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Review Article

Systematic Review of Challenges and Opportunities of Internet of Things in STEM Education: Policy Insights

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Abstract

Integrating the Internet of Things (IoT) in STEM education has gained attention for its potential to transform traditional teaching and learning. The paper reviews and examines the challenges and opportunities of incorporating IoT into STEM curricula, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. An initial Web of Science (WoS) and Scopus search identified 1,014 records. After removing duplicates (159), non-English sources (3), book series (261), conference proceedings (243), systematic review papers (70), and studies lacking relevance (254), only 24 articles met the final inclusion criteria. The review reveals seven key challenges to IoT integration: resource limitations, skill gaps, lack of standardized curriculum, data security and privacy concerns, integration with existing systems, effectiveness, and reliability. Conversely, seven opportunities were identified, including adaptive and hands-on learning, actionable STEM education, improved problem-solving skills, innovation and creativity, industry alignment and career readiness, real-time data analysis, and global connectivity. These challenges and opportunities were grouped into five themes: personnel management, IoT infrastructure, financial considerations, skill alignment, and educational administration. We offer policy insights

derived from the identified challenges and opportunities of integrating IoT into STEM education.
Keywords: *Challenges and Opportunities; Internet of Things; PRISMA; STEM Education; Systematic Literature Review*

1. Introduction

The rise of digital transformation and the Fourth Industrial Revolution has ushered in a new educational paradigm, Education 4.0. Unlike traditional systems, Education 4.0 is driven by emerging technologies such as artificial intelligence, data analytics, cloud computing, robotics, and networks (Moraes et al., 2023). This model reimagines the learning environment by promoting personalized, flexible, and technology-integrated approaches to prepare students for a highly dynamic workforce. Education 4.0 also emphasizes developing soft skills such as creativity, adaptability, and critical thinking, which remain irreplaceable by automation (Bonfield et al., 2020). This paradigm requires digital strategies, secure infrastructures, and cross-sectoral collaboration to ensure scalable educational delivery.

In the age of Education 4.0, STEM (Science, Technology, Engineering, and Mathematics) education has become more than a response to industrial needs. It is a critical driver of innovation, sustainability, and global competitiveness. STEM disciplines are central to addressing real-world challenges and equipping learners with the cognitive and technical skills needed for data-driven, technology-rich environments. As data science, artificial intelligence, and content creation become key components of the global job market (Schwab & Zahidi, 2020), STEM education must adapt by improving problem-solving, computational thinking, and interdisciplinary collaboration. Integrating digital tools and platforms into STEM classrooms enriches learning and cultivates future-ready skills for thriving in the Industry 4.0 landscape (Liston et al., 2022).

Among the technologies shaping Education 4.0, the Internet of Things (IoT) stands out for its transformative potential in STEM education. IoT refers to the network of interconnected physical devices embedded with sensors and software that collect and exchange real-time data via the internet (Rose et al., 2015). IoT enables interactive, data-driven, and experiential learning in educational settings by connecting students to smart devices, real-time experiments, and collaborative platforms. For instance, students can conduct science experiments using internet-enabled lab equipment or monitor environmental data through sensor networks (Bilén et al., 2014). These applications nurture hands-on learning and bridge the gap between theoretical knowledge and practical application. IoT's impact extends beyond pedagogy. It reshapes institutional operations, enhances resource management, and personalizes learning experiences through wearable devices and intelligent environments (Zeeshan et al., 2022; Mircea et al., 2021). Despite its promise, implementing IoT in education presents challenges, especially in developing countries, such as infrastructure limitations, digital literacy gaps, data security, and moral ascendancy concerns (Jorolan et al., 2025). Moreover, understanding students' experiences with IoT tools is crucial to evaluate their role in preparing learners for Industry 4.0 demands (Zikria et al., 2021; Moraes et al., 2023). As IoT applications evolve, their increasing mobility, scalability, and complexity introduce unprecedented opportunities and critical implementation challenges.

While existing systematic literature reviews have explored various dimensions of the IoT, such as research agendas (Rejeb et al., 2022), sensor applications in sustainable cities (Zeng et al., 2024), blockchain integration (Zubaydi et al., 2023), and general educational impact (Kandil et al., 2025), there remains a notable gap in studies that systematically examine the challenges and opportunities of IoT, specifically within STEM education. Although research findings have highlighted the integration of IoT in learning environments, there is a lack of consistent perspectives that critically assess both the enabling and limiting factors affecting its implementation. In particular, the transformative potential of real-world, sensor-generated data to enhance hands-on learning, critical thinking, and real-life STEM applications has not been sufficiently explored. This study addresses this gap by synthesizing existing research to map the key challenges and opportunities associated with IoT in STEM education (Kassab et al., 2020).

To address the identified research gaps, this study conducts a systematic literature review guided by the PRISMA (Preferred

Reporting Items for Systematic Reviews and Meta-Analyses) framework. A systematic review allows for a comprehensive and structured evaluation of existing research, which enables the synthesis of relevant studies on the integration of IoT in STEM education. The primary aim of this paper is to examine both the opportunities and challenges presented by IoT technologies in STEM teaching and learning. Specifically, the review analyzes how IoT has been implemented, what pedagogical strategies have emerged, and what barriers hinder its practical use. Through existing findings, the study intends to identify effective integration practices and highlight key educational implications. The review is structured around the following three research questions:

a) What are the challenges in integrating Internet of Things (IoT) technologies into STEM education that affect students' learning outcomes and their understanding of STEM in practical contexts?
b) What are the opportunities to integrate IoT technologies into STEM education that enhance students' learning outcomes and engagement with real-world STEM applications?
c) What are the emerging themes and patterns across the identified challenges and opportunities in integrating IoT in STEM education?

The answers to these research questions provide a foundation directed towards educators, policymakers, and researchers to promote knowledgeable decision-making and also the development of strategies for leveraging the IoT to improve STEM education and student learning experiences, facilitating informed decision-making and strategic development in integrating IoT to enhance STEM education and students' learning outcomes.

This paper is organized in the following structure: The approach of systematically reviewing the literature to extract challenges and opportunities of integrating IoT in STEM education is detailed in Section 2. Specific descriptive findings are presented in Section 3. Section 4 addresses the challenges and opportunities recognized within specified themes, and the future research agenda that explains the challenges and opportunities connected with integrating IoT applications in STEM education is presented in Section 5. It ends in Section 6, which shows the conclusion and discussion of future work.

2. Methods

This section presents the stages in the literature review, following the steps in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Moher et al., 2009) using the four systematic procedures: identification, screening, eligibility, and inclusion. The PRISMA standards' main benefits were emphasized, including specific research questions, well-defined inclusion and exclusion criteria, and the ability to evaluate large scientific databases in a given time. Moreover, a thorough search for terms related to creative teaching is made possible by the PRISMA statement.

2.1. Information Sources

This study captured on the Web of Science (WoS) and Scopus databases to ensure the inclusion of high-quality and peer-reviewed literature. These databases are well-regarded for their comprehensive coverage of scholarly publications. Focusing on these two databases, the study ensures robust selection and basis for identifiying the challenges and opportunities in incorporating IoT into STEM education.

2.2. Search Criteria

The search criteria consist of two parts, defined as follows:

a) Keywords related to IoT such as "Internet of Things," and "IoT".
b) Keywords related to STEM and Education such as "STEM Education," "Engineering Education," "Mathematics Education," and " Math Education".

Truncation and Boolean operators were utilized. An example of a search done in the various bibliographic databases is ("Internet of Things" OR "IoT") AND ("STEM Education" OR "Engineering Education" OR "Mathematics Education" OR "Math Education"). We composed the search string manually based on the search functionality offered by the database.

2.3. Inclusion and Exclusion Criteria

The inclusion criteria required are the following: (1) the study was not a systematic literature review, (2) was written in English, (3) was relevant to the defined search terms, and (4) qualified as an empirical research paper, an experience report, or a workshop paper. In addition, only studies published between 2014 and 2024. This timeframe was selected based on publication trends observed through Scopus, where a notable rise in IoT research began around 2014. Before this year, IoT-related publications were relatively limited, averaging fewer than 1,000 yearly. Publication volume increased from 2014 onward, which marks the beginning of broader academic engagement with the topic. The exclusion criteria are the following: (1) were systematic literature reviews, (2) did not focus specifically on the IoT, or (3) did not address the STEM education domain. Furthermore, we excluded conference proceedings, prefaces, editorial comments, anecdotal papers, books or book series, and presentation slides, as these sources are not typically peer-reviewed.

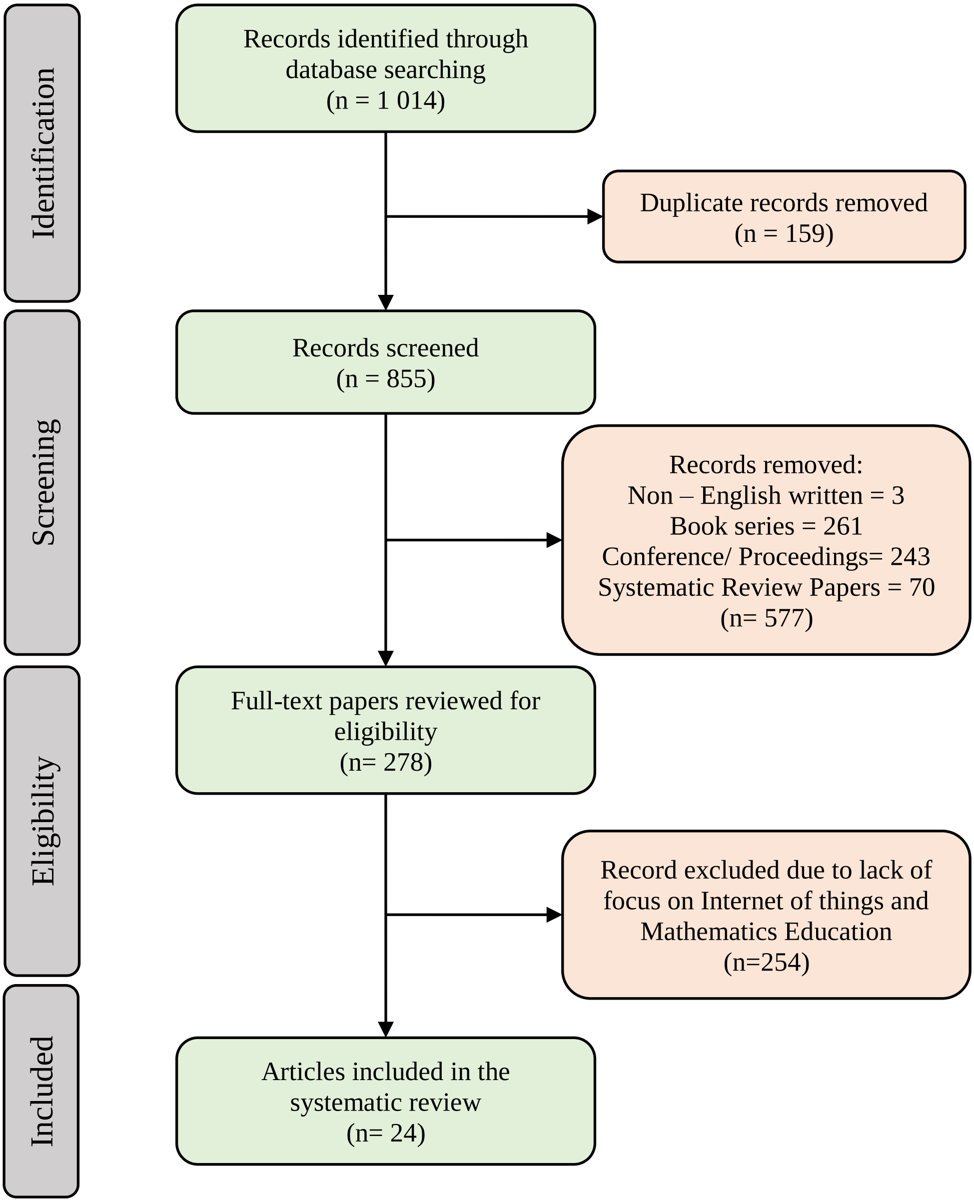
2.4. Conducting the Review

In this section, we present the process of conducting our research, the extraction of studies, and the information mentioned from the databases.

2.4.1. Study Search and Selection

The search captures 1,014 papers found on WoS and Scopus. These were thoroughly evaluated based on the inclusion and exclusion criteria. The evaluation captures 159 were duplicates. Hence, 855 papers met the qualifying criteria and were kept for further examination. The inclusion criteria included the selection of English-language empirical research publications that supported the application of technology in STEM education. In total, 577 papers that did not fit the research criteria were eliminated from the analysis since they were book series, conference proceedings, non-English written, and systematic review papers. All 278 papers that were investigated for retrieval were successfully recovered. As a result, 278 papers were analyzed to determine eligibility. In addition, 254 papers were removed because they did not match the required research criteria related to IoT, hence, the review included 24 papers.

Figure 1.
Overview of the PRISMA approach used



2.4.2. Methodological quality assessment

In evaluating the methodological quality of the primary studies focused on IoT in STEM education, we employed the quality screening processes presented in Figure 1. Following the PRISMA framework for systematic reviews, we assessed each selected study to ensure a thorough evaluation. Firstly, we removed duplicates comprising 16% of the total hits from various databases. Secondly, about 57% of the records, which are non-English written articles, book series, conference/proceedings, and systematic review papers, were removed. Thirdly, the full-text papers reviewed for eligibility are about 27% of the studies. Finally, articles included in the systematic review account for 2% of the total retrieved articles. This methodological quality assessment ensures that only studies meeting thorough criteria contribute to synthesizing findings regarding IoT in STEM education.

2.4.3 Data Extraction and Synthesis

Following the definition of the search and selection procedures, we reviewed the full texts of the selected primary studies to begin data extraction. This process was guided by the framework of Kitchenham and Brereton (2013) to ensure a structured approach. Each study was organized in a spreadsheet based on key attributes: type of paper, scope of the study, aims and objectives, main topics, methods used, evaluations performed, and main results. The method allowed us to capture and compare relevant information across studies systematically. As with the selection process, data extraction followed the PRISMA guidelines (Moher et al., 2009) to maintain transparency and rigor.

3. Results and Discussions

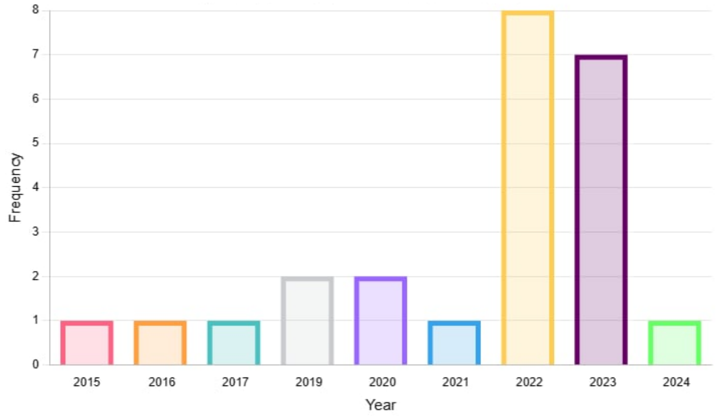
In this section, we have organized the synthesis of the findings into six main categories: chronological publication distribution, publisher contributions, journal contributions, country-wise contributions, classification of participants and sample sizes, and content analysis. These categories are illustrated and discussed in detail.

3.1. Chronological Publication Distribution

STEM Education has grown in popularity since 2015, mainly due to the popularity of research incorporating IoT into STEM education. Figure 2 depicts how interest in integrating IoT in STEM education has increased over the past nine years due to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.

Figure 2

Number of published works each year

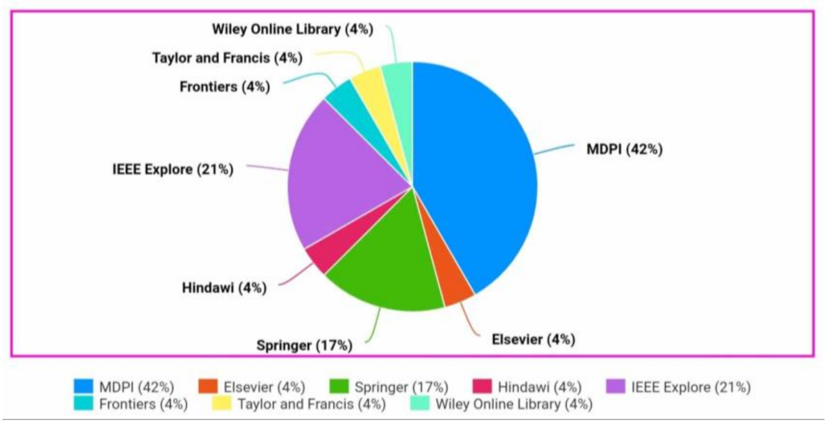


3.2. Publishers' Contributions

MDPI provided many available sources (10 of 24) (see Figure 3). Discussions regarding potential opportunities and challenges associated with integrating IoT into STEM education are explored in journals from different publishers. These findings indicate an increasing interest among experts in related domains.

Figure 3

Publications sourced from various publishers



3.3. Journals' Contributions

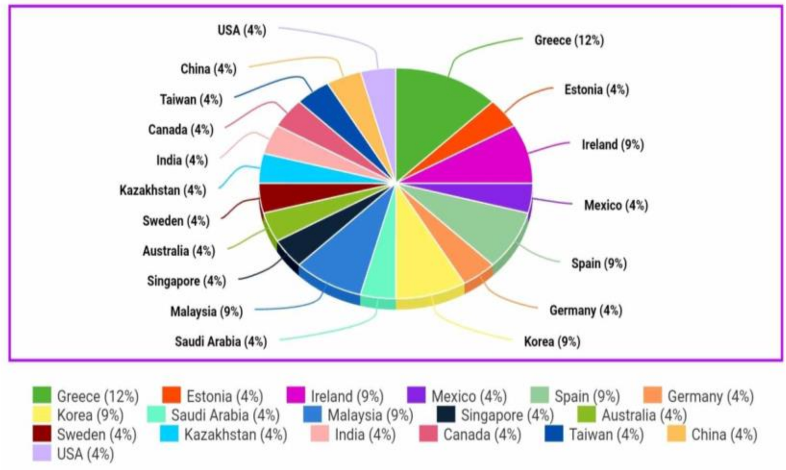
Table 1 lists the journals and the number of publications collected for this investigation. The challenges and opportunities of integrating IoT into STEM education are covered in various periodicals. The distribution of papers in various journals indicates that the incorporation of IoT in STEM education has been studied in various fields.

Table 1

Number of included papers in each publishing journal.

Name of Journal	Publisher	No. of Papers Collected
International Journal of Education Technology in Higher Education	Springer	1
Interactive Learning Environments	Taylor & Francis	1
Electronics	MDPI	2
Education Sciences	MDPI	1
Sustainability	MDPI	5
Frontiers in Education	Frontiers	1
Diagnostics	MDPI	1
Educational Studies in Mathematics	Springer	1
Education and Information Technologies	Springer	1
Technologies	MDPI	1
IEEE Transactions on Education	IEEE	2
Computer Applications in Engineering Education	Wiley	1
IEEE Access	IEEE	1
IEEE Internet of Things Journal	IEEE	1
Smart Learning Environments	Springer	1
Journal of Applied Mathematics	Hindawi	1
IEEE Communications Magazine	IEEE	1
Internet of Things	Elsevier	1

Figure 4
Number of publications according to the country of origin



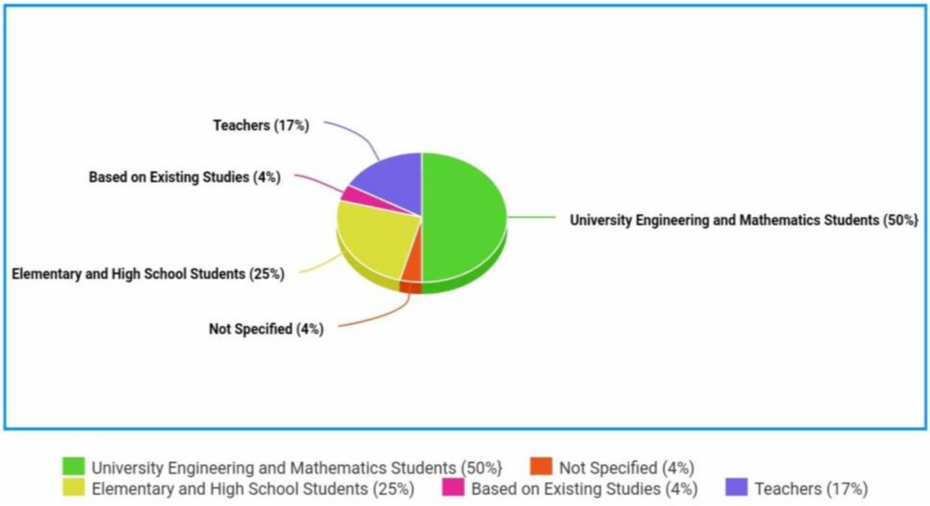
3.4. Country-wise Contributions

Based on the findings in Figure 4, developing nations are primarily responsible for pioneering research into the opportunities and challenges of integrating IoT in STEM education. The authors from Greece have the most significant percentage of publications (12%). It was followed by Ireland, Spain, Korea, and Malaysia (9%). The remaining fifteen countries, Australia, Kazakhstan, Canada, China, Estonia, Mexico, Germany, Saudi Arabia, Singapore, Sweden, India, Taiwan, and the USA, account for 4% of all publications.

3.5. Classification of Participants and Sample Sizes

This subsection covers the diversity of participants in the studies reviewed to illustrate the range of educational contexts in which IoT technologies are being explored (see Figure 5).

Figure 5
Classification of Participants' Involvement



The most frequently studied respondent group (n=12) comprised university engineering and mathematics students (e.g., Lee et al., 2023; Collaguazo et al., 2023; Wu et al., 2023; Verma et al., 2017). Emerging literature also involved educational sectors (n = 6) from elementary and high school students (Viberg et al., 2023; Liston et al., 2022) and university graduates (Boltsi et al., 2024), as well as from a range of organizations, including professional and educational stakeholders (Jin et al., 2022; Benita et al., 2021), and agriculture/technical perspective (Loukatos et al., 2022). Other studies included involved educators (n=4), specified in-service teachers (Thurm & Barzel, 2022), and professional education teachers (Viberg et al., 2023; Kusmin, 2019). One study (n=1) was based on existing studies and education perspectives built on the primary literature (Ghashim & Arshad, 2023). Finally, in one study (n=1), information regarding the various categories of people included in the research was not given.

The sample sizes in the reviewed studies ranged from a minimum of 65 students (Byrne et al., 2016; Chen et al., 2020) to a maximum of 10,000 participants, including students, multi-stakeholders, and partners in a study by Benita et al. (2021). However, studies with smaller sample sizes were more common than those with larger ones.

3.6. Content Analysis

Evaluation of the 24 selected journal articles was conducted to identify the challenges and opportunities associated with integrating IoT into STEM education. Following the data extraction process guided by Kitchenham and Brereton (2013), key information from each article was organized into a structured spreadsheet. The researchers then applied content analysis to systematically examine the extracted data, focusing on recurring themes related to barriers (challenges) and benefits (opportunities). Through this process, overlapping points were consolidated, identifying seven distinct challenges and seven distinct opportunities, as presented in Tables 2 and 3. Each item is supported by references to relevant articles to ensure traceability and transparency in the analysis

Table 2

List of challenges in implementing IoT in STEM Education

Code	Challenges	Concise Overview	References
C1	Resource Limitations	The scarcity of supplies in infrastructure availability, equipment pricing, skilled personnel, sustainability, and accessibility pose challenges for establishing and sustaining conventional hands-on learning spaces in educational institutions.	Ghashim & Arshad (2023); Kusmin (2009); Boltsi et al. (2024); Cornetta et al. (2019); Hazrat et al. (2023); Verma et al. (2017); Loukatos et al. (2022); Collaguazo et al. (2023); Benita et al. (2021)
C2	Skill Gap	Implementing technology-driven learning methodologies in STEM education may pose challenges due to variations in instructors' proficiency with digital tools, while encouraging students to utilize multiple skills through teaching methods (e.g., Project-Based Learning (PBL)) underscores a skill gap that requires attention.	Boltsi et al. (2024). Viberg et al. (2023); Chen et al. (2020); Collaguazo et al. al. (2023); Ayuso et al. (2022); Loukatos et al. (2022)

C3	Lack of Standardized Curriculum	The absence of standard guidelines for integrating digital technology into STEM education may result in disparate teaching strategies and learning experiences for students.	Boltsi et al. (2024). Ahmed et al. (2022); Ayuso et al. (2022); Chen et al. (2020)
C4	Data Security and Privacy Concerns	Gathering and preserving private information presents challenges in protecting against misuse or unauthorized access.	Boltsi et al. (2024). Verma et al. (2017); Hazrat et al. (2023); Ghashim & Arshad (2023); Jeong et al. (2015)
C5	Integration with Existing Systems	Difficulties in integrating new digital tools with the educational infrastructure that is in place now. Workflows and procedures must be modified accordingly.	Verma et al. (2017); Viberg et al. (2023); Ahmed et al. (2022); Boltsi et al. (2024); Loukatos et al. (2022); Byrne et al. (2016)
C6	Effectiveness	Comprehensive assessment methods are important for evaluating the impact of IoT on improving STEM education learning outcomes, necessitating an examination of both students' and teachers' experiences to identify key factors contributing to successful educational scenarios and prioritize evaluating intervention effectiveness.	Viberg et al. (2023); Ayuso et al. (2022); Verma et al. (2017); Byrne et al. (2016); Chen et al. (2020)
C7	Reliability and Performance	The effective use of IoT in STEM instruction depends on its consistent functionality and capacity to resist technical difficulties.	Cornetta et al. (2019). Jin et al. (2022); Sotelo et al. (2023)

Table 3

List of Opportunities in Implementing IoT in STEM Education

Code	Opportunities	Concise Overview	References
O1	Adaptive and Hands-on Learning	Using modern technologies for adaptive and hands-on learning fosters favorable, flexible environments for skill development and digital transformation awareness.	Sotelo et al. (2023); Loukatos et al. (2022); Lee et al. (2023); Ahmed et al.; Chen et al. (2020); Ayuso et al. (2022); Spyropoulou et al. (2020); Verma et al. (2017); Collaguazo et al. (2023); Benita et al. (2021); Wu et al. (2023); Kusmin (2019)
O2	Actionable STEM Education	It examines math teachers' use of technology and students' perceptions of STEM disciplines (i.e., chemistry, computer science, civil engineering, calculus, etc.). It focuses on integrating IoT with computer science, natural sciences, digital tools, and Industry 4.0 to enhance constructivist math teaching and student learning.	Ayuso et al.(2022); Byrne et al. (2016), Benita et al. (2021); Liston et al. (2022); Thurm & Barzel (2022); Hazrat et al. (2023), Kossybayeva et al. (2022); Chen et al. (2020)
O3	Enhanced Problem-Solving Skills	Involve overcoming challenges and coming up with solutions, essential for using technology to teach mathematics.	Sotelo et al. (2023); Lee et al. (2023); Jin et al. (2022); Wu et al. (2023); Chen et al. (2020); Ayuso et al. (2022); Verma et al. (2017); Loukatos et al. (2022); Benita et

			al. (2021); Kusmin (2019)
O4	Innovation and Creativity	IoT integration encourages hands-on learning, and the PGDCIDE model for creative engineering education and teacher belief analyses enables a transdisciplinary approach in elementary education that improves artistic and engineering skills.	Liston et al. (2022); Chen et al. (2020); Kossybayeva et al. (2022); Kusmin (2019); Sotelo et al. (2023); Hazrat et al. (2023); Ayuso et al.; Verma et al. (2017); Loukatos et al. (2022)
O5	Industry Alignment and Career Readiness	STEM education should incorporate IoT frameworks and Digital Twins to meet industry expectations, enhance career readiness by providing students with practical skills (e.g., emerging technologies, problem-solving abilities, critical thinking), and prepare students for diverse roles in the evolving digital workforce.	Jeong et al. (2015); Ahmed et al. (2022); Hazrat et al. (2023); Boltsi et al. (2024); Spyropoulou et al. (2020).; Chen et al. (2020); Loukatos et al. (2022); Byrne et al. (2016); Kusmin (2019)
O6	Real-Time Data Analysis	Incorporating real-time data analysis through IoT technologies fosters learners' skills (i.e., creativity, imagination) and interdisciplinary learning among STEM educators.	Liston et al. (2022); Mirza et al. (2022); Boltsi et al. (2024); Verma et al. (2017); Jeong et al. (2015); Wu et al. (2023)
O7	Global Connectivity and Entrepreneurship Opportunities	Entrepreneurs are driving the development of innovative IoT technologies to enhance educational experiences, encourage hands-on experimentation, and cultivate creativity in STEM education worldwide.	Cornetta et al. (2019). Boltsi et al. (2024); Jin et al. (2022)

3.7. Thematic Analysis of Challenges and Opportunities in IoT Integration into STEM Education

From the identified seven challenges and seven opportunities for integrating IoT into STEM education, we came up with themes that could be useful while formulating decisions and policies. Table 4 and Table 5 map these challenges and opportunities to specific themes, indicated by a check (✓) mark. It is pivotal to note that specific challenges (e.g., resource limitations) and opportunities (e.g., adaptive and hands-on learning) may be associated with various decision-making domains in IoT STEM education integration. Hence, responding to such challenges and opportunities requires a more effective strategy to pinpoint clearly (i.e., themes) within an organization and devise appropriate response strategies for each. With this, recognizing those themes and their challenges and opportunities would make economies of size and scope possible. This occurs because a particular response strategy on a theme can address multiple challenges and opportunities within that same theme, resulting in a more efficient achievement of the intended goals.

Table 4
Challenges about the identified categories.

Challenges	Concise Overview	Personnel Management	IoT Infrastructure	Financial	Skill Alignment	Educational Administration
Resource Limitations	The scarcity of supplies in infrastructure availability, equipment pricing, skilled personnel, sustainability, and accessibility pose challenges for establishing and sustaining conventional hands-on learning spaces in educational institutions.	✓	✓	✓	✓	✓
Skill Gap	Implementing technology-driven learning methodologies in STEM education may pose challenges due to variations in instructors' proficiency with digital tools, while encouraging students to utilize multiple skills through teaching methods (e.g., Project-Based Learning (PBL)) underscores a skill gap that requires attention.	✓		✓	✓	
Lack of Standardized Curriculum	The absence of standard guidelines for integrating digital technology into STEM education may result in disparate teaching strategies and learning experiences for students.	✓			✓	✓
Data Security and Privacy Concerns	Gathering and preserving private information presents challenges in protecting against misuse or unauthorized access.		✓	✓		✓
Integration with Existing Systems	Difficulties in integrating new digital tools with the educational infrastructure that is in place now.		✓	✓		✓

	Workflows and procedures must be modified accordingly.					
Effectiveness	Comprehensive assessment methods are important for evaluating the impact of IoT on improving STEM education learning outcomes, necessitating an examination of both students' and teachers' experiences to identify key factors contributing to successful educational scenarios and prioritize evaluating intervention effectiveness.	✓	✓		✓	
Reliability and Performance	The effective use of IoT in STEM instruction depends on its consistent functionality and capacity to resist technical difficulties.	✓	✓		✓	

Table 5

Opportunities for identified categories

Opportunities	Concise Overview	Personnel Management	IoT Infrastructure	Financial	Skill Alignment	Educational Administration
Adaptive and Hands-on Learning	Using modern technologies for adaptive and hands-on learning fosters favorable, flexible environments for skill development and digital transformation awareness.	✓			✓	✓
Actionable STEM Education	It examines math teachers' use of technology and students' perceptions of STEM disciplines (i.e., chemistry, computer science, civil engineering, calculus, etc.). It focuses on integrating IoT with computer science, natural sciences, digital tools, and Industry 4.0 to enhance constructivist math teaching and student learning.		✓		✓	✓
Enhanced Problem-Solving Skills	Involve overcoming challenges and coming up with solutions, essential for using technology to teach mathematics.	✓			✓	
Innovation and Creativity	IoT integration encourages hands-on learning, and the PGDCIDE model for creative engineering education and teacher belief analyses enables a transdisciplinary approach in elementary education that improves artistic and engineering skills.	✓	✓	✓	✓	
Industry Alignment and Career Readiness	STEM education should incorporate IoT frameworks and Digital Twins to meet industry expectations, enhance career readiness by providing students with practical skills (e.g., emerging technologies, problem-solving abilities, critical thinking), and prepare students for			✓	✓	✓

	diverse roles in the evolving digital workforce.					
Real-Time Data Analysis	Incorporating real-time data analysis through IoT technologies fosters learners' skills (i.e., creativity, imagination) and interdisciplinary learning among STEM educators.	✓	✓	✓		
Global Connectivity and Entrepreneurship Opportunities	Entrepreneurs are driving the development of innovative IoT technologies to enhance educational experiences, encourage hands-on experimentation, and cultivate creativity in STEM education worldwide.	✓	✓	✓		✓

The themes presented in this study were derived through a thematic analysis of the extracted data on challenges and opportunities related to integrating digital tools and technologies in STEM education, particularly within the context of IoT. In developing these themes, we drew guidance from the framework proposed by Miranda et al. (2021) and the future research agenda outlined by Costan et al. (2021). The paper adapted the structures to reflect the specific context while incorporating concepts such as smart sensors, IoT systems, and digital infrastructure—these critical components in preparing learners for a digitally-driven world. We expanded the thematic structure to capture broader issues relevant to higher education. As a result, five key themes were identified: personnel management, IoT infrastructure, financial, skills alignment, and educational administration. These themes provide a comprehensive framework for analyzing STEM education, IoT integration challenges, and opportunities. We aim to understand the nature of this integration better and support more informed, strategic decision-making in educational planning and policy.

3.7.1 Personnel Management

In educational institutions, personnel management typically consists of faculty, administrative, instructional, and operational support personnel. The essential components of personnel management include the teacher's training and promotion process, assessment and compensation, and the selection and recruitment process (Stone et al., 2015). Integrating IoT into STEM education is very important to ensure teachers and staff have the necessary training and expertise for utilizing IoT technologies in the classroom. Technology's application in school exhibited a desire to improve student learning (Hew & Brush, 2007).

Integrating these tools fosters an engaging learning environment and will successfully prepare students for the technological future. To give students individualized, flexible, and exciting learning experiences, IoT can also be utilized to develop innovative personal learning environments, known as PLEs (Kamruzzaman et al., 2023).

With these skills, resource limitations **(C1)** are among the most prevalent challenges of IoT in STEM education integration (Cornetta et al., 2019). The establishment and maintenance of hands-on learning spaces in educational institutions may face difficulties in acquiring the necessary resources to effectively implement IoT-based teaching and learning technologies due to scarcity of supplies, equipment pricing, skilled personnel, sustainability, and accessibility of IoT devices (Ghashim & Arshad, 2023). To close the skill gap **(C2)** (Boltsi et al., 2024) among educators, personnel management strategies that prioritize skill development and training programs are necessary for ensuring effectiveness **(C6)** in the use of IoT technology (Viberg et al., 2023). Besides, tending to issues with the reliability and performance **(C7)** of IoT innovations in STEM education is supported by personnel management (Cornetta et al., 2019). Teachers need assistance in identifying reliable IoT platforms and devices and resolving any technical problems that may arise during implementation. The lack of a standardized curriculum **(C3)** for integrating IoT into STEM education presents a further challenge (Boltsi et al., 2024). These challenges can be overcome, and educational institutions can fully utilize IoT technologies to improve STEM teaching by prioritizing personnel learning and development efforts.

Regardless of the challenges stated, there are opportunities for integrating IoT into STEM learning. With the support of interactive projects and experiments made possible by IoT devices, students can participate in real-world exploration, making hands-on learning **(O1)** more accessible (Sotelo et al., 2023). Students can collaborate with peers and professionals worldwide through global connectivity **(O7)**, broadening their perspectives and improving their educational experiences (Cornetta et al., 2019). Students' problem-solving skills **(O3)** will develop when we integrate IoT to solve real-world issues (Sotelo et al., 2023; Wu et al., 2023; Chen et al., 2020). This empowers innovation and creativity (**O4**) as they innovate and implement technology solutions (Liston et al., 2022; Chen et al., 2020). By gaining experience from data accumulated by IoT gadgets, real-time data analysis **(O6**) enables students to contribute to IoT-driven change and make well-informed judgments about various academic subjects (Liston et al., 2022; Mirza et al., 2022). Educational institutions can fully implement the benefits of integration by embracing these chances and managing people's development well.

3.7.2 IoT- Infrastructure

IoT infrastructure in STEM education refers to incorporating IoT technologies into teaching and learning environments to build students' understanding of science, technology, engineering, and mathematics concepts. It involves advancing problem-solving skills, fostering creativity, and supporting experiential learning through IoT devices, sensors, and data analysis tools. With this approach, students may explore applications of STEM concepts in real-world settings and gain practical experience building, designing, and programming IoT gadgets. IoT infrastructure integration presents challenges for STEM education (Cornetta et al., 2019). Lack of funding and equipment is an undeniable barrier preventing educational institutions from making investments in the necessary technology (Ghashim & Arshad, 2023; Kusmin, 2019; Boltsi et al., 2024; Cornetta et al., 2019; Hazrat et al., 2023) and resources **(C1)**. Data security and privacy problems **(C4)** must be developed to protect student and research data from breaches or abuse. Another difficulty is integrating IoT devices with current systems, which requires compatibility and smooth operation with educational technology (Boltsi et al., 2024; Verma et al., 2017). To make sure that IoT infrastructure improves rather than interferes with teaching and learning activities **(C5)**, this integration process has to be adequately controlled (Ahmed et al., 2022; Boltsi et al., 2024; Verma et al., 2017; Viberg et al., 2023). Assessing how well (C6) IoT infrastructure (Loukatos et al., 2022) enhances student experiences is critical. Maximizing the edge of integrating IoT technologies into STEM education requires ongoing evaluation and adjustment. To avoid interfering with educational activities, it is important to consider IoT devices' reliability and performance **(C7)** (Sotelo et al., 2023). For learning to occur effortlessly, IoT devices must operate reliably and effectively. Resolving these issues is essential to integrating and effectively deploying IoT infrastructure in STEM education.

There are chances to improve students' learning experiences and better prepare them for the complexity of the modern world by integrating IoT infrastructure into STEM education. Students may actively interact with actionable STEM education (Ayuso et al., 2022; Byrne et al., 2016) **(O2)** by utilizing IoT devices, sensors, and data analysis tools. This helps to fill the gap between theoretical understanding and actual utilization. In addition, incorporating IoT infrastructure ignites students' innovation and creativity (Liston et al., 2022) **(O4)** by pushing them to try emerging technologies and develop different approaches to problems. Students may analyze dynamic data using IoT devices' real-time capabilities (Boltsi et al., 2024) and draw knowledge and conclusions from real-time data streams **(O6)**. This strengthens their analytical skills and increases their self-assurance that they can utilize technology to accomplish noble objectives. Integrating IoT into STEM education (Jin et al., 2022) encourages entrepreneurial thinking, empowering students to transform ideas into solutions that benefit their communities while fostering global connectivity **(O7**) through collaborative problem-solving and innovation.

3.7.3 Financial

The quick development of technology has transformed the teaching and learning process by providing access to a wide range of the accessibility of resources and information. However, the implementation of IoT in STEM education has been restricted to students, educational institutions, and school property because of inadequate budget (Ghashim & Arshad, 2023). Institutions aiming to adopt IoT technologies often face substantial upfront costs associated with acquiring hardware, software, and infrastructure necessary for implementation **(C1)**. In this connection, educational institutions, especially those with constrained budgets, need help to allocate funds towards IoT in STEM education integration, prioritizing other pressing needs such as staffing, facility maintenance, or curriculum development. With enough funding, institutions find it easier to maintain and improve IoT systems effectively, reducing their capacity to improve instruction and learning outcomes **(C5)** (Saadé et al., 2023). With this, poor connectivity holds back data transmission, device organization, and real-time interaction, decreasing the effectiveness of IoT-enabled learning experiences **(C2)** (Srivastava et al., 2020). Also, ensuring secure communication channels, implementing encryption protocols, and using detection systems are critical measures to lessen these risks and safeguard student privacy **(C4)** (Boltsi et al., 2024).

To modify the current situation, drives and projects must align with educational institutions' capabilities and specifications. Through partnerships, the vast landscape of interconnected networks, technologies, and infrastructure can be implemented, and information can be shared globally **(O7)** (Cornetta et al., 2019). The transformative power of connectivity is changing how IoT in STEM education is usable. Furthermore, strategically allocated insights, training programs, and professional development projects promote innovation and security by making resources available for creative activities to achieve the objectives and making the data security that has been gathered **(O4)** (Kusmin, 2019), as it imparts knowledge and skills in educational institutions to sufficiently impart lessons from the IoT in STEM education.

Today's education sector tends to prepare learners well for industries in the Fourth Industrial Revolution, as they are at the center of new demands **(O5)** (Hazrat et al., 2023). Aligning educational objectives with industry needs and standards better prepares and masters students for career pathways in IoT-related industries, specifically in the fields of STEM. With the help of teachers who use the tool actively, students are provided with immediate feedback and a more engaging learning experience than traditional methods. At the same time, it requires students to critically evaluate information, identify patterns, and make data-driven decisions. This process cultivates critical thinking skills essential for STEM fields **(O6)** (Liston et al., 2022). Allocating IoT resources in STEM education is bound with financial needs, the extent of which must be thoroughly understood. This parallels IoT integration in STEM education, where investing in digital infrastructure and educational technology carries, although it could facilitate learning progressions (Gonzales, 2022), but also demands considerable financial commitments.

3.7.4 Skills Alignment

Skills alignment in STEM education refers to tailoring the educational experience to give learners the necessary practical skills, knowledge, and mindset to succeed in IoT. The IoT serves as a valuable educational resource for students, utilizing technology to tackle previously past challenges, thereby enhancing their training skills. Wearable technology monitors and records students' academic behavior, improving their learning results. Nonetheless, incorporating IoT in education is accompanied by various challenges. Resource limitations **(C1)** pose a significant challenge in aligning IoT education with STEM skills, hindering access to necessary hardware, software, and training materials (Cornetta et al., 2019; Ghashim & Arshad, 2023). More funding and infrastructure challenge the IoT's integration in STEM education, impeding students' development of practical skills (Tokarz et al., 2020). Addressing the skill gap **(C2)** associated with integrating IoT technologies into STEM education, particularly the computer science curriculum, remains a pressing concern for educators and institutions (Boltsi et al.,2024). Without a standardized curriculum **(C3)**, students have different levels of learning ability due to social and economic aspects they have gone through in their lives (Boltsi et al., 2024; Mahapatra et al., 2023). Without a universally accepted framework, educators face difficulties in designing cohesive IoT courses that cover relevant topics and address the various needs of the learners. Assessing the effectiveness **(C6**) of IoT education in STEM becomes challenging due to the need for such tools for teachers in their teaching practice (Fidai et al., 2019; Maidatsi et al., 2022; Viberg et al., 2023). Reliability and performance **(C7)** issues with IoT devices and platforms hinder seamless integration into educational settings, impacting the overall learning experience; it can also create disparities in students' exposure to cutting-edge tools, limiting their ability to adapt to diverse industry requirements (Cornetta et al.,2019).

Some of the opportunities of IoT in STEM education integration are linked to aligning skills. The most convincing one is the adaptive and hands-on learning skills **(O1)**. IoT integration in STEM education is unparalleled, enabling students to interact directly with connected devices and gain practical experience (Glaroudis et al., 2019). Actionable STEM Education **(O2)** mainly focuses on utilizing IoT within STEM education to close the gap between practical abilities and theoretical knowledge required for future STEM vocations in secondary education (Ayuso et al.,2022). Engaging in this actionable STEM education boosts students' motivation and encourages active learning involvement (Mora et al., 2020). IoT-infused STEM education enhances problem-solving skills **(O3)** as students tackle real-world challenges using connected devices and proposes a method of instruction based on the repetitive structure to enhance students' problem-solving skills (Chen et al., 2020). The dynamic nature of IoT applications inspires innovation and creativity **(O4)**. The transformation of emerging technologies emphasize the importance of initiating skill development in education early in teaching by providing appropriate models to help students understand and acquire digital citizenship (Almufarreh et al., 2023). Focusing on industry alignment and career readiness **(O5)** can develop a skilled workforce capable of meeting future industry demands in engineering, particularly in IoT technologies (Hazrat et al.,2023). Within STEM education, they are focusing on using digital twin technology in math education through games and gamification strategies, aiming to better prepare university students for future careers in fields such as IoT (Lee et al., 2023). Graduates are equipped to apply their knowledge in professional settings, overcoming the gap between academic studies and career expectations.

3.7.5 Educational Administration

In IoT integration into STEM instruction, educational administration is at the forefront of modern educational innovation (Kulakoglu & Kondakci, 2023). As technology advances, educators increasingly recognize the ability of IoT devices to transform great experiences in instruction and learning. From interactive experiments in scientific labs to real-time data gathering and analysis in engineering projects, IoT promotes hands-on, engaging learning opportunities that allow students to explore STEM ideas deeply. However, effective implementation requires skilled educational administration to ensure fair access, cybersecurity, and curriculum conformity. Administrators are promoting professional growth, providing resources, and encouraging stakeholder engagement to realize IoT potential in STEM instruction.

Educational administration frequently faces resource limitations **(C1)**, including money, staff, and infrastructure. These constraints hinder the implementation of new initiatives, the acquisition of required technology, and staff training, affecting areas such as curriculum creation, teacher training, and student support services (Ghashim & Arshad, 2023). In addition, the absence of a standardized curriculum **(C3)** across schools or districts contributes to differences in educational quality and student results, as teachers need help to match instruction with educational goals (Boltsi et al., 2024). Meanwhile, the increased use of technology in education creates data security and privacy concerns **(C4)**, necessitating strong safeguards for sensitive information on students, teachers, and staff (Ghashim & Arshad, 2023). Additionally, integrating new educational initiatives, technology, or procedures with existing systems **(C5)** presents complicated issues that require a careful assessment of compatibility, proper training and support, and overcoming community opposition (Boltsi et al., 2024). Creative solutions, cooperation, and strategic planning are essential to overcome these obstacles and create an atmosphere that contributes to student learning and development.

To help students learn and succeed, educational administration provides opportunities. Adaptive and hands-on learning **(O1)** strategies are essential for tailoring educational experiences to individual student needs and fostering deeper understanding through experiential engagement (Loukatos et al., 2022), building the foundation for actionable STEM education **(O2)**, which gets learners ready for the needs of the contemporary workforce by acquiring practical problem-solving and critical thinking abilities (Benita et al., 2021). This, combined with the Industry Alignment and Career Readiness **(O5)** initiatives, bridges the gap between school and employment by ensuring that students are capable and knowledgeable enough, which is required for success in various industries (Hazrat et al., 2023). Global Connectivity and Entrepreneurship Opportunities **(O7)** complements these initiatives by providing students with the skills and mindset required to thrive in an interconnected world, encouraging them to embrace entrepreneurship and collaborate effectively across borders for success in the global economy (Cornetta et al., 2019).

4. Policy Insights

The developed policy recommendations aim to address the IoT in education, focusing on key policy areas critical to enhancing STEM education. The policy brief identifies the challenges and opportunities associated with (1) IoT-enhanced learning environments, (2) curriculum development, (3) assessment and evaluation, (4) equity and access, (5) educational administration, and (6) learner-centered IoT projects. An in-depth analysis provides recommendations to overcome the existing barriers and leverage IoT's potential to create more inclusive and engaging learning experiences. These insights propose strategies to ensure equitable access to IoT resources, improve educational outcomes for all students, and prepare them for success in the evolving digital world. Table 6 presents the policy insights derived from the review.

Table 6
Evidence-based Policy Insights

Policy Area	Challenges & Opportunities	Evidence Summary	Policy Insights
IoT-Enhanced Learning Environments	Challenges: Limited IoT infrastructure; lack of integration guidelines. Opportunities: Enables hands-on learning; fosters problem-solving skills.	Challenges: Resource limitations related to infrastructure, skilled personnel, and accessibility (Ghashim & Arshad, 2023; Kusmin, 2009; Boltsi et al., 2024; Cornetta et al., 2019). Opportunities: Adaptive and hands-on learning supports flexible digital transformation (Sotelo et al., 2023; Loukatos et al., 2022; Lee et al., 2023).	Increase funding and establish standards for IoT integration in classrooms.
Curriculum Development and Alignment	Challenges: Absence of a standardized IoT curriculum. Opportunities: Promotes interdisciplinary learning; supports real-world problem solving.	Challenges: Lack of standardized curricula causes inconsistency in instructional methods (Boltsi et al., 2024; Ahmed et al., 2022; Ayuso et al., 2022). Opportunities: Actionable STEM education enhances cross-disciplinary learning and digital integration (Ayuso et al., 2022; Liston et al., 2022).	Develop a national IoT curriculum framework aligned with STEM education goals.
Assessment and Evaluation with IoT	Challenges: Difficulty in measuring the effectiveness of IoT-enhanced instruction. Opportunities: Offers real-time feedback and personalized assessment.	Challenges: Lack of comprehensive assessment approaches to evaluate impact (Viberg et al., 2023; Verma et al., 2017; Chen et al., 2020). Opportunities: Real-time feedback and personalized learning improve assessment	Implement IoT-based assessment systems with clear performance metrics.

		(Liston et al., 2022; Mirza et al., 2022).	
Equity and Access in IoT Education	Challenges: Financial barriers and limited infrastructure. Opportunities: Provides equal access; prepares underrepresented groups for digital careers.	Challenges: Financial constraints and limited infrastructure restrict equitable access (Boltsi et al., 2024; Loukatos et al., 2022; Benita et al.). Opportunities: Promotes global connectivity and equal learning access (Cornetta et al., 2019; Jin et al., 2022).	Provide targeted funding and subsidies for under-resourced schools and communities.
IoT and Educational Administration	Challenges: Outdated systems and infrastructure. Opportunities: Supports efficient, data-driven decision-making.	Challenges: Reliability and performance issues hinder system integration (Cornetta et al., 2019; Jin et al., 2022; Sotelo et al., 2023). Opportunities: Industry alignment and efficiency through IoT-enabled systems (Ahmed et al., 2022; Jeong et al., 2015).	Modernize educational management systems through IoT integration.
Learner-Centered IoT Projects	Challenges: Integration issues with legacy systems. Opportunities: Enables real-time data-driven learning; encourages critical thinking and innovation.	Challenges: Integrating new tools with current infrastructure presents workflow disruptions (Ahmed et al., 2022; Verma et al., 2017; Viberg et al., 2023). Opportunities: Real-time data analysis enhances learning engagement (Verma et al., 2017; Wu et al., 2023).	Promote collaboration between educators and IoT developers to design adaptive, learner-centered tools.

First, the integration of IoT into educational environments has the potential to transform traditional learning practices into more interactive and technology-driven experiences. The limited resources for IoT infrastructure and devices are challenging in IoT-enhanced learning environments due to their cost to implement and maintain. Also, the absence of standard guidelines for integrating digital technology into STEM education may result in distinct teaching strategies and learning experiences for students (Boltsi et al., 2024; Ghashim & Arshad, 2023). As a result, educators must be offered sufficient training to enhance the learning environment within the teaching and learning process. Integrating IoT technologies for hands-on learning enhances various skills for students (Loukatos et al., 2022; Sotelo et al., 2023). It fulfills the industry's changing expectations, which require multidisciplinary skills and digital transformation (Hazrat et al., 2023). Cultivating students' problem-solving skills helps them overcome challenges and develop innovative solutions to real-world problems (Hazrat et al., 2023; Lee et al., 2023). Governments and educational institutions should prioritize funding to enhance IoT infrastructure. Allocating budget resources for IoT devices and secure connectivity solutions will provide equitable access to digital learning tools. This learning environment stimulates deeper engagement and well-equipped students with relevant skills for STEM fields.

Second, a well-designed curriculum is the backbone of effective IoT integration to ensure alignment between educational goals and industry needs. The lack of a standardized curriculum hinders IoT in higher education (Ayuso et al., 2022; Boltsi et al., 2024), which stresses the need for cohesive educational frameworks. Educators can acquire valuable insights into leveraging IoT to enrich online education through data mining, leading to adaptive and hands-on learning environments (Njeru et al., 2017). IoT in STEM curricula is a favorable direction for building the connection between classroom learning and industry needs. Through this integration, students can actively participate in practical learning experiences resembling real-world applications. Learners have the opportunity to explore the interconnectivity of wide-ranging fields such as programming, engineering, and data analytics in the IoT space. Establish a standardized IoT curriculum framework to integrate IoT-related content into STEM subjects like math, science, and computer science. This framework allows students to gain practical experience and understand interdisciplinary applications. With a standardized, aligned curriculum, students will gain practical IoT experience and make STEM education more relevant to real-world scenarios. This hands-on approach improves a deeper understanding of STEM concepts and builds foundational skills necessary for careers in fields like data science and engineering. This exposure enhances their academic journey and prepares them to contribute to high-tech industries, strengthening the future workforce.

Third, assessment and evaluation are critical for measuring the effectiveness of IoT integration in achieving learning outcomes. Without structured evaluation systems, it is difficult to determine the educational value of these technologies (Verma et al., 2017; Viberg et al., 2023). IoT offers the potential to support real-time assessment and personalized learning, improving student feedback and engagement (Wu et al., 2023). Introducing IoT-based tools with standardized metrics can ensure that student progress and efficacy of instructional strategies are effectively monitored. Regular system maintenance and reliability checks must be implemented to guarantee accurate data collection and analysis. This enables educators to tailor instruction to individual needs and empowers students with immediate, actionable insights into their learning progress.

Fourth, equity and access are foundational principles for ensuring inclusive STEM education. Financial and infrastructural constraints prevent under-resourced schools from integrating IoT technologies, limiting opportunities for disadvantaged learners (Boltsi et al., 2024; Zeeshan et al., 2022). Ensuring equal access to digital tools is crucial to bridging the digital divide and preparing all students, regardless of socioeconomic background, for the modern workforce. Government subsidies and institutional grants can support the deployment of IoT infrastructure in underserved areas, fostering digital literacy and social mobility (Tene et al., 2024; Zikria et al., 2021). By addressing these disparities, educational systems can offer every student an equal chance to acquire critical STEM skills and contribute meaningfully to the digital economy.

Fifth, effective integration of IoT into educational administration demands the modernization of management systems to support dynamic learning environments. Some universities' current management systems and infrastructure must be updated to ensure competitive and adequate operation. Therefore, there is a need to use digital technology and adapt IoT in STEM education to enhance the chance of using university infrastructure that can cater to students' dynamic and personalized learning environments (Cornetta et al., 2019; Jin et al., 2022). Universities should prioritize upgrading their management systems to incorporate IoT technologies that support real-time data collection and operational efficiency. Improving educational administration, supervising plan strategies, and implementing structure will enhance the students' educational system and change technical structures and industrial and societal progress. As IoT capabilities evolve, educational administration must enhance operational efficiency in personalized learning, predictive analytics, and adaptive systems. This approach can lead to cost savings and more effective fiscal administration.

Lastly, learner-centered IoT projects provide an innovative framework for engaging students in active problem-solving and personalized learning. The identified challenge of integrating existing systems indicates incorporating IoT technologies into educational environments while considering pre-existing infrastructure (Sahu, 2024; Verma et al., 2017). This challenge highlights the practical barriers that must be overcome to ensure successful implementation. In contrast, the opportunities presented by adaptive and hands-on learning emphasize the learner-centric approach, focusing on individualized, interactive experiences facilitated by IoT technologies (Kayyali, 2024; Wu et al., 2023). This aligns with the larger goal of customizing learning requirements and preferences. Partnerships between educators and IoT developers are encouraged to design learner-centered IoT projects that focus on real-world problem-solving and critical thinking. These projects should provide opportunities for students to support different learning styles and encourage more profound understanding. Students will have more opportunities to engage in personalized learning experiences appropriate to their needs and abilities. This active involvement in data analysis and problem-solving can improve their comprehension of STEM concepts and equip them for future academic and professional pursuits.

5. Conclusion

The paper examines the integration of the Internet of Things (IoT) in STEM education through a systematic review of 24 peer-reviewed academic papers. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, employing four key procedures: identification, screening, eligibility, and inclusion. The literature was sourced from Web of Science (WoS) and Scopus. After a rigorous screening and eligibility assessment, 24 studies met the inclusion criteria for final analysis. Data extraction from these studies led to the identification of seven key opportunities (adaptive and hands-on learning, actionable STEM education, improved problem-solving skills, innovation and creativity, industry alignment and career readiness, real-time data analysis, and global connectivity) and seven prominent challenges (resource limitations, skill gaps, lack of standardized curriculum, data security and privacy concerns, integration with existing systems, effectiveness, and reliability). Through content and thematic analysis, the paper captured five overarching themes that summarize the integration dynamics of IoT in STEM education: personnel management, IoT infrastructure, financial considerations, skill alignment, and educational administration. The identified challenges and opportunities reveal interconnections and their influence on this thematic structure. The findings capture insights for an inherent need for strategic interventions for the transformative potential of IoT in STEM education. Based on the challenges, opportunities, and emergent themes, policy insights were formulated across key areas, including IoT-enhanced learning environments, curriculum development, assessment and evaluation, equity and access, educational administration, and learner-centered IoT initiatives. These insights aim to support structured integration that promotes improved learning outcomes through immersive, hands-on experiences.

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