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Towards a Digital Frontier: Exploring Challenges and Opportunities in ICT Integration for Mathematics Learning

Kahkashan Qaisar
Research Scholar, MANUU College of Teacher Education, Darbhanga, Email: kahkashanqaisar20@gmail.com
Dr. Danish Nadim
Assistant Professor, MANUU College of Teacher Education, Darbhanga, Email: danishnadim@manuu.edu.in

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ABSTRACT

In today's rapidly advancing technological era, it has become imperative to utilize technology in education to enhance students' critical thinking skills and maintain their engagement with technological advancements. Despite the progress, many educators struggle to integrate technology effectively into mathematics instruction. This paper aims to explore the importance of integrating Information and Communication Technology (ICT) in teaching mathematics, and the challenges faced by teachers in implementing ICT in traditional classrooms. Drawing upon previous research, the paper emphasizes the significance of ICT in mathematics education, highlights difficulties in integration, and finally discuss the opportunities to successful integration of ICT in mathematics classroom.

Introduction

‘’Education may be defined as a systematic process of determining the extent to which instructional objectives are achieved’’ (Best, 1997). Its importance can be determined from the words of famous American educator John Dewey, in which he said, "Education is a social process, education is

development, education is not preparation for life, but education is life itself." All the books on our syllabus each have their own importance and relevance for our daily lives. For example, science, social sciences, Urdu, and mathematics. The present age is scientific and technological. Advances in technology, science, research, trade, and commerce are some of the factors that have given special emphasis to mathematics at all levels. Whether it is primary, secondary, or higher secondary, In the 21st century, it is crucial to teach children the concepts of mathematics, as it is interconnected with all other subjects, fostering the habit of reasoning in their minds. The profound impact of mathematics on civilization is evident in the rapid technological advancements and extensive scientific developments of the first decade of the twenty-first century, which are undoubtedly attributed to the practical application of mathematics. Mathematics is treated as one of the important branches of science, and its influence on science and technology is greater compared to other disciplines. It is challenging to teach other academic disciplines, particularly science courses, without an understanding of mathematics. Mathematics has been given a significant place in the educational curriculum in the contemporary scientific world. Therefore, math proficiency is essential for all students. It is anticipated that children would succeed satisfactorily if teachers use a planned and creative approach.

However, many students read and learn mathematics solely to gain marks or pass examinations. This indicates that somewhere, teachers may have failed to effectively teach or instill a love for mathematics among students. There are various reasons for this, such as teachers using traditional lecture methods and not incorporating more engaging methods like teaching mathematics using ICT or integrating ICT into mathematics classes.

Objectives of the study

- To explain the concept of ICT integration in mathematics teaching.
- To highlight the importance of ICT integration in mathematics teaching.
- To examine the challenges and opportunities of ICT integration, mathematics teaching.

The 21st-century technological advances and the effects of Industry 4.0 technologies changed the face of the world and all the social structures. The education systems and schools faced this rapid change. According to Durmuş, 2019, “Schools are the keystones of societies, and this fact led to the idea of education 4.0 and the emergence of an innovative study environment and style within the ongoing digital transformation”. NCTM (2008) emphasized the usage of technology among the six principles of mathematics education. According to NCTM, 2008, By using appropriate technology in education,

students can enhance their interpretation, problem solving, and reasoning capabilities. According to,"(Keong,Horani, & Daniel,2005), Technology enhances the pathways of the mathematical thinking of students "(the quality and quantity of realistic mathematical studies, and fosters the mathematical ideas)." Wachira & Keengwe, 2011. Moreover, technology is a time-saving tool that focuses on and enhances the mathematical activities Dreyfus, 1994. Mathematics education uses ICTs for problem-solving, practicing numerical skills, and investigating mathematical relationships According to Sivakova et al., 2017. "Modern calculators and technology-based solutions are among the important resources in mathematics education." (Trouche & Drijvers, 2010). Most of the prior research on technology integration in education has focused on identifying influences, and such influences may come from many different factors. Arguably, one of the most seminal of these early studies was conducted by Ertmer (1999). From this foundational work, Ertmer (1999) and Snoeyink & Ertmer (2001) identified challenges to integrating technology into two main types: external barriers and internal barriers. External barriers involve problems or limitations outside the teacher's sphere of control, such as limited resources, inadequate technical support, and lack of confidence in using technological tools. Internal barriers, however, reflect teachers' beliefs and attitudes, including the wider school culture (Snoeyink & Ertmer, 2001). Later research developed these categories further. For example, there were also various major external barriers, "including lack of training and limited time." (Ertmer, Ottenbreit-Leftwich, & York, 2006; Kilinc, Tarman, & Aydin, 2018). Besides, "internal barriers included such factors as teachers' motivation, their personal conceptions of computers, their instructional philosophies, and previously established classroom practices." (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Mueller, Wood, Willoughby, & Ross). There are several benefits of using ICT in mathematics education. As discussed by Khan et al. (2012), the transforming potential of ICT in education may be used to enhance the design work of teachers, enhance the roles of the teacher and students while learning, and also build the collaborative learning environments that support learning improvement. There exist various opportunities as well as challenges to integrating ICT in higher order mathematics instruction. It is notably known, children are more interested in learning mathematics these days when interactive methods and ICT technologies are used in the classroom. These methods facilitate the better understanding of concepts because they help students in visualizing mathematical problems; hence, they are able to understand the practical meaning of mathematical tasks. This paper throws light on some of the tools of ICT for learning and teaching mathematics.

Various ICT tools are available for teaching mathematics, aiding students in learning effectively. Teachers integrate applications of ICT like math editors, PowerPoint (PPT), social media, mathematical

software, and Geo Gebra in the mathematics classroom to facilitate easy learning for students. Some ICT tools are:

1. Smart Classroom These are technologically enhanced classrooms that offer a wide range of learning and teaching opportunities through the use of computers, projectors, and screens. Teachers can integrate ICT in a normal classroom by using technologies like Geo Gebra for creating 2D and 3D geometric figures and graphs with the help of a smart classroom.

2. PPT (PowerPoint): PowerPoint is a technology tool that can facilitate the delivery of mathematical concepts and make learning easier for students. It can increase students' achievement and motivation in mathematics, especially in geometry. PowerPoint can also help narrow the gap in achievement levels between well-endowed and less-endowed schools. Teachers use PowerPoint during class to elaborate on mathematical concepts while teaching using the lecture method.

- **Importance of ICT integration in Mathematics teaching**.

The beliefs of teachers of Mathematics learning with or without the use of technology are considered an important matter in teaching and learning of Mathematics since it may influence teaching and learning, as well as curriculum reform (Güven, Çakiroğlu and Akkan, 2009). Integration of information and communication technologies into mathematics education is particularly believed to be vital in transforming the teaching and learning experience.

1. Enhanced Teaching Methods: ICT integration provides mathematics teachers with innovative teaching methods. It motivates students by offering integrative approaches that encourage active participation and independent learning. Students can explore mathematical concepts through interactive tools and simulations, leading to a deeper understanding of mathematical ideas.

2. Visualization of Mathematical Concepts: ICT allows teachers to capitalize on visualizing mathematical ideas. Interactive software, virtual manipulative, and dynamic graphs help students visualize abstract concepts. Visualization aids in comprehending mathematical relationships and patterns.

3. Support for Learning Objectives: By integrating ICT, teachers can focus on specific learning objectives within the curriculum. It provides resources that align with the National Curriculum, ensuring efficient teaching without distractions.

4. Preparation for the Future: Mathematics, often called the “queen of all sciences,” extends beyond academia. In today’s technology-driven world, mathematics intersects with technology and industry.

Integrating ICT prepares students for the global economy, emphasizing data-driven and knowledge-driven skills.

5. Impact on Student Outcomes: Recent research highlights that teacher integration of ICT positively affects student outcomes. However, mere availability of technology in classrooms is insufficient; effective utilization matters.

6. Real-World Context: ICT brings mathematics to life by connecting it to real-world situations. Students can explore mathematical patterns, data analysis, and geometric properties using technology.

7. Collaboration: Online platforms enable collaborative problem-solving. Students can work together, share ideas, and learn from each other.

Opportunities and Challenges of integration ICT in mathematics:

In mathematics education curriculums, there are major challenges regarding ICT applications and opportunities (Sivakova et al., 2017). “The growth of information and communication technologies (ICT) has dramatically reshaped teaching and learning processes. “Mathematics teachers are faced with inhibiting challenges or barriers to computer use.” (Hudson and Porter, 2010). For this reason, “there have been several studies which have specifically focused on ICT integration in secondary Mathematics teaching”. Drent and Meelissen (2008); Ottenbreit-Leftwich, Glazewski, Newby and Ertmer, (2010). Teacher related, challenges impact on fundamental change and are typically rooted in teachers’ core beliefs and are therefore the most significant and resistant to change. Fullan (2007). Teachers related factors refer to teacher comfortability, teacher confidence and teacher competence. School related challenges refer to inadequate provided resources such as infrastructure, support, trainings and time. In Kenya, teachers rated lack of time as one of the most problematic factor to technology utilization in schools. “They further said that mastering technology requires time.” (Kukali, 2013). Some challenges faced by teachers are:-

1. Access to technology: Not all students or schools have equal access to technology, which can create a digital divide and hinder the effective integration of ICT in mathematics education.

2. Teacher Training: Many teachers may not be adequately trained in using ICT tools effectively in the classroom. This lack of training can lead to underutilization of technology or ineffective integration strategies.

3 Cost: The integration of ICT within the classroom environment can be highly expensive. Schools may not be able to afford the required hardware, software, and infrastructure for such integration.

4. Technical Issues: Various technical problems, like network, software, or hardware issues, may disturb lessons and hinder the smooth integration of ICT in mathematics instruction.

5. Curriculum Alignment: Ensuring that ICT tools are aligned with the mathematics curriculum and learning objectives can be challenging. Teachers need to integrate technology in a way that enhances mathematical learning rather than distracts from it.

6. Digital Literacy: Students may lack the necessary digital literacy skills to effectively use ICT tools for learning mathematics. Teachers may need to spend time teaching basic technology skills before integrating more advanced tools.

7. Pedagogical Shift: Integrating ICT in the mathematics classroom often requires a shift in teaching methods and pedagogical approaches. Some teachers may struggle to adapt their teaching practices to effectively incorporate technology.

8. Assessment: Assessing student learning when ICT is integrated can be challenging. Teachers need to develop new assessment methods that accurately measure students' mathematical understanding and ICT skills.

9. Challenges in using mobile learning for mathematical instructions.

The affordances of technologies (mobile devices) can bring a sense of positive and negative perceptions to teachers on how their use will impact their environment (Classroom teaching instruction) (Gibson, 1977). Mobile devices can be beneficial for classrooms, as they enable new ways of using technology. However, they also pose some difficulties, such as requiring changes in how teachers teach. A survey asked teachers about the problems of using mobile devices for math lessons. More than half of the teachers (58.2% or 124) said that they thought mobile phones would cause distractions in the class (for example, phone calls, text, etc.). Some schools have banned mobile phones for students, at this situation, even if teacher's wants to integrate mobile learning in mathematics class, they can't do it because some schools do not allow students to bring their mobile phones, which may discourage teachers from using them in math lessons. Without mobile phones, teachers cannot use innovative teaching methods. This prevents teachers from exploring math concepts with mobile technology. Besides the teachers' hesitation to use mobile devices in teaching, the lack of technology (e.g., students or schools do not have enough

mobile devices) also hindered mobile learning. Apart from the teachers' concern about using mobile devices within instruction. Another challenge described by teachers was the limited availability of wireless Connectivity in schools. To initiate mobile technology in instruction, Wi-Fi has to become ubiquitous. However, not all schools have good Wi-Fi connection and even when they do, the connection often covers only a few areas. Also many challenges has been faced by teachers like Lack of teacher confidence, Resistance to change & negative attitude, Lack of teacher competences, Lack of time etc.

Conclusion

From the above statement it is clear that the ICT of integration is very important for teaching of mathematics. it plays important role for enhancing the students' knowledge as well as development of critical thinking. Considering the importance of integrating mathematics, it can be said that the use of ICT has become crucial in teaching any class. As a result, children learn at their own pace and develop critical thinking skills to solve mathematical problems." The study also shows that in today's technological era, on one hand, ICT plays a very important role in teaching mathematics, while on the other hand, the teacher has to face many challenges in integrating ICT in the mathematics class. There are many challenges in integrating ICT in the mathematics classroom. On the other hand, there are many opportunities too if these challenges can be overcome, the successful integration of ICT is possible in mathematics classroom. There are many such opportunities in the use of ICT which a mathematics teacher can use in the mathematics classroom like smart classrooms, network facilities, and the use of blended learning." Etc. The study indicated that instructors should be trained on how to use ICT infrastructure on a regular basis, with training occurring at zonal levels at least once every six months at the BRC level. The school should hold a conference or seminar to boost teachers' proficiency level in the usage of ICT. Also, the Indian government should give schools with ICT infrastructure so that teachers can integrate ICT into their teaching and learning.

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