

Review

A systematic literature review of ICT integration in secondary education: what works, what does not, and what next?

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Abstract

This study is rigorous of peer-reviewed literature on the integration of information and communication technology (ICT) tools in secondary schools. It analyzed the impact of ICT integration on the teaching and learning process based on 51 sampled studies. The findings are thematically presented under the benefits of improving teaching and learning processes regarding curriculum coverage, equitable access, shared learning resources, and personalized learning. Furthermore, challenges were found in professional development, pedagogical and technological knowledge, and resource maintenance. Among the best practices and strategies to resolve these challenges were regular supply and systems maintenance, curricula realignment, ICT policy formulation, and engaging all stakeholders in ICT integration. Recommendations: practitioners should adopt, adapt, and innovate pedagogical approaches, strategies, and methods to facilitate the use of ICT in teaching and learning and should align and integrate ICT tools with curriculum objectives, content, or standards by exploring and using diverse and dynamic ICT tools and methods in secondary schools.

Keywords Secondary education · Curriculum coverage · Innovative pedagogies · ICT integration

1 Introduction

Information and communication technology (ICT) is a powerful tool capable of transforming education and enhancing learning outcomes. As a result of this technology, students can access information, collaborate with peers and teachers, develop critical thinking skills and problem-solving abilities, and express their creativity and innovation. Additionally, it can assist teachers in designing and delivering more effective and personalized instruction, assessing and monitoring student progress, and engaging in continuous professional development [1, 2]. Despite this, integrating ICT into education is not without challenges; each context and subject area has specific needs, challenges, and opportunities that must be considered during the planning, implementation, evaluation, and improvement process. This analysis, therefore, aims at identifying gaps and limitations in the literature and argues that it is essential to thoroughly review the current literature to synthesize the knowledge about what works, what does not, and the next steps to take to yield the best results out of the integration process.

Furthermore, education has become more integrated with ICT in the twenty-first century, thriving on advancements in computer technology; teaching and learning in secondary schools can be improved in various ways. There is a possibility to support, enhance, or alter the processes and outcomes of teaching and learning in secondary schools through

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the efficient and successful implementation of ICT [3]. As a result of the use of ICT in the classroom, particularly in secondary schools, students' learning outcomes, motivation, engagement, and skill development are improved, as well as teachers' attitudes, practices, and beliefs about teaching and learning [4, 5]. It is, therefore, imperative that stakeholders work together to overcome the obstacles and problems that prevent secondary schools from fully integrating ICT by addressing challenges such as a lack of resources, training, time, support, curriculum alignment, and pedagogical change [6, 7] that interfere with successful integration.

Hence, providing a comprehensive analysis of empirical studies relevant to ICT in secondary schools and learning, the purpose of this systematic literature review is to provide a comprehensive review of the empirical studies. This is because secondary education is integral in preparing young people for life, work, and higher education in the twenty-first century, making integrating ICT into various subjects to be indispensable for improved teaching and learning.

1.1 Research question

The systematic review will analyze the included studies to attain its objective by addressing the following questions:

RQ1: Which benefits of ICT integration exist in secondary schools for teaching and learning?

RQ2: What challenges and barriers hinder ICT's practical and meaningful integration in teaching and learning?

RQ3: Which best practices and strategies have been implemented for effective ICT integration in secondary schools?

The study contributes to the existing knowledge base on ICT integration in secondary schools by providing a comprehensive overview of the current state of the art and highlighting the gaps and areas for further research. The study also offers practical implications and recommendations for policymakers, educators, researchers, and stakeholders interested in ICT integration in secondary schools. The study is particularly relevant for developing countries, where ICT integration in secondary school education is still in its early stages of implementation and faces many challenges [8]. Developing countries are home to many young people who need quality education to achieve their potential and contribute to their nation's social and economic development. Hence, this exploration is timely and essential.

Therefore, to achieve this objective, a systematic literature review was conducted using a six-step process, including team selection, protocol creation, extensive search, screening and selection of studies, data extraction and analysis, and reporting and dissemination of findings. The recommendations from the Cochrane Handbook for Systematic Reviews served as the foundation for the procedure [9]. Both narrative and quantitative approaches were employed for the data synthesis. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework was used to prepare this study [10].

The structure of this article includes Sect. 1, which is the background information on ICT integration in secondary education, and an overview of the systematic review methodology is provided in Sect. 2, encompassing a search strategy, inclusion and exclusion criteria, quality assessment, extraction, and synthesis of data. The results are presented in Sect. 3 as descriptive statistics, thematic analysis, and synthesis. Section 4 discusses the main findings, the implications of this rigorous analysis, and its limitations and directions for possible future research. Finally, Sect. 5 presents the synthesized results and discussion.

2 Method

This study applies a rigorous and transparent methodology based on the Cochrane Handbook for Systematic Reviews [11] and the PRISMA guidelines [10]. The study procedure progressed through six steps: selecting the team, developing the protocol, conducting a comprehensive literature search, screening and selecting studies, extracting and analyzing data, and reporting the results. The main objective was to investigate information and communication technology (ICT) use in secondary school education. Furthermore, the research aimed to understand better the impact and challenges of integrating ICT tools in secondary education. To sufficiently address the research problem and the stated objective, we selected a qualitative methodology based on a systematic literature review (SLR) guided by the PRISMA framework protocol [10] on integrating ICT in secondary school. The research questions were formulated to address the integration of ICT, the impact, and challenges faced in the process of integrating ICT in secondary schools, as shown in Table 1.

Table 1 Scope, research questions, and coding

Scope	Research questions	Initial coding criteria
Integration of ICT	RQ1. Which benefits of ICT integration exist in secondary schools for teaching and learning?	Co-occurrence map by keywords
Challenges of Integration	RQ2. What challenges and barriers hinder ICT's practical and meaningful integration in teaching and learning?	ICT Integration Challenges for Integration
Implication of Integration	RQ3. Which best practices and strategies have been implemented for effective ICT integration in secondary schools?	Implications of Integration Quartile of the journal and year of publication of the article Thematic categorization of the sampled studies

2.1 Eligibility criteria

The sampled articles were considered eligible based on the document characteristics of being published:

- i. in peer-reviewed journals,
- ii. in the English language,
- iii. between 2008 and July 11, 2023.

Additionally, content criteria and empirical studies with quantitative and qualitative methods were included, discarding theoretical studies dealing with ICT in settings other than secondary school.

2.2 Data sources and search strategy

The included studies were identified and retrieved from Scopus and Eric electronic databases. For the search and selection of articles, we used the search terms and their combinations as "integration", "technology", "secondary", "school", "ICT", "ICT in secondary education", "ICT in secondary schools", "implication of ICT in education", "implication of ICT in secondary schools", "benefits of ICT in secondary school", "challenges in the implementation of ICT", "challenges in the implementation of ICT in secondary school", "impact of ICT in secondary school", and "best practices in ICT implementation in secondary schools".

2.3 Quality appraisal

The sample was selected using the JBI Checklist for Systematic Reviews and Research Syntheses. The checklist contains 11 questions, and the inclusion criteria were scored as "yes", "no", "unclear", or "not applicable" [12]. The automated inclusion and exclusion criteria were conducted by the three researchers who examined the search results by evaluating the abstracts to determine whether the study was suitable for the analysis of the benefits, challenges, and strategies employed to enhance ICT integration in secondary schools. In addition, studies were excluded if they did not meet the criteria after an objective comparison of the decisions of the independent researchers. The researchers' independent decisions had an interrater reliability of 94%, which was increased to 100% after the discussion among the three researchers to resolve and determine the suitability of the disputed studies.

2.4 Data analysis

The identified articles were 1363 from Scopus and Eric electronic databases, which were later cleaned up for duplicate records before screening. After the automated inclusion and exclusion process, 553 records were selected for further screening and eligibility assessment, which resulted in 51 sampled studies for this systematic analysis, as presented in Fig. 1.

3 Results

The results section is a descriptive and thematic analysis and presentation of the 51 included studies.

3.1 Description of the articles under analysis

The systematic review included studies from 2008 to 2023 to establish the trends and gaps in the integration and impact of ICT in secondary schools. According to the article distribution in Fig. 3, most of our sampled studies were published in 2020 and 2022, followed by 2023. However, 2023 will likely receive more publications since the literature search was conducted in June 2023. The findings indicate that most of the included studies were published in 2022 and were distributed as in Fig. 2.

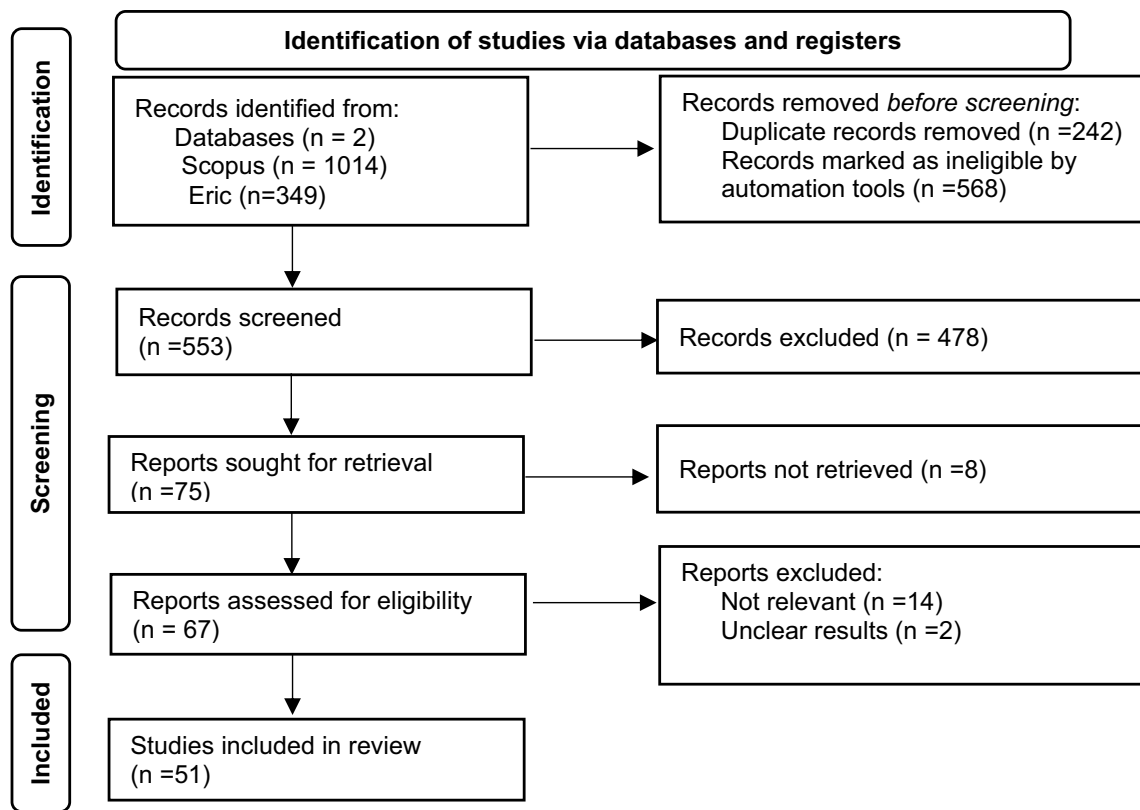


Fig. 1 Flowchart for inclusion and exclusion process

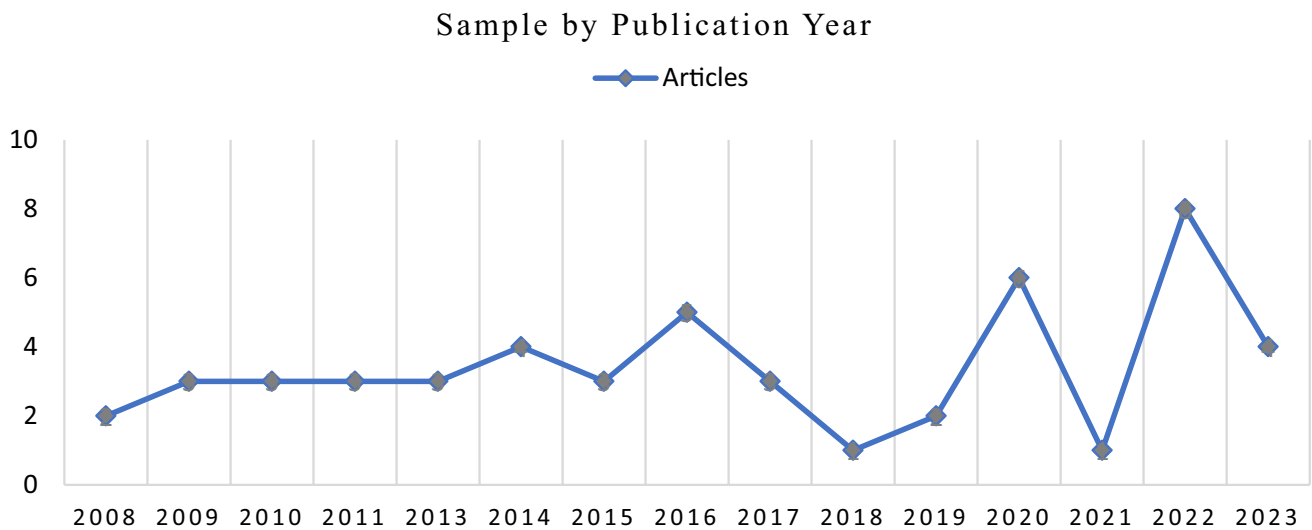


Fig. 2 Publications by year (n=51)

Furthermore, the studies were analyzed based on the methodology used. It was established that mainly quantitative methods were used in most of the sampled studies, and the least used method was the survey, as shown in Fig. 3.

The systematic review categorized the included studies according to the country in which they were published. The article distribution by country indicates that many studies were conducted in Malaysia, as shown in Fig. 4.

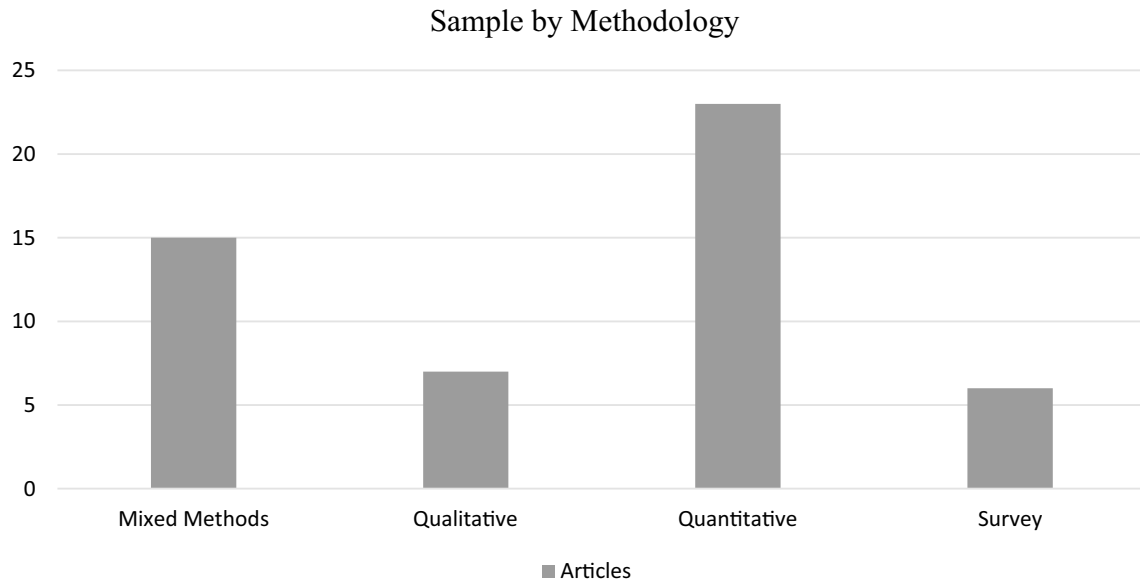


Fig. 3 Sampled studies by methodology

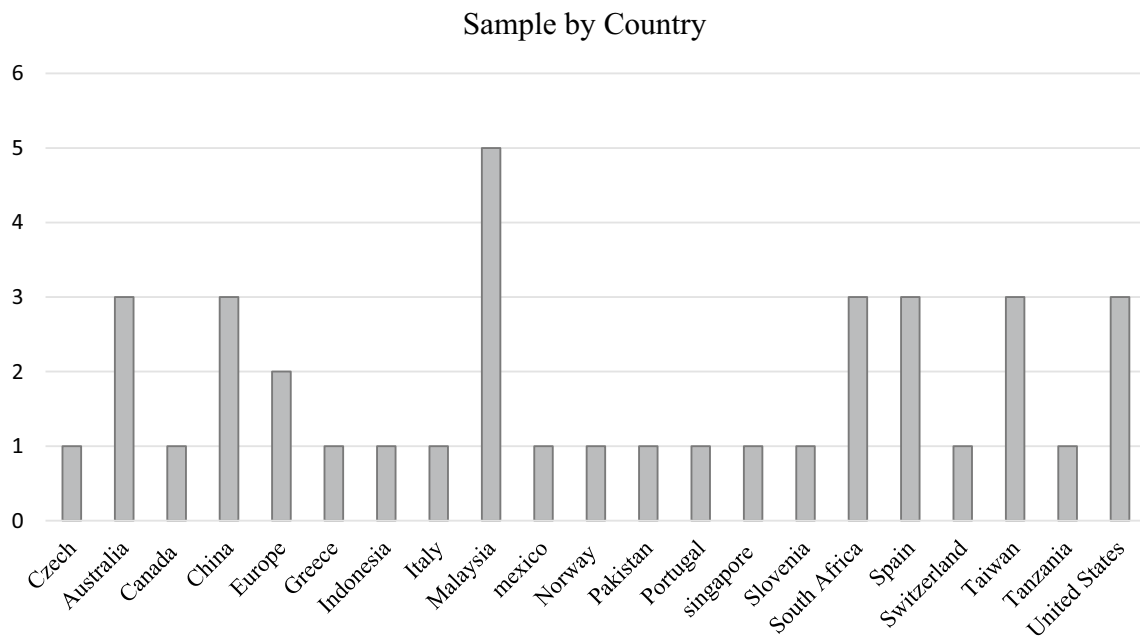


Fig. 4 Distribution by country

3.2 Thematic analysis

This section presents the findings according to the identified themes in relation to the research questions. The theme identification process involved the two authors independently analyzing the included studies with regard to the research questions and eligibility for the full-text screening. There was consultation with a third author in settling any disputes. This procedure of screening the full text and extracting the data was conducted thoroughly, as illustrated in the PRISMA flow diagram in Fig. 1. Then, the initial coding for key terms was summarized into themes that emerged from the process, categorized according to the research questions as in Table 2.

Table 2 Thematic analysis of sampled studies

Key terms	Thematic results	Included studies
RQ1 Benefits Integration Teaching and learning	ICT integration improves: The Teaching processes The Learning processes Curriculum coverage Access to Learning Equitable sharing of learning resources Personalized Learning	[4, 6, 13–19]
RQ2 Challenges Barriers Practical and meaningful integration	ICT integration improves: Professional Development Pedagogical Knowledge Technological Knowledge Resources and maintenance Poor attitudes, beliefs, and practices	[6, 7, 16, 20–27]
RQ3 Best practices Best Strategies Effective ICT integration	ICT Integration Best Practices and Strategies: Regular ICT systems maintenance Supply of suitable ICT tools ICT policy formulation Curriculum alignment Stakeholders' engagement	[4, 6, 7, 14–16, 20, 21, 23–30]

3.2.1 Themes in ICT integration

ICT integration in secondary education is characterized by some common themes, patterns, distinctions, and variations across subjects. The analyzed studies highlight that ICT integration is not only an essential tool to make teaching more interesting and sufficiently transmit twenty-first century skills to learners in current secondary schools but also plays a vital role in enhancing student's learning outcomes, motivation, engagement, and critical and innovative thinking development [13, 18]. Therefore, this study identified three themes surrounding the integration of ICT in secondary schools: the benefits, the challenges, and the best practices and strategies for making ICT an integral and beneficial tool for teaching and learning. Indeed, several factors have influenced and impacted the successful integration of ICT in various subject areas.

These factors can be loosely classified as student factors and teacher factors. Student factors can be termed those that affect students' learning processes, while teacher factors impede the teacher's abilities to deliver the learning experiences in the teaching process. This analysis discovered that student factors can be minimized by integrating appropriate ICT tools, especially tools and methods that align with the subject's learning objectives, content, and pedagogy [4, 31]. For ICT integration to be effective, a number of considerations need to be made, such as the quality of the ICT tools and methodologies, student involvement, learning interaction, and the assessment methods to be used [16, 28].

On the other hand, teacher factors such as inadequate professional development, lack of sufficient school support, and pedagogical knowledge influence teachers' attitudes, beliefs, and behaviors, which determine their desire and actual ICT integration in various subjects. Based on the findings, instructors can use ICT tools in a variety of ways, and how they adapt and use them can affect how they view, adopt, and use these tools [27, 29]. ICT integration skills can be developed through professional development [32], while school leadership and support can also assist teachers with ICT integration by providing them with resources, guidance, and motivation [21, 33]. The teacher's pedagogical expertise and views may also contribute to the tactics they use to integrate ICT into their classrooms, such as whether they prefer student- or teacher-centered approaches [25]. The integration of ICT tools may be affected not only by student and teacher factors but also by the nature of the subject area and its associated learning experiences. Therefore, the distribution of ICT integration of the sample by subject areas demonstrates that the highest integration level of ICT tools was recorded at 33% in ICT as a subject, followed by STEM subjects at 17%, as shown in Fig. 5.

4 Discussion

Based on this systematic literature review, we provide insights into how ICT is used in schools to improve teaching and learning. To comprehensively explain the findings, the research questions that guided this study have been categorized and discussed.

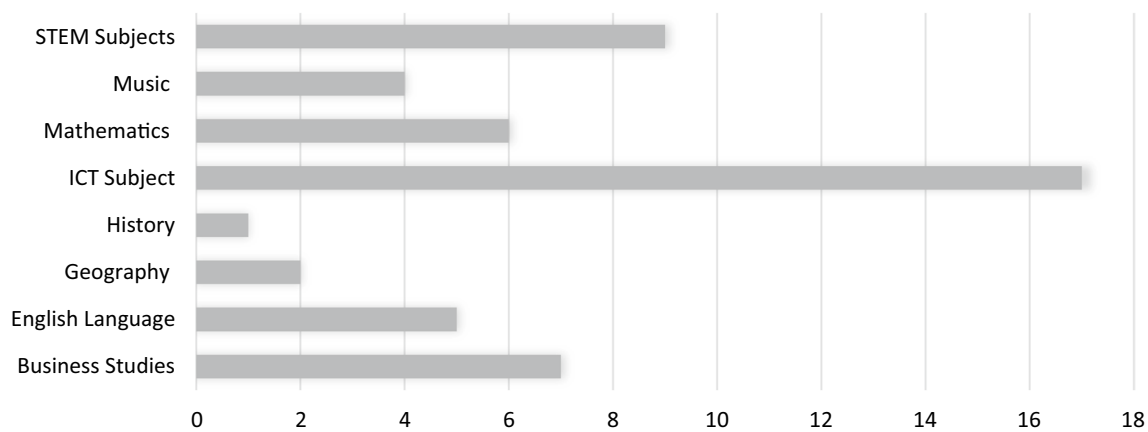


Fig. 5 Distribution of ICT tools integration in subjects

RQ1: What are the benefits of using ICT in secondary education?

RQ1 examined how ICT integration impacts secondary schools' learning outcomes, motivation, engagement, and skill development. About Eleven studies covering mathematics, science, language, and social studies addressed this question based on the rigorous inclusion criteria. The integration of ICT in secondary schools has been found to benefit the teaching and learning processes by improving the quality and pace of curriculum coverage. It is without doubt that integrating computers in the teaching and learning process, if well done, may translate into efficiency, but if not well done, it becomes disruptive. It may disorient both the teachers and learners from attaining their academic goals.

Therefore, this study aimed at synthesizing the benefits of effective ICT integration, which would foster impactful advances in secondary schools' educational attainments. The twenty-first century has registered considerable advancements in computer technology, transforming various sectors of society and increasing demand for advanced computer skills. This requires that teaching and learning at all levels, particularly in secondary schools, be improved to support, enhance, and alter the processes and outcomes of teaching and learning through the efficient and successful implementation of ICT tools in schools [3]. As a result, using ICT in the classroom improves students' learning outcomes, motivation, engagement, skill development, and teachers' attitudes, practices, and beliefs about the teaching and learning process [4, 31]. Therefore, stakeholders must work together to promote fully effective and practical integration of ICT tools by addressing issues such as a lack of resources, training, time, support, curriculum alignment, and pedagogical change [6, 7] that interfere with successful integration. Apart from human resource skills development, other suitable resources and tools, such as software packages, should be made available to secure a meaningful integration.

According to Latifi [34], GeoGebra software, for instance, was used to teach geometry in Mathematics, improving students' geometry knowledge and performance. Furthermore, it showed that academic achievement, conceptual understanding, problem-solving skills, and creativity were all positively affected by the ICT integration on student learning outcomes. Indeed, Woodrich [13] confirmed that students' writing skills, creativity, motivation, and achievement in biology increased using Moodle LMS [6]. In a study conducted by Thibaut [20], students' inquiry skills and scientific literacy were also improved through WebQuest. It is clear that effective ICT integration in different subjects positively influences the motivation, engagement, and skill development of both the teacher and the learners, making their work more exciting and easier to understand. Therefore, when ICT tools are appropriately used, curriculum content and information are accurately and diversely presented, enhancing learners' ability to grasp concepts and ideas more efficiently and accurately, making the teaching and learning process easier and more interesting.

Another set of benefits can be presented under access to the learning process. Furthermore, the effective integration of ICT in the educative process gives learners better access to curriculum content and information; for example, a teacher can make the learning experiences available for learners at all times. That is, learners are made to conveniently access online learning experiences as they enjoy the freedom to continue learning at their convenience. In addition, effective ICT integration enables learners to collaborate with peers and teachers, develop critical thinking and problem-solving abilities, and express their creativity and innovation during their learning. Moreover, effective ICT integration can also enhance and make learning more personalized. In this regard, ICT tools can assist teachers in designing and delivering more effective and personalized instruction assessments, monitoring student progress, and engaging them in different learning activities.

Furthermore, personalized learning enables the equitable sharing of learning resources such as e-textbooks, course wares, computers, digital media, and other resources available to learners according to their learning needs. The equitable sharing of learning resources has been confirmed by different studies to positively affect students' interest, curiosity, confidence, and satisfaction in learning when ICT tools are effectively integrated into the teaching and learning processes. For example, learning resources shared through WebQuest promoted active participation, collaboration, communication, and self-regulation among students, while Lie [14] found that equitably shared digital libraries also increased student engagement and reading comprehension. In this case, digital storytelling increased students' motivation and collaboration, as supported by Smeda [4] and Karahan [15], who stated that the Auto-graph software stimulated students' curiosity and confidence in mathematics. These and many other benefits can be accrued from an effective ICT integration in secondary schools, as shown in Table 2 and further discussed under RQ3 below on the effectiveness of ICT tools and different strategies and practices that have been implemented in the school environment.

RQ2: What challenges and barriers hinder ICT's practical and meaningful integration in teaching and learning?

The results identified some limitations and challenges associated with using ICT in secondary schools. There were technical challenges, such as lack of access, reliability, compatibility, and security of ICT tools and resources. Some concerns were pedagogical issues related to curriculum alignment, assessment methods, and instructional strategies. Students and teachers were sometimes not motivated, interested, or ready to use ICT due to psychological problems.

Therefore, a total of 16 studies, among the included studies in this review, identified barriers and challenges to effective and meaningful integration of ICT in secondary schools. They identified factors that negatively affect ICT integration, such as lack of resources, training, time, support, curriculum alignment, and lack of pedagogical change. According to Chen [17], technical difficulties or insufficient guidance contributed to some students' frustrations with WebQuest, while Toma [18] discovered that teachers had negative attitudes toward digital storytelling because they had not been properly trained or supported. Further, Dockendorff [19] highlighted that some curricula did not adequately include or evaluate ICT integration and evaluation.

Inadequate ICT tools and resources: inadequate, inaccessible, unreliable, and insecure ICT tools pose challenges for teachers and students to use ICT effectively and efficiently. It was found by Planinc [7] that some preservice mathematics teachers lacked access to GeoGebra software and computers at school or home. According to Smeda [4], some language teachers face technical difficulties when using digital storytelling tools. At the same time, the Moodle Learning Management System (LMS) had compatibility issues and security concerns for some in-service science teachers [23].

Insufficient or inadequate training: Teachers lack access to adequate, relevant, high-quality, or frequent professional development opportunities to enhance their abilities to integrate ICT effectively. According to Mohd Ayub [28], some in-service mathematics teachers lacked the training and experience to use GeoGebra effectively, and in-service biology teachers were not given enough support or training when using Moodle LMS [6]. Similarly, preservice language teachers lacked training and feedback while using digital storytelling in their classrooms [24].

Insufficient Planning Time: There is a lack of time for teachers to plan, implement, evaluate, or improve their ICT integration practices because of insufficient allocation, management, or flexibility of time. Mostly, teachers face this challenge, as they are not always able to use ICT effectively or efficiently due to a lack of time. Lie [14, 20] found a lack of time for designing and implementing WebQuest projects in the classroom among preservice science teachers. Some in-service language teachers did not have adequate time to explore digital libraries or use them to enhance their teaching; according to Lie [14] in their study, Bratland [25] reported that some in-service mathematics teachers did not have time to learn and use GeoGebra software.

Inadequate Technical Support: There is a lack of support for teachers on technical, pedagogical, and emotional levels in terms of provision, quality, relevance, or frequency to improve their ability and competence in integrating ICT. Usually, this is coupled with a lack of appropriate ICT support for teachers, resulting in their inability to use ICT effectively or efficiently. Karahan [15] found that in-service math teachers lacked technical support when using Autograph software. When using WebQuest for teaching social studies, some in-service teachers lacked sufficient pedagogical support [16].

Misaligned Curriculum: ICT tools and methods are not aligned, integrated, or coherent with curriculum objectives, content, or standards for teaching and learning when they are not aligned, integrated, or coherent. There may be an inconsistency between the use of ICT and curriculum goals or expectations, which affects both teachers and students. Chen [17] found that WebQuest was not aligned or integrated with curriculum standards and objectives among in-service language teachers. It has been reported by Toma [18] that some in-service language teachers lack coherence between digital storytelling and curriculum content. The use of ICT in teaching and learning is not adequately incorporated or evaluated in some curricula [19].

Inadequate ICT Pedagogic Skills: ICT may not be sufficient for supporting, enhancing, or transforming teaching and learning if pedagogical approaches, strategies, or methods are not adopted, adapted, or innovated. This challenge mainly affects teachers, who may not have enough pedagogical changes to use ICT effectively. Several preservice mathematics teachers were not sufficiently adopting GeoGebra software or adapting it to their existing pedagogical practices [7]. Digital storytelling did not lead to enough innovation in pedagogical practices for some in-service language teachers [4]. For some in-service teachers, ICT was ineffective in shifting science teachers from teacher-centered to student-centered learning [35].

RQ3: Which best practices and strategies have been implemented for effective ICT integration in secondary schools?

According to the research conducted on RQ3, teachers' attitudes, beliefs, and practices regarding the integration of ICT are influenced by professional development, school support, leadership, pedagogical understanding, and technical knowledge. The review included 14 studies that addressed this question. These studies covered various aspects of teacher education, including preservice training, in-service training, mentoring, coaching, collaboration, reflection, feedback, evaluation, and certification. Most studies indicate that enhancing teachers' ICT integration skills and competencies requires professional development opportunities. Professional development significantly influenced teacher attitudes, beliefs, and practices related to ICT integration, as in the following examples:

- Planinc and Kolnik [7] found that GeoGebra workshops improved preservice mathematics teachers' technological pedagogical content knowledge (TPACK) and confidence in using GeoGebra.
- Ilona-Eleferyja [6] established that biology teachers who attended a Moodle LMS course were more self-efficacious and motivated to use Moodle LMS in the classroom.
- Thibault [20] identified that preservice science teachers who worked on WebQuest designed projects improved their inquiry skills as well as their pedagogical reasoning and
- Lie [14] reported that mentored in-service language teachers became more proficient in digital literacy and pedagogical strategies for utilizing digital libraries.

Furthermore, school support, leadership, and culture can facilitate or hinder ICT integration in secondary education. In addition to providing adequate resources, infrastructure, and technical assistance for ICT integration, school support includes creating a shared vision, mission, and goals for ICT integration; fostering a supportive, collaborative, and innovative school climate for ICT integration; and rewarding, and recognizing teachers and students for their efforts and achievements. School leadership modeled, promoted, and advocated ICT integration, empowering, encouraging, and inspiring teachers and students. It also involved monitoring, evaluating, and improving the effectiveness and quality of integrating ICTs in the teaching and learning process, as itemized in the following examples which;

- teachers' attitudes and practices regarding using Autograph software in mathematics were positively correlated with school support and leadership, as Karahan [15] observed,
- Ruggiero and Mong [16] stated that obtaining school support and leadership was one of the most critical factors in implementing WebQuests to teach social studies and finally,
- strong school leadership and school support can foster a culture of innovation and collaboration among teachers and students in the use of ICT, as Ramos and de Andrade [21] suggested.

Therefore, there should be a holistic and systemic approach to incorporating ICT tools in secondary education to achieve effective ICT integration. This empirical review shows that ICT integration involves changing teachers' and students' beliefs, attitudes, and behaviors, not just pedagogical or technical issues. Hence, the sampled studies attempted to address this issue by investigating how ICT tools could be meaningfully integrated into the learning environment in a quest to integrate useful ICT tools to improve the learning process and the well-being of its users. Sampled studies investigated the integration of a variety of ICT tools and methods, such as digital storytelling, WebQuest, GeoGebra, Moodle LMS, Autograph, and digital libraries. The studies described ICT tools and methods in terms of their features, functions, advantages, and disadvantages and granting examples of the impacts of these ICT tools in the learning environment.

As an example, Multimedia stories can be created and shared using digital tools and platforms. Through the study of digital literacy, students can improve their writing skills, creativity, motivation, collaboration, and communication skills. Moreover, it allows students to express their opinions, emotions, and experiences meaningfully. Language, social studies, and the arts are all possible applications of this technique [4, 13, 18, 29]. Online resources are used to create and complete WebQuests, which are inquiry-based tasks. Student learning can be enhanced by improving inquiry skills,

scientific literacy, critical thinking, problem-solving, and self-regulation. It also allows students to explore everyday issues, questions, and problems in a structured environment. In addition to science, mathematics, and social studies, this approach benefits all subjects [16, 17].

Furthermore, GeoGebra uses algebraic expressions to create geometric constructions that can be modified dynamically. Students will learn geometry concepts more deeply, become more curious, and gain greater self-confidence through the program. Besides, it may be used to visually represent, explore, or prove geometric relationships, properties, and theorems. This approach may teach mathematical subjects [7, 25, 28]. You can manage and deliver online courses with multiple modules and activities with the Moodle Learning Management System. When students are motivated, engaged, and collaborate during the learning process, they are more likely to achieve, be motivated, and be engaged. Teachers can also use this software for designing, delivering, assessing, and monitoring online courses. It can cover various topics [6, 23].

In addition, Using an Autograph program, dynamic graphs can be manipulated using numerical data and functions. Exposure to graphing concepts results in students performing better, understanding more, feeling more confident, and being more curious. Also, students can interact with graphs by visualizing, exploring, and analyzing them. To practice mathematics, users can access digital resources such as books, articles, images, and videos through digital libraries [14, 15] and students can become more engaged, read more, and understand digital literacy better. As a result of a digital resource management system [14] digital resources can also be provided, organized, and recommended for use in a wide variety of subjects. In secondary education, ICT tools and methods suggest that it is a dynamic phenomenon that requires an adaptable and flexible approach to address diverse topics and situations. ICT integration is used to develop, implement, evaluate, and improve ICT-based learning activities to support, enhance, and transform teaching and learning. Based on our systematic review, Table 3 summarizes our discussion of challenges and possible solutions associated with the integration of ICT in secondary schools.

4.1 Implications for policy and practice

The implications of this systematic literature review for policy and practice in secondary education are numerous. Policymakers should consider implementing ICT integration in secondary education with clear, coherent, comprehensive policies and guidelines addressing various dimensions and factors. These factors are associated with ICT integration, including resources, training, support, curriculum alignment, and pedagogical changes. In secondary education, providing adequate and appropriate resources, infrastructure, and technical assistance is essential to ensuring that ICT tools and resources are available, accessible, reliable, compatible, and secure. Improving teachers' attitudes, beliefs, and practices related to ICT integration should support and facilitate effective and meaningful professional development opportunities. In addition, a shared vision, mission, and goals for ICT integration in secondary education should be created by cultivating a supportive, collaborative, and innovative school culture and climate. A culture and climate that inspires teachers and students to use ICT in education and recognizes, rewards, and celebrates teachers and students' ICT integration achievements.

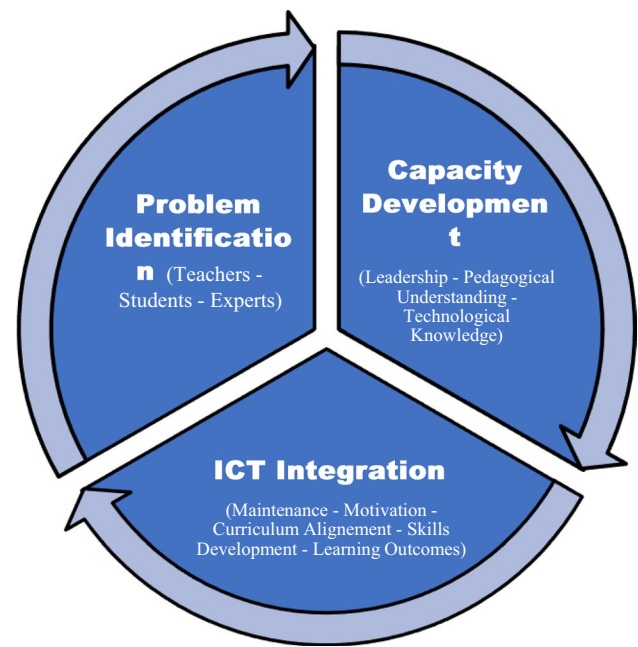
Practitioners should incorporate ICT tools in teaching and learning to enhance, support, and transform student learning outcomes, motivation, engagement, and skills development. This can be achieved by adopting and adapting strategies and pedagogical methods to integrate ICT tools into the secondary school learning environment efficiently. The integration should be aligned and well coordinated with the curriculum's objectives, content, and standards for teaching and learning purposes. Therefore, Table 3 outlines how the practitioners can address the different issues surrounding the ICT tools integration in the learning process. For example, various topics and situations in teaching and learning may require practitioners to explore, use, or suggest ICT tools and methods to address each context and subject area's specific needs, challenges, and opportunities. There should be effective mechanisms for monitoring, assessing, and improving the quality and effectiveness of ICT integration in teaching and learning by planning, implementing, evaluating, and improving ICT-based learning activities. It is evident from this systematic literature review that a framework is needed to promote better computer-aided learning in secondary schools and to integrate ICT effectively. Therefore, to ensure an effective and beneficial integration of ICT tools in schools, the researchers have proposed the ICT integration framework as in Fig. 6, illustrating how different aspects of an effective integration interact within an integration system.

According to the sampled studies, effective integration of ICT depends on students' and teachers' motivation [13, 18, 19, 28] Additionally, the authors recommend that secondary schools align ICT integration with their curricula [6, 20] and learning objectives as well as maintaining ICT tools [4, 14] and develop appropriate ICT skills for teachers as well as learners [15–17]. Therefore, ICT integration depends mainly on capacity development [6, 7], which should be focused

Table 3 Challenges and possible solutions

Challenge	Solutions	Included studies
Ineffective integration of ICT	Encourage motivation and positive attitudes	[4, 6, 13–20, 28, 36, 37]
Lack of resources and stable electric supply	Ensure availability and accessibility of ICT tools for teachers and learners	
Insufficient ICT training for learners	Motivate and encourage positive attitudes toward the use of ICT	
Insufficient ICT time	Consistent, adequate, efficient supply and maintenance of ICT infrastructure and tools regardless of school location	
Lack of sufficient technological Support	ICT skills development for secondary school learners	[6, 7, 14–16, 20, 21, 24–27, 29]
Insufficient ICT training	Professional development	
Curriculum alignment	Provide school support and leadership for teachers' ICT use	
Pedagogical change	Improve teachers' technological knowledge and ICT pedagogical understanding	[4, 6, 13, 15, 17, 18, 20, 21, 28, 29]
Lack of suitable ICT tools	Curriculum alignment and pedagogical change.	
	Encourage teachers' positive attitudes and beliefs toward ICT integration	
	Procure or develop suitable and diverse kinds and characteristics of ICT tools and methods	
	Usage of various but suitable ICT situations includes digital storytelling, WebQuest, GeoGebra, Moodle LMS, Autograph, and digital libraries	

Fig. 6 ICT integration framework



on harnessing technological knowledge with pedagogical understanding [16, 21] in a conducive learning environment supported by all stakeholders [15, 20, 29]. Finally, capacity development should further enable students, teachers, and other experts to identify challenges and address them efficiently [23, 25, 26]. This framework is a cyclic model of effectively integrating ICT in a learning context.

4.2 Limitations and future research

A systematic literature review has several limitations, including that the scope of the review was limited to the use of information and communication technology in secondary schools for teaching and learning. Therefore, the study findings cannot be generalized or applied to any other level or setting of education, such as primary schools, higher education, or informal education. Studies that are included in a review determine its quality. Methodological aspects such as sample size, design, measurement, or analysis may affect the included studies' results. Thus, the strengths and weaknesses of the synthesis methods may affect the synthesis results.

ICT integration in secondary education should be explored in more diverse and dynamic ways to accommodate various topics and situations in secondary education. Every context and subject area may present different needs, challenges, and opportunities, which require tools that can be applied to them. Examine holistic and systemic approaches to integrating ICT into secondary school teaching and learning that address the resource, training, support, curriculum alignment, and pedagogical changes associated with ICT integration.

5 Conclusion

This study was conducted to comprehensively and rigorously review peer-reviewed studies on integrating information and communication technology in secondary schools. This study followed PRISMA guidelines and the Cochrane Handbook for Systematic Reviews [9] as the framework, assuring rigor and transparency. In this analysis, three research questions on ICT integration in secondary education were explored with regard to benefits, challenges, best practices, and barriers. As this systematic review highlights, several types and characteristics of ICT tools and methods can be utilized in teaching various secondary education topics. For adequate and appropriate ICT integration resources, infrastructure, and technical assistance, policymakers should develop and implement clear, coherent, and comprehensive policies and guidelines. To foster a supportive, collaborative, and innovative school climate, teachers must be able to participate in practical and meaningful professional development opportunities. For information and communication technology to be effectively utilized for teaching and learning, practitioners must adopt, adapt, or innovate pedagogical approaches,

strategies, and methods that align and integrate ICT tools with curriculum objectives, content, or standards. They should explore, use, and propose diverse and dynamic ICT tools and methods for a wide range of topics to ensure that learners get the best out of the learning process.

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Declarations

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Appendices

Appendix 1: Summary of included studies highlighting ict integration and impacts in secondary schools

Study	Integration	Impact	Challenges
[7]	ICT for special educational needs	Ability to achieve high quality teaching standards	Excessive number of pupils with special needs
[28]	Autograph with computer algebraic system in teaching	Conventional strategy group performed better than the Autograph group	Time constraints, students' lack of focus during the teaching and learning activity
[13]	Online word processing tool	Encourage participation among students	Different language backgrounds, including English-language learners
[6]	Augmented reality (AR)	Improved students' motivation and learning	Low level of motivation and teachers' technology acceptance
[20]	Istem (integration of STEM)	Professional development and school context variables positively affected teachers' attitudes	Difficulties in the implementation of iSTEM
[14]	Online learning	Aid in resolving the issues and providing equal opportunities for all students	Teachers in remote regions would need a more top-down intervention from education authorities
[4]	Digital storytelling	Powerful tool to create more engaging and exciting learning environments	Difficulties in integrating instructional messages with learning activities to enhance student engagement
[15]	STEM-integrated media design processes	Positively impacted the students' attitudes toward science and media design activities	Lack of calls for new curricular activities and teaching practices and the integration of art in STEM

Study	Integration	Impact	Challenges
[16]	Technology to facilitate student learning	encouraged teachers to use student-centered practices and create learning opportunities with technology	Lack of in-service training, available technology, and restricted curriculum
[21]	Real ICT integration for visually impaired students	Increased confident in technological capabilities	Lack of specific training in integration of ICT
[38]	Digital whiteboard or interactive whiteboard (IWB)	Improved teaching and learning	Integration of information and communication technology (ICT) in teaching practice
[29]	ICT in systematic teaching and learning	Improved teachers' role, methods of instruction and assessment	Teacher-centered methods of instruction and paper-based assessments
[23]	Digital technology-based teaching	Mitigate factors that impede the implementation of ICT	High workload, lack of accessibility, stable network connection, and support assistance
[24]	ICT in teaching	Support the professional development of practising teachers	Inadequate trainings for teachers
[25]	Technology integration	Improved teachers' knowledge, practices and use of technology	The gap between available technology in the classroom and teachers' use of this technology for educational purposes

Appendix 2: Highlights on the impact of ICT in secondary schools

- [26] Automated writing improved teachers' and students' attitudes, writing and revision processes, and writing test score outcomes
- [27] Barriers had only a minor impact on the frequency of technology use in the classroom in the large majority of countries
- [30] Technological knowledge (TK) strongly influences CFL instructors' technology use
- [39] Improves the exchange of information and content through online spaces, participation, and collaboration
- [40] Enhanced students' interest toward learning science
- [41] Encouraged teachers' leadership and responsibility
- [18] Improved performance and developed participatory skills
- [42] Demonstrated Technological and pedagogical content knowledge
- [17] Webquest promote learning effectiveness in music appreciation courses, and improve creative higher order thinking ability
- [43] Administration support predicts teachers' computer self-efficacy, while collegial support predicts both teachers' TPACK and computer self-efficacy
- [33] Improves technology leadership and teachers' mobile technology integration in the teaching process
- [44] Students' awareness about the interrelationship between Science and Technology and its integration in classroom activities improved students' attitudes toward ICT
- [45] Teacher-training remains insufficient and that teachers have great difficulties in changing their practice as conceived by the Teaching Mathematics with Technology (EMAT)
- [46] Poor usage of computers, power-point, word-processing, emails, printing, and data storage
- [47] ICT integration created learner-centered teaching environments
- [48] Increased access to ICT in developing nations
- [49] Improved technology leadership roles of principals to encourage teachers' effective ICT utilization and students' academic performance
- [32] Improved teachers' technology integration knowledge and skills
- [50] Measures used to integrate ICT in the educational administration and education centers affects the effectiveness of the process
- [51] Digital libraries for History curriculum made readers understand that using the technology is relevant to the teaching of all subjects
- [52] The results confirmed the four-factor structure of the ICAP-TS and revealed good instrument accuracy
- [53] Confirmed that training hours and teachers' perceived school support are the most important factors that impact ICT integration
- [19] Geogebra promote mathematical processes such as conjectures
- [54] Interactive whiteboards were highly effective
- [55] Moodle LMS led to better performance

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