

ICT Integration in Mathematics Teaching and Learning Activities: A Literature Review

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ABSTRACT

This review aims to assess the current state of knowledge on the role of ICT in teaching and learning mathematics, with the goal of identifying effective approaches and strategies that can be employed to enhance mathematics education through the use of ICT. It also focuses on the possible advantages of ICT integration in mathematics instruction. The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to review the related literature. The related literature was searched using key terms such as "ICT," "mathematics education," and "teaching-learning activities" in electronic databases such as ERIC, Google, Google Scholar, Scopus, and Web of Science. The search was limited to 22 articles published from 2015 to 2023. The findings of this study show that the attitude of teachers and students toward using ICT in teaching and learning mathematics was found to be positive; however, they faced the problem of integrating ICT in mathematics in the fields of algebra, statistics, vectors, geometry, and analysis. To effectively integrate ICTs into mathematics instruction, educational institutions must offer the necessary training to teachers.

1. INTRODUCTION

Utilizing ICT in teaching and learning activities has become increasingly common. Various studies reported that the use and rapid growth of digital technology provided the opportunity for multiple flexible learning alternatives, including part-time and distance learning, and assisted in helping internationalize and commercialize higher education (Komba, 2009). Various studies (e.g., Daher et al., 2018; Joshi et al., 2022) have suggested information and communication technology (ICT) as a

potential tool for improving math instruction and student learning. ICT had a positive impact on learning, in particular on pupils' behavioral and affective engagement (Hammond et al., 2011). Students' success and learning outcomes depend upon the caliber of their teachers (Jamieson-Proctor et al., 2010). It is well established that teachers' training programs are crucial for ensuring that teachers have the necessary ICT knowledge, abilities, and attitudes to realize ICT integration in instructional practices

(Khanal, Joshi, Adhikari, Khadka, et al., 2022). Even though instructors of the future must consider a variety of technologies that can improve students' learning, it is evident that they lack enough ICT preparation and require ongoing education (Adhikari et al., 2022). However, teachers lack knowledge about ICT, and they have difficulties integrating technology into their teaching and learning processes. Pre-service and in-service teachers both believe that the use of ICT will be beneficial for their teaching (Khanal et al., 2021) and make learning more effective and useful (Hammond et al., 2011). Sang et al. (2010) reported that successful ICT integration is associated with belief, self-efficacy, and attitude toward ICT.

The majority of private colleges and schools already have internet facilities for teachers and students in Nepal; however, government universities and schools are still waiting for funding support to incorporate ICT into their teaching and learning activities (Rana & Rana, 2020). Teachers are still waiting for training in ICT in the context of Nepal. The future of mathematics can be brightened by teachers' upbeat attitudes and innovative ideas with ICT (Chapai, 2022). However, Anyagh et al. (2018) investigated and found that teachers had displayed a negative attitude towards their students in the learning of mathematics. This finding suggested that the teacher's actions and inactions have a significant impact on the way that students learn mathematics and how they view it. Therefore, teachers must be motivated, tech-savvy, critical, reflective, and passionate. ICT has gained popularity in recent years as a powerful educational tool and is increasingly being used in math instruction (Borko et al., 2010). The adoption of technology by teachers can be facilitated or hampered by their attitudes and beliefs, and intrinsic factors like a technology's perceived usefulness are crucial for its implementation in educational settings. However, little is known about whether teachers share particular attitudes or beliefs and can, therefore, be assigned to teacher groups that are characterized by

similar attitudes and beliefs. Additionally, more research is still needed to determine how effectively ICT may be incorporated into mathematics instruction at educational institutions (Baya'a et al., 2019). There is still a need for greater research on how to use ICT in mathematics instruction at the Nepalese educational institution.

This literature review aims to evaluate the current state of knowledge on the role of ICT in teaching and learning mathematics and tries to find effective approaches and strategies that may be used to improve mathematics education using ICT. The identified knowledge gap will be addressed by this review, which will analyze the current state of research regarding the role that ICT plays in mathematics teaching and learning activities. To fulfill the aim of this study, the researcher devised the following questions:

1. What are the attitudes of teachers and students toward using ICT in teaching and learning mathematics?
2. What are the challenges faced by teachers when using ICT in teaching and learning mathematics?
3. What is the effect of ICT on teaching-learning activities in mathematics education?

2. METHODOLOGY

The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to review the related literature. The related literature was searched using the terms "ICT," "mathematics education," "teaching-learning activities," etc. in electronic databases such as ERIC, Google, Google Scholar, Scopus, and Web of Science. The search was limited to 22 articles published from 2015 to 2023. The articles for this review were chosen based on empirical, qualitative, or quantitative data and centered on how ICT is integrated into teaching and learning mathematics. Also, this study reviewed the literature that was published in a peer-reviewed journal with clear research methodology and methods

of data analysis and pertinent information regarding the research question. However, the study excluded those articles that were not reviewed and were not related to mathematics learning activities.

2.1 ICT TOOLS

ICT has the power to alter how teachers and students participate in the study and teaching of mathematics. Users can learn anytime, anywhere, and without having to travel by using ICT technologies. Electronic devices are popular with and available to our youth. By appropriately leading them, the entire scenario of learning and teaching can be altered (Aggarwal, 2020). Various ICT tools are developed for teaching and learning mathematics. Nowadays, different software is used rapidly, such as Matlab, Math CAD, Mathematica, Maple, SPSS, Graphing Calculator 3D, Graphmatica, Geogebra, Graph Sketch, Yenka, Calc 3D Pro, Mathematica Player, Euler Math Toolbox, GAP, Maxima, Microsoft Mathematics, Math Editor, etc., and is used for numerical computing, matrix manipulations, plotting of functions and data analysis, image processing, signal processing, curve fitting, regression analysis, solving various types of equations, plotting graphs, calculating roots of functions, performing matrix operations, etc.

2.2 INTEGRATION OF ICT TOOLS

The study reviewed by Asare et al. (2023) suggested that interactive whiteboards, educational software, and online resources are effective in enhancing teaching and learning mathematics. Further, this study focused on adequate infrastructure, professional development opportunities, and teacher support for the effective integration of ICT. To increase access to information, Amuko et al. (2015) advise that new frontiers in technology integration be made available to teachers and students for educational purposes. They also advise that teachers' capacity building for technology integration be increased and awareness among pre-service teacher trainees integrating ICT in

teaching and learning mathematics be built.

2.3 ATTITUDE, KNOWLEDGE AND SKILL OF INSTRUCTORS IN ICT INTEGRATION

The study conducted by Marpa (2020) finding indicates that math teachers have positive attitudes regarding using technology in terms of behavioral engagement and confidence with it, as well as very positive attitudes in terms of affective engagement. Results also show that views about employing technology in mathematics instruction are considerably different between male and female teachers. Males display better attitudes than females do. Along these lines, it can be inferred that the use of technology in mathematics education is relevant to and significant to mathematics teachers since they have a favorable attitude toward it. Eickelmann and Vennemann (2017) indicate that positive attitudes and beliefs are considered to be key factors and predictors of teachers' use of ICT in instruction. Their study showed that a small percentage of teachers regularly used ICT for education. For instance, 18.3% of the partial enthusiasts claimed to have done so, while an additional 37.6% of the group's teachers reported using ICT in the classroom at least once every week.

The findings of Mazana et al. (2018) revealed that while students initially have a good attitude about mathematics, as they advance to higher educational levels, this attitude begins to change. The students' ability, instructional, and social-psychological contextual elements were the ones that affected whether they liked or disliked math. The findings also indicate that ineffective learning and assessment strategies, institutional resources, failure to comprehend instructions, and instructor didactic strategies are all factors in exam failure.

Joshi et al. (2022) indicate that teachers had a high perception of support for students using ICT for learning mathematics in terms of encouragement and adaptation to tools. Teachers who had computers or laptops in their classrooms

versus those who did not, teachers who had projectors in their classrooms versus those who did not, and teachers who taught in government schools versus private schools all had significantly different perceptions of how to encourage students to use and adapt to ICT.

Gündüz (2020) found that there was a positive and moderate relationship between pre-service teachers' perceptions of education and support for ICT and ICT competencies and concluded that perceptions of education and support for ICT were significant predictors of ICT competency.

Mailizar and Fan (2020) found that Indonesian secondary mathematics teachers have largely inadequate knowledge of ICT and knowledge of ICT use in teaching-learning activities. Based on the findings, they suggested that it is essential to improve Indonesian teachers' knowledge of both aspects, and more training courses for teachers' knowledge development are required.

Zakaria and Khalid (2016) suggested that the use of ICT in teaching mathematics is beneficial. They reported that ICT boosts students' motivation and performance in mathematics, supports lifelong learning, and promotes pleasant interactions and connections, among other benefits. According to researchers, there is a need for mathematics educators to have more training in ICT and computer usage for educational reasons. To encourage math instructors to incorporate ICT components into their instruction, technical support should also be a priority.

Hu et al. (2018) reported that there were conflicting effects of student attitudes toward ICT on their academic progress. Particularly, there was a negative relationship between academic achievement and student enjoyment of social engagement surrounding ICT, although there was a positive correlation between student interest, competence, and autonomy in utilizing ICT.

2.4 EFFECT OF ICT IN TEACHING LEARNING ACTIVITIES IN MATHEMATICS

ICT is beneficial for the development of permute pedagogical skills, teaching efficiency, professional skills, content knowledge and teaching skills, communication skills, adjustment skills, and other related skills of teachers and increases knowledge, skills, abilities, performance, achievement, self-learning capacity, communication skills, problem-solving skills, motivation to learn, promotion of mathematical understanding, funny learning, and engagement with mathematical problem solving in the students (Joshi, 2017).

Tossavainen and Faarinen (2019) reported that the distribution of students' motivational values is greatly impacted by their choice between conventional and ICT-based learning methods; students report higher accomplishment, utility, and cost values while learning mathematics the traditional way, with paper and pencil.

To ascertain the impacts of technology use on student achievement, motivation, and attitude, the study employed Higgins et al. (2019) systematic review process. The type of intervention, the type of therapy, the length of the intervention, the area of mathematics, and the context of the learning environment are all addressed. Results from 24 papers (4,522 subjects) show that technology has a large overall impact on student accomplishment, motivation, and attitudes. However, results vary depending on the particular intervention aspect that was examined.

Hu et al. (2018) indicated that ICT skills had a more positive effect on student academic performance; students' ICT availability at school was positively associated with student academic success, whereas student ICT availability at home was negatively associated with student academic success. Further, this study found that ICT academic use negatively correlated with student performance, while ICT entertainment use positively correlated with student performance.

Granberg and Olsson (2015) reported that by giving students a shared workspace and feedback that served as the

basis for their creative argumentation, ICT tools like GeoGebra fostered teamwork and innovative thinking. Additionally, the students' group projects that encouraged them to share their arguments improved their imaginative reasoning.

Perienen (2020) found that regular users of computers demonstrated a high opinion of the pedagogical worth of technology and perceived the tool as being useful for enhancing mathematical education. However, the researcher found that minorities were using technology in their teaching practices.

Mlotshwa et al. (2020) conducted research in two classes, one using the traditional chalk-and-talk method as the control group and the other being exposed to Moodle as the experimental group. They discovered that students created their knowledge by utilizing resources embedded in Moodle and doing so within the context of social constructivist theory.

Das (2019) conducted the study to determine the impediments to the integration of ICT in mathematics teaching and learning at teacher-training colleges and secondary school levels and reported that ICT integration in mathematics education has a positive impact on both the teaching and learning processes.

Dhakal (2018) reported that teachers had favorable views and that ICT tools were necessary for the professional development of teachers and to improve student performance because the tools' recent advancements have engaged students.

Asare et al. (2023) indicate that the use of ICT in mathematics education has a positive impact on the teaching and learning of mathematics. The study also showed that the use of ICT can develop student engagement, motivation, and achievement in mathematics, as well as increase teacher effectiveness and confidence in their ability to teach mathematics.

2.5 CHALLENGES FACED BY INSTRUCTORS IN TEACHING LEARNING ACTIVITIES IN MATHEMATICS

Information, communication, and technology are widely used globally in every sector. Hence, it is also necessary to integrate it into education. Education should produce people who can quickly adapt to change, are open to innovation and growth, and solve problems they encounter in daily life. Further, it is expected that ICT integration in teaching-learning activities should help students think critically, have good communication skills, have empathy, and be conducive to society and culture. However, teachers expressed a variety of issues, including gain density, insufficient lesson hours, incompatibility between the central exam program and the program, reading comprehension, associating with daily life, readiness, inadequate economy, a lack of material, distance education, fear of mathematics, peer pressure, and a lack of motivation (Karali, 2022).

Amuko et al. (2015) pointed out that educator encounter significant hurdles, including the need to enhance their technological expertise and understanding, and the necessity for self-directed learning when it comes to incorporating ICTs into their teaching. Despite their eagerness, teachers were observed to be slow in integrating technology into their instructional practices due to the absence of adequate support for skills development.

Dhakal (2018) found barriers such as the lack of knowledge to integrate the tools, the availability of the resources, affordability by the learners, and insufficient teacher training provisions.

Zakaria and Khalid (2016) identified inadequate training and learning opportunities for ICT, a lack of technical assistance, and a lack of ICT understanding among educators are the obstacles and limits to teaching and learning mathematics.

The research conducted by Khanal, Joshi, Adhikari, and Khanal (2022) shows that algebra, statistics, vectors, geometry, and analysis are problematic areas for teachers teaching mathematics using ICT tools. Although the degree of problems varied depending on the age and

experience of the teachers at the university level, this study indicated that the institution types, ICT training status, and years of laptop use by secondary school teachers were the main factors determining the problem of teaching mathematical content during online instruction.

Joshi et al. (2022) indicate that the problems in using software and drawing figures are the main predictors of the problems in instructing mathematical content concerning the non-educational background and untrained teachers in ICT. Further, this study showed that problems in drawing symbols and teaching equations are the main predictors in mathematical content instruction concerning educational background and training in ICT teachers. Joshi et al. (2023) indicate that mathematics teachers face problems in instructing mathematical content with ICT, which has major contributing factors like internet surfing, class control, interest in online courses, and digital content.

3. RESULT AND DISCUSSION

This review aims to evaluate the current state of knowledge on the role of ICT in teaching and learning mathematics and tries to find effective approaches and strategies that may be used to improve mathematics education using ICT. This review of the literature shows that teachers had a high perception of support for students using ICT for learning mathematics in terms of encouragement and adaptation to tools. ICT in teaching mathematics is beneficial because it boosts students' motivation and performance in mathematics, supports lifelong learning, and promotes pleasant interactions and connections, among other benefits. ICT helps teachers improve their pedagogical abilities, teaching effectiveness, professional skills, content knowledge and teaching abilities, communication skills, adjustment skills, and other related abilities. It also helps students become more motivated to learn, develop problem-solving abilities, promote mathematical understanding, have fun while learning, and engage in mathematical practice. ICT

stimulates students' interest in learning mathematics, boosts their motivation and performance, promotes lifelong learning, and makes it easier for them to interact with others and develop strong bonds (Khadka et al., 2022).

The review of the literature shows that lack of digital content, internet surfing, lack of ICT training, technological expertise, and knowledge are the challenges faced by mathematics teachers. Further, the result shows that mathematics teachers face a problem with instruction by integrating ICT in mathematics in the fields of algebra, statistics, vectors, geometry, and analysis, which are problematic areas for teachers teaching mathematics by using ICT tools. The results of this study provide credence to the idea that ICT use can enhance math instruction at educational institutions. To effectively integrate ICTs into mathematics teaching methods, educational institutions must offer teachers the necessary training. The results of the study by Sang et al. (2010) suggest that the community of practice context can work as an escalator to encourage in-service mathematics teachers' decisions to include ICT in their mathematics instruction. Hence, the educational institution should also make sure about the community practices of teachers and students and access the availability of essential technology. ICT implementation costs should also be carefully considered by the government, and alternative financing sources should be looked into as needed.

4. CONCLUSION

Information and Communication Technologies (ICTs) serve as valuable tools in the realm of mathematics instruction and learning. The results of this study indicate that ICTs have the potential to enhance student engagement, foster active learning, and boost students' mathematical performance. Hence, it is crucial to incorporate new learning modalities to improve the technological abilities and attitudes of mathematics teachers. Additionally, math educators should cultivate and strengthen a favorable

attitude toward studying and instructing using technology. Leveraging information and communication technology in teaching and learning is imperative for the development of both educators and learners. Research indicates that ICT can facilitate the acquisition of higher-order skills among students and cultivate a heightened interest in mathematics. There is a pressing need for further research to determine optimal methods for integrating

ICT into mathematics instruction, as well as to address the challenges associated with its implementation in educational settings.

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