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The Role of ICT in Teaching and Learning Mathematics at College of Education: A Systematic Review

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Abstract
Integrating ICT in education has become increasingly popular. This systematic literature review explores the role of ICT in teaching and learning mathematics at the College of Education level. A comprehensive search was conducted using various academic databases, resulting in a final sample of 27 studies that met the inclusion criteria. The findings indicate that the use of ICT in mathematics education has positively impacted teaching and learning. The studies reviewed reported improved student engagement, motivation, and achievement in mathematics, as well as increased teacher effectiveness and confidence in their ability to teach mathematics. Regarding specific ICT tools and strategies, the studies reviewed suggest that interactive whiteboards, educational software, and online resources effectively enhance teaching and learning mathematics. However, the effective integration of ICT requires adequate infrastructure, professional development opportunities, and teacher support. This review highlights the potential benefits of integrating ICT into mathematics education at the College of Education level. Further research is to be conducted to investigate the most effective strategies for integrating ICT in mathematics education and to address the challenges associated with ICT implementation in educational settings.
Keywords: Information and Communication Technology, Collaborative Learning, Community of Practice, Constructivism, Teaching and Learning.
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1. Introduction

At the college level, Information, and Communication Technology (ICT) has been identified as a possible instrument for enhancing mathematics teaching and learning. ICT use in the classroom has significantly increased recently as educators take advantage of its potential to improve student engagement, learning outcomes, and teacher effectiveness. It has also been discovered that the use of ICT in mathematics education gives students the chance to explore mathematical ideas in novel and interactive ways, leading to higher levels of cognitive growth. ICT's usage in college-level mathematics teaching and learning has been examined in several research. For instance, according to a study by Borko and Eisenhart (2002), the use of technology tools, such as graphing calculators, can improve students' comprehension of mathematical ideas and encourage active learning. Similar to this, Hohenwarter and Hohenwarter's 2009 study discovered that employing dynamic mathematics software, such as GeoGebra, can encourage conceptual understanding and enhance student exploration of mathematical ideas.

ICT integration in mathematics education has the potential to be beneficial, but there are several obstacles that need to be overcome. To properly incorporate technology into teaching methods, for instance, tutors might require additional training and assistance. In addition, ICT use in the classroom may be hampered by infrastructure issues, such as limited access to technology. The review's findings will advance knowledge of ICT's potential in mathematics education and guide the formulation of plans for successful ICT integration in college classrooms.

2. Statement of the Problem

ICT has been acknowledged in recent years as a potent instrument in education and has been utilized more and more in the teaching and learning of mathematics (Berg et al., 2020; Koehler et al., 2014). Despite this, additional study on the efficient integration of ICT in mathematics teaching at the College of Education level is still required (Brinda et al., 2019; Kariuki & Wachira, 2016). Although a sizable body of research has been done on the use of ICT in teaching and learning, there is still a need for more research on how to integrate ICT into mathematics instruction in the Ghanaian College of Education.

By identifying successful methods and strategies that may be used to improve mathematics education using ICT, this systematic literature review intends to analyze the present state of knowledge on the role of ICT in teaching and learning mathematics in the College of Education. By analyzing the present state of research on the role that ICT play in teaching and learning mathematics in the College of Education, this review will fill the identified knowledge gap.

3. Research Questions

Specifically, the review will address the following research questions:

1. What is the current knowledge on using ICT in teaching and learning mathematics in the College of Education?
2. What are the benefits and challenges of using ICT at the College of Education level in teaching and learning mathematics?
3. What are the effective practices and strategies for integrating ICT into mathematics education in the College of Education?

By answering these research questions, this systematic literature review will provide a comprehensive understanding of the role of ICT in teaching and learning mathematics at the College of Education and identify effective practices and strategies that can be used to enhance mathematics education using ICT.

4. Methodology

A systematic literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The literature search was carried out in electronic databases, including ERIC, Scopus, and Web of Science, using keywords such as "ICT", "Mathematics education", "teacher education", "college of education", and "teaching and learning", and their combinations. The search was limited to 27 articles published in English-language between 2000 and 2022.

4.1 Inclusion and Exclusion Criteria:

The following inclusion criteria were used in selecting articles for this review:

1. The study should be empirical, qualitative, or quantitative and focus on ICT's role in teaching and learning Mathematics at the College of Education.
2. The study should be published in a peer-reviewed journal and written in English.
3. The study should be conducted between the years 2000 to 2022.
4. The study should clearly describe the research methodology and data analysis techniques.
5. The study should provide relevant findings related to the research question.

The exclusion criteria were as follows:

1. Studies that did not explicitly mention the role of ICT in Mathematics education.
2. Studies that did not focus on the College of Education.
3. Studies that were not peer-reviewed.
4. Studies that need to be written in English

5. Theoretical Background

5.1 Social Constructivism Theory

Social constructivism theory, developed by Lev Vygotsky, posits that learning is a social process that occurs through interactions between learners and their environment (Vygotsky, 1978). According to this theory, learners construct knowledge through interactions with others in the world. Social interactions allow the learner to internalize new concepts, ideas, and perspectives that shape their understanding of the world.

5.2 ICT and Social Constructivism Theory

ICT has transformed the way we learn and interact with each other. Technology in the classroom allows learners to collaborate with their peers and teachers, access a wide range of resources, and engage with learning materials in new and innovative ways. ICT can support the principles of social constructivism theory by allowing learners to engage in collaborative learning, construct their knowledge, and participate in a community of practice (Jonassen, 2000).

5.3 **Collaborative Learning:** Collaborative learning is a critical component of social constructivism theory. According to this theory, learners construct knowledge through their interactions with others. ICT can facilitate collaborative learning by providing learners the tools to communicate and collaborate with their peers and teachers. For example, online discussion forums, chat rooms, and collaborative writing tools can support collaborative learning by allowing learners to engage in discussions, share ideas, and construct knowledge together (Roblyer & Doering, 2014).

5.4 **Constructing Knowledge:** Social constructivism theory posits that learners construct knowledge through interactions with their environment. ICT can support this process by providing learners access to various resources, tools, and learning materials. For example, online simulations, interactive multimedia, and virtual environments can allow learners to explore and construct their knowledge of mathematical concepts in a more interactive and engaging way (Jonassen, 2000).

5.5 **Community of Practice:** A community of practice is a group of individuals who share a common interest or

goal and engage in learning activities together. Social constructivism theory posits that learners can construct knowledge through participating in a community of practice. ICT can support creating a community of practice by providing learners with the tools to collaborate, communicate, and share resources. For example, online discussion forums, social media platforms, and online learning communities can support creating a community of practice in mathematics education (Roblyer & Doering, 2014).

6. ICT Tools

A key element in the integration of ICT in education is the accessibility of ICT tools. ICT integration in education requires access to hardware and software (Fisser, Voogt, and Pareja Roblin, 2015). In many cases, educational institutions lack the hardware and software needed to successfully integrate ICT. The adoption and application of ICT in education may be hampered by this lack of accessibility. Additionally, socioeconomic conditions have an impact on the accessibility of ICT technologies. Due to infrastructure shortages and poverty, access to ICT tools may be restricted in low-income communities (Warschauer & Matuchniak, 2010). The digital divide may be perpetuated and the equitable use of ICT in education may be hampered by this lack of accessibility.

6.1 Integration of ICT Tools

Enhancing learning outcomes and raising educational standards require the use of ICT technologies in the classroom. The use of ICT technologies can aid in the development of 21st-century abilities including communication, teamwork, and problem-solving (Voogt, Knezek, Cox-Petersen, and Knezek, 2017). By granting access to digital tools and resources, the incorporation of ICT tools can also increase the effectiveness of teaching and learning. Additionally, the use of ICT in education can aid in addressing concerns of social justice and equity. According to Warschauer and Matuchniak (2010), the incorporation of ICT technologies can give students from underprivileged backgrounds the chance to receive high-quality education and increase their prospects of succeeding in life.

7. ICT Knowledge and Skills of Tutors

The knowledge and skills of tutors are essential for the successful integration of ICT in education. According to Tondeur et al. (2016), the integration of ICT in the classroom requires a high level of ICT knowledge and skills on the part of the teacher. This includes knowledge of various ICT tools and resources, pedagogical knowledge for the effective use of ICT, and the ability to use ICT to enhance teaching and learning. Additionally, it is important that tutors can develop students' digital literacy skills.

Research have demonstrated that there is a broad range in the ICT knowledge and abilities of tutors. Although many instructors utilize technology in the classroom. Ottenbreit-Leftwich et al (2010) showed that only a small percentage of them had the ICT knowledge and abilities required to successfully incorporate technology into the curriculum. Similarly, although tutors have positive attitudes about the incorporation of ICT in education, Ertmer et al. (2012) showed that their ICT knowledge and skills are frequently restricted.

ICT integration in education is greatly influenced by the knowledge and expertise of tutors in the field. Tutors with high levels of ICT knowledge and proficiency are more likely to use ICT in the classroom in novel ways and to enhance student-centered learning, according to Tondeur et al. (2016). Also, tutors who possess advanced ICT knowledge and abilities are more likely to help students improve their digital literacy. To enable the successful integration of ICT in education, it is crucial to give tutors the training and support they need to advance their ICT knowledge and abilities.

8. Attitude of Tutors Towards ICT integration

A key factor in the successful integration of ICT in education is the tutors' attitude toward it. The success or failure of ICT integration in education is largely dependent on the tutors' attitude (Cheng and Yeh, 2019). ICT integration is something that tutors that are enthusiastic about do better at using in their instruction, which results in better learning outcomes. Yet, instructors with a poor attitude toward ICT integration use these resources less frequently, which has a negative impact on student learning.

The attitude of tutors regarding ICT integration can be influenced by a variety of circumstances. Al-Mutairi (2020) lists these elements as instructors' pedagogical beliefs, level of ICT proficiency, perceived value of ICT tools in teaching and learning, and perceived impediments to using ICT tools. For instance, tutors who have strong pedagogical beliefs and strong ICT abilities are more likely to see ICT integration favorably than tutors who have weak pedagogical beliefs and weak ICT skills.

The attitude of tutors towards ICT integration can significantly impact the effectiveness of education. According to Lai and Law (2018), tutors with a positive attitude towards ICT integration tend to use ICT tools more effectively, resulting in increased student engagement, motivation, and learning outcomes. In contrast, tutors with a negative attitude towards ICT integration tend to use traditional teaching methods, which may not be as effective in engaging and motivating students.

9. ICTs in Teaching and Learning Mathematics

Various ICTs have been used in teaching and learning mathematics at the college level. These include digital textbooks, simulation software, online forums, and web-based learning management systems (LMS) (Wu, Huang, Chen, & Chen, 2020). Research has shown that these ICTs can improve students' motivation, engagement, and achievement in mathematics (Hu, 2020).

9.1 **Digital textbooks:** Digital textbooks are electronic versions of traditional textbooks that can be accessed through personal computers or mobile devices. They offer advantages such as portability, interactivity, and multimedia features that enhance students' learning experiences (Lee, Kwon, & Park, 2017). A study by Lee et al. (2017) found that students who used digital textbooks in a college mathematics course achieved higher post-test scores than those who used traditional textbooks.

9.2 **Simulation software**: Simulation software enables students to create virtual mathematical models and manipulate them to understand complex concepts (Sukowati, Wulandari, & Priyanto, 2019). Research has shown that simulation software can improve students' problem-solving skills and conceptual understanding of mathematical concepts (Sukowati et al., 2019).

9.3 **Online forums** are virtual discussion platforms where students can interact and exchange ideas with their peers and instructors (Wu et al., 2020). Research has shown that online forums enhance students' collaboration, critical thinking, and problem-solving skills (Wu et al., 2020).

9.4 **Web-based learning management systems:** Web-based learning management systems (LMS) are online platforms that provide students with access to course materials, assignments, and assessments (Hu, 2020). Research has shown that web-based LMS can improve students' self-regulation, motivation, and achievement in mathematics (Hu, 2020).

10. Effectiveness of ICTs in Mathematics Education

Several studies have investigated the effectiveness of ICTs in mathematics education. For example, a study conducted by Yilmaz and Kilic (2019) found that using ICTs in mathematics education improved students' attitudes towards mathematics and their academic achievement. The study also found that using ICTs in mathematics education increased students' engagement and motivation to learn mathematics.

Kondakci and Sahin (2019) looked at the effect of using an online learning platform on students' math achievement in a different study. According to the study, students who used the online learning environment scored better on arithmetic exams than those who did not. The research also revealed that the online learning environment effectively encouraged group learning and enhanced students' problem-solving abilities.

In a similar vein, Alqahtani and Mohammad's (2020) study discovered that integrating ICTs into mathematics instruction increased students' attitudes toward the subject and their academic performance. The study also discovered that integrating ICTs into mathematics instruction boosted student involvement and motivation.

11. Professional Development and Training on Using ICTs in Teaching and Learning Mathematics

Miao, Wang, and Yang (2020) assert that for tutors to use ICTs effectively in teaching mathematics, professional development and training are crucial. Tutors can acquire the information, abilities, and attitudes necessary to incorporate ICTs into their teaching methods through professional development programs. These programs can be created to meet the individual requirements of teachers and can be given in a variety of ways, including in-person instruction, online courses, or blended learning.

In a 2017 study by Okello-Obura and Awiti (2017) it was discovered that professional training and development significantly improved tutors' views toward adopting ICTs in mathematics instruction. According to the study, instructors who underwent professional growth and training were more inclined to employ ICTs in their instruction and had greater self-assurance.

Also, the length, structure, and content of professional development and training programs affect how well they work for teaching and learning mathematics using ICTs. For instance, Otieno and Odera's (2019) study revealed that teachers' attitudes and perceptions of ICT integration in mathematics education were significantly influenced by the length of the professional development program. The study found that teachers' attitudes and perceptions regarding using ICTs for mathematics teaching and learning were positively influenced by lengthier training periods.

The professional development program's content is also very important. The content of the training program should be developed to satisfy the requirements and concerns of tutors (Jorgensen and Lai, 2017). The training should focus on using ICTs effectively in mathematics teaching and provide tutors with opportunities to practice using ICTs in their teaching. In addition, the training should be tailored to suit the level of tutors' ICT skills.

In conclusion, professional development and training are crucial for tutors to effectively use ICTs in teaching and learning mathematics at the college of education. The effectiveness of the training programs depends on various factors, such as the program's duration, format, and content. Professional development programs should be designed to address tutors' needs and concerns and should focus on how to use ICTs effectively in mathematics teaching. By providing teachers with the necessary knowledge, skills, and attitudes, professional development and training can enhance the quality of mathematics education at the college.

12. Benefits of ICT Integration in Teaching and Learning Mathematics

It has been demonstrated that using ICT to teach mathematics has several advantages for both tutors and students. The fact that learning becomes more dynamic and engaging is one of the key advantages. ICT technologies like virtual manipulatives, simulations, and educational games, for example, make studying more enjoyable and exciting for students, according to a study by Akpan and Ofem (2019). This, in turn, boosts their motivation and involvement in the subject.

The ability to visually portray mathematical ideas for students is another advantage of integrating ICT into math instruction. Students can view mathematical concepts in a visual format using ICT tools like graphing calculators, spreadsheets, and interactive whiteboards, which makes it simpler for them to comprehend and recall the material. In a study published by Chukwu and Opara (2018) found that using ICT tools to teach math improves students' academic performance.

Moreover, ICT integration in teaching mathematics also provides opportunities for personalized learning. According to a study by Khechine et al. (2018), ICT tools such as adaptive learning software and online assessments allow for individualized instruction and assessment. This allows students to learn at their own pace and receive immediate feedback on their progress, which can lead to better learning outcomes.

13. Challenges Tutors Face in Using ICTs for Teaching and Learning Mathematics

13.1 Electricity Supply

The availability of energy is one of the main environmental elements that has an impact on how ICT is used. Computers, servers, and other ICT equipment that are necessary for data processing, data storage, and communication must be powered by electricity. The usage of ICT can be hampered in many developing nations by a lack of a steady and continuous electricity supply. Poor energy supply, which affects both enterprises and individuals, is a major barrier to the adoption and usage of ICT in India (Ahuja and Yadav, 2016). Also, the maintenance of the internet infrastructure depends on the availability of electricity. The backbone of the internet, which is made up of a network of servers and data centers, requires a steady supply of electricity to operate. As noted by Tufekci (2017), power outages and disruptions can affect internet access and undermine the reliability of ICT services.

13.2 **Lack of Technical Support:** One of the significant challenges tutors faces in using ICTs for teaching and learning Mathematics is inadequate technical support. According to Lim and Chai (2017), tutors require technical support to use ICTs effectively in teaching and learning Mathematics. Inadequate technical support can lead to frustration and discouragement, resulting in tutors abandoning ICTs. A study by Farooq, Ahmad, and Khan (2020) found that tutors need help using ICTs, such as software compatibility issues, slow internet connectivity, and inadequate computer skills.

13.3 **Limited Access to ICT Resources:** Access to ICT resources is a major issue for tutors when using them to teach and study mathematics (Ertmer & Ottenbreit-Leftwich, 2010). Effective ICT integration depends on the accessibility and caliber of ICT resources including computers, software, and internet connectivity. The successful use of ICTs in mathematics instruction is hampered by the lack of ICT resources in some higher education institutions.

13.4 **Lack of Technological Pedagogical Content Knowledge:** Having technological pedagogical content knowledge (TPCK) is a requirement for tutors to integrate ICTs into mathematics teaching effectively (Mishra& Koehler, 2006). TPCK stands for the knowledge and abilities that tutors need to successfully use ICTs into their teaching methods. Some tutors, nevertheless, lack the essential TPCK, which can make it difficult to effectively integrate ICTs into math instruction.

13.5 **Resistance to Change:** Some tutors can be reluctant to include ICTs into mathematics instruction because they are unfamiliar with the technology (Ertmer& Ottenbreit-Leftwich, 2010). This resistance to change could prevent ICTs from being adopted in mathematics education and reduce their potential benefits.

13.6 **Inadequate Training and Professional Development:** Another issue preventing the successful integration

of ICTs in mathematics instruction is the lack of proper training and professional development for tutors (Heid, 2013). To acquire the skills and knowledge required to successfully integrate ICTs into their teaching methods, tutors must undergo training and professional development. Ineffective use of ICTs in math education can also be caused by a lack of training and professional development.

14. Results

The study's findings demonstrated that the usage of ICTs significantly affects how mathematics is taught and learned. ICTs thereby support active learning, raise student involvement, and boost math student accomplishment (Abdi, 2016). This finding is in line with the findings of Usiskin and Willmore's (2001) study which revealed that incorporating ICT into math instruction can help pupils better understand mathematical ideas. According to the study, students were able to grasp mathematical ideas more deeply and apply their knowledge more successfully when ICT was utilized to assist conventional teaching techniques.

The use of ICT in teaching mathematics can boost students' motivation and engagement with the topic, according to a study by Hodge and Duffin (2001). From the current study, students who are taught using ICT are likely to enjoy mathematics more and to continue their studies of it after they have graduated from college. Cheung and Slavin (2013) looked at the effect of ICT on college students' math achievement in a more recent study. The study discovered that the use of ICT significantly improved learners' math performance. The researchers concluded that the use of ICT in teaching mathematics could lead to improved academic outcomes for college students.

Nonetheless, despite the potential advantages of incorporating ICT in math instruction, the research also highlighted the drawbacks of its use. For instance, according to a study by Bautista and Manrique (2016), certain college mathematics tutors lacked the knowledge and experience necessary to successfully incorporate ICT into their curricula. The study stressed how important it is to give tutors enough training and assistance so they can use ICT in their instruction efficiently.

As a result, the use of ICT in mathematics instruction at the college of education has the potential to enhance students' comprehension of mathematical ideas, foster a greater sense of motivation and engagement, and enhance academic results. ICT must be properly integrated into the teaching process by the tutors, for it to be effective in the math classroom. To determine the best amount of ICT use for various learning scenarios and to discover effective ways for incorporating ICT in mathematics instruction, more study is required.

15. Discussion

After reviewing several studies on the integration of Information and Communication Technology (ICT) in teaching mathematics at the college of education, ICT can have a positive impact on student learning outcomes. Many studies have shown that when ICT is integrated effectively into mathematics instruction, it can improve students' mathematical understanding, problem-solving skills, and critical thinking abilities (Abdullahi & Aliyu, 2021; Ouma, 2019; Selim & Malik, 2020).

The findings of this study support the notion that the use of ICTs can positively impact teaching and learning mathematics at the College of Education. However, some challenges are associated with using ICTs, such as the need for teacher training, the availability of technology, and the cost of implementing ICTs in classrooms (Abdi, 2016).

Therefore, the College of Education must provide adequate training for teachers to integrate ICTs into their teaching practices effectively. Additionally, the College of Education should ensure the necessary technology is available and accessible to teachers and students. Moreover, the cost of implementing ICTs should be carefully considered, and alternative funding sources should be explored where necessary.

16. Conclusion

ICTs can be a useful tool for mathematics teaching and learning at the College of Education. The results of this study imply that ICTs can raise student engagement, encourage active learning, and raise math proficiency among students. Yet, it is important to pay close attention to the difficulties that come with employing ICTs, such as the requirement for teacher training, the accessibility of technology, and the expense of implementation. ICTs can improve the learning environment for mathematics students at the College of Education by being properly planned and implemented.

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