a cutting-edge and impactful learning environment for its students.

3.2 Learning Through AR and IoT

The second theme explores how AR and IoT enhance learning experiences. The findings related to learning through AR and IoT highlight the significance of incorporating these technologies into academic programs to enhance learning experiences and prepare students for the demands of the digital era and Industry 4.0. Integrating AR and IoT in technical education allows students to engage in hands-on experiments, developing practical skills and competencies in working with these technologies taken from the previous studies [34]. In technical education, AR allows students to interact with digital content overlaid in the real-world environment, enhancing their understanding and engagement with complex concepts taken from the previous studies [15]. The studies also demonstrate the positive impact of incorporating IoT and AR in various learning contexts. In piano education, the AR and IoT-assisted system significantly improves learners' musical literacy and piano skills, transforming traditional training into a more engaging and effective experience taken from the previous studies [22]. This suggests the positive potential of incorporating IoT and AR technologies into piano training. The need to integrate emerging technologies in educational modules is emphasized. AR and IoT can provide a more interactive and practical approach to understanding subjects like industrial robots, smart vehicles, and the IoT. The smart learning environment that incorporates IoT, AR, and e-learning platforms provides students with an interactive and engaging learning experience through gamified learning processes and real-time data collection are taken from the previous studies [16,23]. Overall, the results emphasize the importance of implementing IoT and AR in education to create dynamic and immersive learning experiences that prepare students for the technology-driven world and foster critical thinking and practical skills taken from the previous

studies [21]. Integrating these technologies offers new opportunities to transform traditional teaching methods and engage students in active and personalized learning.

3.3 Potential and Challenges

The third theme focuses on the potential and challenges of integrating AR and IoT in learning environments. The potential benefits of AR and IoT integration include engaging and interactive learning, real-world context, hands-on experiences, and personalized learning taken from the previous studies [18]. However, challenges such as technical infrastructure, teacher training, content development, and cost considerations need to be addressed for successful implementation are taken from the previous studies [27,33]. Additionally, possible areas for future research include security and privacy issues with respect to the Metaverse taken from the previous studies [21] and the need for curriculum development and updates to adapt to the Fourth Industrial Revolution (4IR) era. Nigeria's higher education curriculum also faces challenges in keeping up with technological advancements, requiring investment in educational reform and access to digital infrastructure taken from the previous studies [25]. Its adaptability is seen as important in ensuring that the curriculum is aligned with the requirements of the 4IR, ultimately better preparing students for the challenges and opportunities presented by the rapidly changing technological environment. Despite the challenges, the potential for IoT and AR technologies to revolutionize education as well as improve learning outcomes remains promising. Addressing these challenges and leveraging the potential of these technologies will require collaborative efforts from educational institutions, policymakers, and technology developers are taken from the previous studies [19,30].

In the realm of AR-IoT education, emerging applications could involve the integration of advanced artificial intelligence algorithms for personalized learning experiences taken from the previous studies [39]. Challenges persist in the form of technical infrastructure limitations, ongoing teacher training needs, and potential ethical concerns surrounding data privacy. To tackle these obstacles, solutions may encompass increased investment in robust technical infrastructure, continuous professional development for educators, and comprehensive cybersecurity measures. Collaborative efforts among educational institutions, industry stakeholders, and policymakers are crucial for developing standardized content and curricula, ensuring a seamless and effective integration of AR-IoT technologies in education. Moreover, fostering a culture of digital literacy and responsible technology use can address ethical considerations, contributing to a positive and impactful transformation in the educational landscape.

4. Conclusions

In conclusion, the systematic review of the incorporation of AR technology with the IoT in learning environments sheds light on the promising potential and challenges of these technologies in education. The review highlights the transformative role of technology integration in education, with cutting-edge technologies such as AI, VR, AR, IoT, and Robotics offering interactive, immersive, and personalized learning experiences. These technologies bridge the gap practically and theoretically, improve student participation, and enhance learning outcomes, presenting exciting prospects for the future of education.

Furthermore, the results determined the significance of integrating IoT as well as AR in learning experiences. By integrating these technologies into academic programs, students gain practical skills and competencies, preparing them for the demands of the digital era and Industry 4.0. AR and IoT

offer real-world context, interactive learning, and hands-on experiences, making complex concepts more accessible and engaging.

Despite the potential benefits, challenges exist in implementing AR and IoT in education. Technical infrastructure, teacher training, content development, and cost considerations pose hurdles that need to be addressed to ensure successful integration. However, with proper collaboration and investment, these challenges can be overcome.

The systematic review identifies gaps in the existing literature and suggests future research directions to explore further the possibilities and challenges associated with AR and IoT in education. Policymakers, educators, and researchers can benefit from the valuable insights provided in the review, aiding informed decisions regarding the adoption and implementation of AR and IoT in educational settings.

Overall, the review highlights the transformative potential of AR and IoT in revolutionizing learning experiences and emphasizes the need for concerted efforts to overcome challenges and fully leverage the benefits of these technologies in education. By embracing AR and IoT, educational institutions may develop immersive and dynamic learning environments that encourage students to the technology-driven world and promote critical thinking and practical skills. With the growth of smartphones, laptops, wearable technology, etc., the last few years have seen an explosion of mobile applications, which has driven the development of the IoT taken from the previous studies [40]. This can be adapted to the latest educational technology integration.

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