



Two Poles on the Use of ICT in Mathematics Education: Opportunities and Challenges

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Article Info

Abstract

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This article is a literature-based article exploring the different opportunities and challenges in using ICT. The article examines the use of ICT by categorizing two poles of learning mathematics. This article has explored the fundamental use of ICT in mathematics teaching. The article has also explored what and how different types of ICT tools were used in secondary schools in Nepal, and what challenges arose in learning mathematics with ICT. It is found that numerous opportunities were found for the use of ICT such as the increase in motivation, student engagement, self-paced learning, and maintaining justice in learning mathematics. Similarly, the analysis of different challenges such as cost constraints, knowledge constraints, maintaining equity and access, sustainability, and skilled human resources were found in the use of ICT in classroom instruction.

Keywords: Information communication technology, GeoGebra, Google classroom, Messenger

Introduction

The use of information and communication technology (ICT) in the classroom has completely changed the methods and procedures in modern times. ICT resources, which span from basic calculators to advanced programs like GeoGebra and Desmos, are now essential for improving students' comprehension of challenging mathematical ideas. The integration of digital tools and resources, such as computers, software, the internet, and interactive whiteboards is necessary to improve the teaching and learning process. ICT makes abstract concepts more concrete and approachable for students by facilitating a variety of instructional activities like interactive learning, collaborative work, instant feedback, and visualization of difficult mathematical concepts. Nonetheless, there are frequently two opposing views on the use of ICT in mathematics education. One emphasizes the advantages and encourages the use of technology to create profound conceptual understanding and the other warns against its excessive usage, which may impede the development of foundational skills. This examines two extremes and emphasizes the necessity of well-rounded strategies for the efficient integration of ICT in mathematics courses. There are a special set of opportunities and difficulties when teaching mathematics content. Since mathematics is the basis of many other fields, it is essential for the growth of numeric literacy, logical reasoning, and problem-solving abilities. But teaching may be tough, especially in a world where technology and students' learning variation has shifted into social norms are all contributing factors to the rapid evolution of educational processes.

Objectives of the study: This article is one of the literature-based articles in which different articles were reviewed to fulfil the following objectives:

- To explore the different opportunities and challenges on the use of ICT in mathematics teaching and learning
- To explore the appropriate strategies for balancing opportunities and challenges in the effective use of ICT in mathematics teaching.

Methods and Procedures

The explorative design with qualitative information was reviewed and analyzed concerning articles, books, and research. For this purpose, I have reviewed more than 15 pieces of literature as mentioned in the refer-

ence section for the exploration of possible opportunities and challenges in the use of ICT. The information that was mentioned in the reviewed articles was further explained in the context of the use of ICT in the Nepalese education system. For the exploration of the opportunities and challenges on the use of ICT in mathematics learning. Each article was reviewed from the perspective of opportunities and challenges with the balancing strategies in the effective use of ICT.

Results and Discussion

The First pole: Opportunities for the use of ICT

ICT for mathematics education has several benefits, one of which is its capacity to give abstract ideas greater tangible form and accessibility. Students can investigate mathematical concepts in ways that traditional approaches might not be able to use dynamic geometry software, interactive simulations, and visualizations. Students can alter the form and observe the immediate results of their actions with a program like GeoGebra, Mathematica, and Desmos that helps them comprehend geometry and algebra on a deeper level. ICT tools may also give immediate feedback, which is an important part of learning. Students can use different solutions to get prompt corrections and modify their strategies as necessary. This improves their ability to solve problems and foster growth mentally, in which errors are seen as teaching moments rather than as setbacks. ICT also makes differentiated education easier to understand. The task can be modified by teachers to accommodate the different needs of their students, offering more difficult challenges for advanced students and more assistance for those who need it.

The customized method with the use of teaching-learning materials in digital form aids in overcoming the disparities in mathematical ability across students in the same classroom. In addition to bringing innovation to educational institutions, new technology tools can expedite information flow, spark student engagement, and enable process automation, among other factors that should be considered. It enhances understanding and focuses the mathematical understanding. Engaging students in activities via digital and interactive technologies improves their focus, which speeds up their assimilation of information and improves learning (Balalle, 2024). With the intention of strengthening what they have learned, this kind of tool engages students in more hands-on learning. It encourages students' adaptability and independence. Students can learn autonomously than to new technologies. By utilizing digital options like online classes. Students may maximize their time and resources by learning at their own speed. The adaptability brought by networking and digitalization. It promotes critical thinking. Students are exposed to different perspectives due to the variety of information sources offered by technologies. Information and communication technology promote discussion and tolerance for differing viewpoints in this way. Students can also learn about various cultures through online forums like Vivor, Facebook, Instagram, Messenger, and others through the sharing of ideas. Teachers and students can communicate easily through various technological platforms including Google Classroom, Google Forms, Messenger and more. The same resources are easily accessible to the entire educational community. Digital tools make it possible to communicate directly and instantly without having a person physically.

Digital tools were highly practiced and applied for teaching and learning to students during the COVID-19 pandemic in Nepal. Utilizing modern technology in the classroom is not an easy task. Different obstacles can occur in the use of ICT in classroom instruction. In particular, that facilitates access to online content and enhances learning productivity. To complete the task, it foster a collaborative environment. Technology encourages students to complete the many activities that teachers provide, which motivates them to learn. Using technology in the classroom increases students' enthusiasm and is a convenient and efficient way to encourage the learning of new ideas. Since the younger generations rely on digital tools for daily communication, they use them with ease in this setting. It integrates innovative teaching strategies. One other benefit of ICT in education is that it allows educators to implement innovative teaching. Strategies, which enhance students' performance and promote classroom energy. It integrates innovative teaching strategies. One other benefit of ICT in education is that it allows educators to implement innovative teaching strategies, which enhances students' performance and promotes classroom energy. In this context, the role of ICT in teaching and learning mathematics were explored as follows:

Integration of technology

The teaching and learning in mathematics and other subject has changed due to the incorporation of technology into mathematics education. A more dynamic and attractive learning environment is made possible by tools

like virtual simulations, internet platforms, and interactive software. Mathematics is now more accessible and individualized to services like Khan Academy, GeoGebra, Mathematica and Matlab etc. that provide Interactive lessons and activities that adjust to each student's learning style (Borba, et al.2016)

Promoting critical thinking and problem-Solving

Teaching mathematics is essential for developing critical thinking and problem-solving abilities. In addition to being essential for scholastic achievement, these abilities are also prioritized in the workplace. As mentioned in National Research Council (2012), students get the systematic problem-solving skills, data analysis, and logical reasoning skills necessary for success in a variety of professions, including data science, engineering, economics, and mathematics According to Voogt and Roblin (2012), ICT enables students to interact with a variety of digital tools /resources, supporting the development of higher-order thinking abilities. It helps to improve learning through teamwork and creativity. Further, interactive applications like learning simulations demand the use of logic, creativity and reasoning capacity to overcome difficult problems. On the other side, ICT helps to develop problem-solving capacity with the help of coding and analysis of data with tools, improving the capacity to find the possible solution to the problem by developing reasoning capacity and logic (Kong, 2014).

Development of abstract and logical thinking

NCTM (National Council of Teachers of Mathematics). "Principles and Standards for School Mathematics." NCTM, (2000) focuses on logical and abstract thinking abilities that are encouraged by mathematics. To solve more difficult issues, students gain the ability to identify patterns, comprehend relationships and build upon fundamental notions. For success in post-secondary education and professional domains demanding analytical thinking. This cognitive development is essential.

Interdisciplinary connections

The interdisciplinary nature, with other academic fields, mathematics provides chances for interdisciplinary teaching and learning. Students can better understand mathematics applicability in the real world by applying mathematical ideas to fields like physics chemistry biology, economics and even the social sciences (Shulman, 1986). This multidisciplinary method can improve students' comprehension and engagement by showing how mathematical ideas are used in real-world situations. Students gain the ability to identify patterns, comprehend relationships and build upon fundamental notions in mathematics with the help of ICT (Moreno-Guerrero et al. 2020). Personalized learning pathways are made possible with the help of ICT like adaptive learning software, which lets students connect mathematics with other topics at their own speed and according to their interest and learning requirements.

Addressing the diverse needs of learners

Taking into account the various demands of students in one of the biggest obstacles in the teaching of mathematics. The past knowledge, learning preferences, and attitudes towards mathematics of the students vary. Because of this variability, educators must use differentiated education techniques that can be difficult and time-consuming in practice (Tomlinson, 2001) that can be addressed by the use of ICT. ICT provides individualized and flexible learning environments that accommodate varying learning styles, aptitudes and speeds to meet the unique demands of learners. With the practice of assistive technologies, multimedia materials and e-learning platforms, ICT allows students with different needs to interact with the materials in ways that work best for them. Students with learning difficulties can benefit from interactive, gamified learning modules that make concepts more accessible, while visually impaired students can use screen readers. ICT also makes individualized instruction possible, enabling teachers to provide assignments based on the unique learner profiles of each students, guaranteeing effective learning for all. This adaptability promotes inclusive education by taking into accounts a diverse range of abilities and preferences within the classroom, in addition to supporting students with special needs.

Management of mathematics anxiety

Mathematics anxiety is a well-researched phenomenon that can make it more difficult for students to study and perform in the subject. Social prejudices poor experiences with mathematics or a lack of confidence in one's skills can all contribute to this anxiety. Teachers must establish a safe learning atmosphere that promotes perseverance. Taking risks and having a growth mindset to help students overcome their fear in mathematics (Boaler, 2016). Offering creative and individualized learning possibilities, the use of ICT gives a number of possible options for addressing mathematics phobia by using different types of applications and interactive

software, interactive PowerPoint, YouTube tutorial videos, Lectures' videos etc. It helps to create interest and encourages the atmosphere to learn at their own speed and pace. It helps to get immediate feedback and helps to develop confidence (Geist, 2015). The use of ICT in learning mathematics promotes a more positive learning environment by removing unpleasant feelings related to mathematics (Pereira, 2001).

Maintaining the curriculum standard

The requirements of curriculum and benchmarks for standardized testing may limit a teacher's ability to try out innovative teaching methods. Standardization's primary objectives of the curriculum are accountability and consistency, but it may also strangle creativity and the adaptability needed to suit the requirements of every individual student (Berlinder, 2011). ICT in education has become indispensable for upholding curricular standards and guaranteeing that the methods of instruction and learning are in line with contemporary educational objectives. With the use of ICT technologies, learning experiences may be made more dynamic, engaging, and individualized adhering to curricular rules. This helps students develop important skills like cooperation, digital literacy, and problem-solving. Additionally, ICT makes it easier for teachers to continuously assess and monitor students' progress enabling them to make data-driven decisions that are in line with curriculum requirements in mathematics subject.

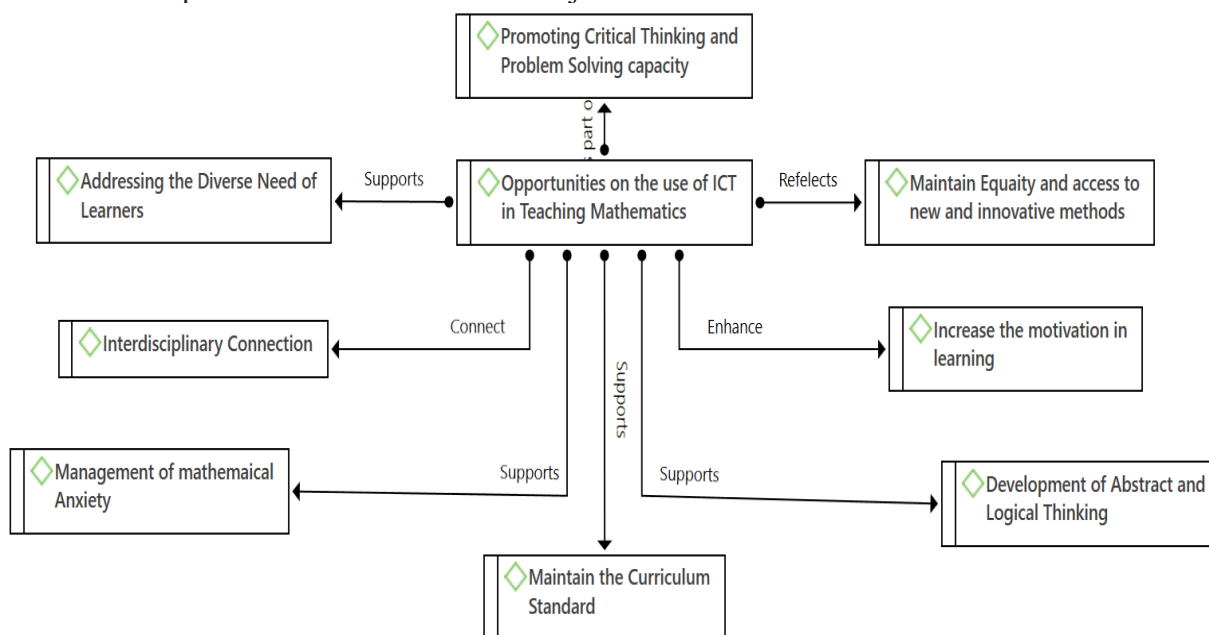


Figure 1. Opportunities on the use of ICT in Learning Mathematics

The Second pole: Challenges on the use of ICT in teaching mathematics

While there are many benefits to integrating information and communication technology (ICT) into mathematics instruction, many difficulties have occurred. These difficulties can be roughly divided into three categories: institutional, pedagogical, and technological. Various educational institutions encounter obstacles such as insufficient financial status, inadequate facilities, and insufficient ICT resources like computers, fast internet etc (Tondeur et al, 2016). Similarly, a lack of professional development due to a lack of time to adjust to the new technologies causes to use ICT successfully (Ertmer & Ottenbreit-Leftwich, 2010). In the other side, there were technological problems related to the availability of software, cost of software, and loss and damage of hardware and accessories hinder the practice of ICT in the mathematics classroom instruction. The main difficulties for ICT practice has been provided with the following areas.

Maintain equity and access to new and innovative ideas

Unequal access to technology is one of the main problems. Students from rural or low-income having lack the gadgets or internet access needed to make efficient use of ICT resources (Selwyn, 2011). Inadequate hardware or bandwidth in schools are examples of inadequate technical infrastructure that can impede the successful integration of ICT in mathematics teaching (Mooij, 2007)

Differential quality of teachers, learning spaces, and educational resources can result in unequal opportunities for children from diverse socioeconomic backgrounds. To give every student an equal opportunity to ex-

cel in mathematics, it is imperative that these inequalities be addressed by ICT (Gutiérrez, 2008). Students from underprivileged communities have access to the same learning resources as students in well-equipped schools that integrate ICT in education. This support in closing the achievement gap between wealthy and disadvantaged students initiatives such as the provision of free internet connection, low-cost devices and digital literacy training enable excluded communities to engage with the digital economy (Mvan Dijk, 2017). The summary of different opportunities for the use of ICT in mathematics classes has summarized in the following figure 2.

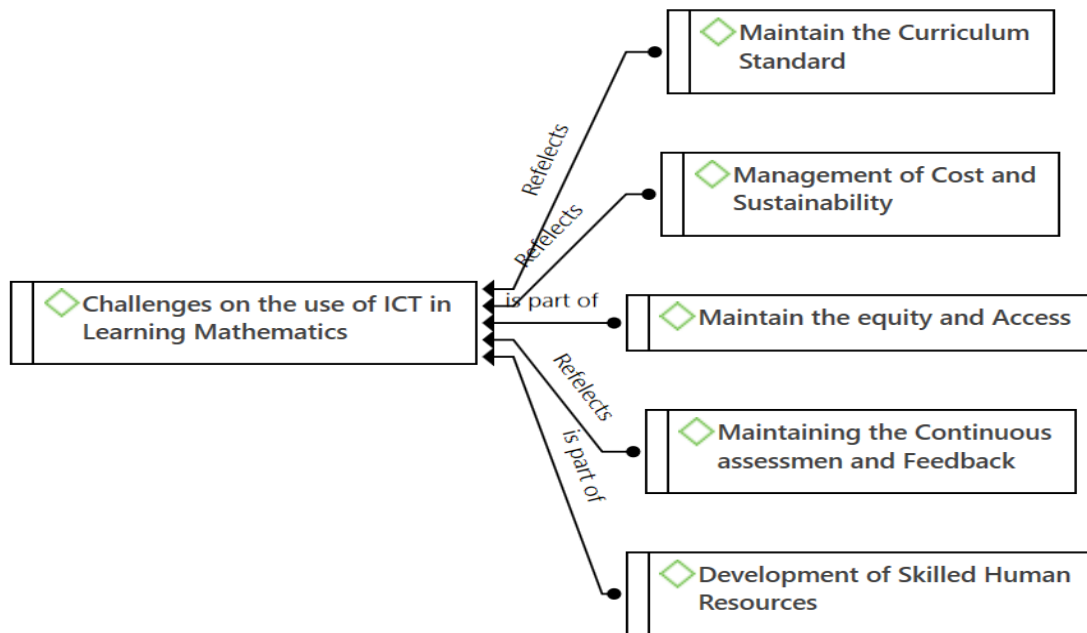


Figure 2. Summary of Challenges on the use of ICT in Learning Mathematics

From the above figure 2, it is concluded that different factors hinder the opportunities for the use of ICT in teaching mathematics. The opportunities were related to critical thinking, problem-solving capacity, addressing the diverse need of learners, interdisciplinary connection. Management of mathematics knowledge. Moreover, ICT support maintaining the equality and access by developing motivation and development of abstract logical thinking.

Development of skilled human resources

Many educators lack the necessary training to incorporate ICT into their lesson plans. This may lead to inefficient instructional methods or underuse of the resources that are available (Hew & Brush, 2007). Educators may be reluctant to embrace novel technologies due to lack of assurance, knowledge or conviction regarding ICT's capacity to enhance mathematical comprehension (Ertmer, 2005).

Maintaining the curriculum standard

ICT integration that observes the present curriculum and academic requirements may be difficult. ICT technologies often do not align with the curriculum's mandated learning objectives (Voogt & Knezek, 2008). It is only suggested that ICT can be used according to the demand of the contents. It is possible that standard assessment methods are inappropriate for determining students' comprehension when ICT is actively used in the classroom. In a world, information and communication technology is one of the most difficult tasks in developing new assessment techniques that accurately measure learning outcomes.

Management of cost and sustainability

The initial cost of purchasing hardware, and software, for ICT infrastructure may be prohibitive for many schools, especially in underdeveloped countries (Tondeure et al, 2008). Educational institutions may incur significant financial and technical costs to maintain ICT tools that are up-to-date and functional throughout time (Harris, Mishra & Koehler, 2009).

Management of continuous evaluation and feedback

ICT technologies can occasionally lead to distractions since students may decide to focus more on the tech-

nology than its proper use (Clark & Mayer, 2011). ICT can have a variety of effects on learning outcomes for mathematics, depending on how it is used and integrated into the teaching and learning process (Chaeung & Slavin, 2013). Effective use of ICT tools may be hampered by their inability to be easily adapted from one educational or cultural setting to another (Aviram & Tami, 2004). When the primary language of teaching differs from the language used in many of these technologies, language barriers may limit the effectiveness of ICT tools (Unwin, 2005)

Balancing strategies for opportunities and challenges

The overuse of ICT can have detrimental effects on students' social and cognitive development (Twenge, 2017 & Greenfield, 2014), but they also have a positive influence on academic success. Students who rely much time on digital resources may become passive information consumers rather than active learners which might impair their capacity for critical thought and problem solving. Striking a balance between the advantages and disadvantages of ICT use can be challenging as excessive screen time has also been linked to issues like reduced attention span, poor academic performance, and negative effects on mental health, such as increased anxiety and despair. Securing a balance between these two extremes is essential for effectively integrating ICT in mathematics education. Teachers must use technology sensibly and ensure that it supports their learning objectives. The following figure 3 shows the various methods that teachers utilize on a regular basis.

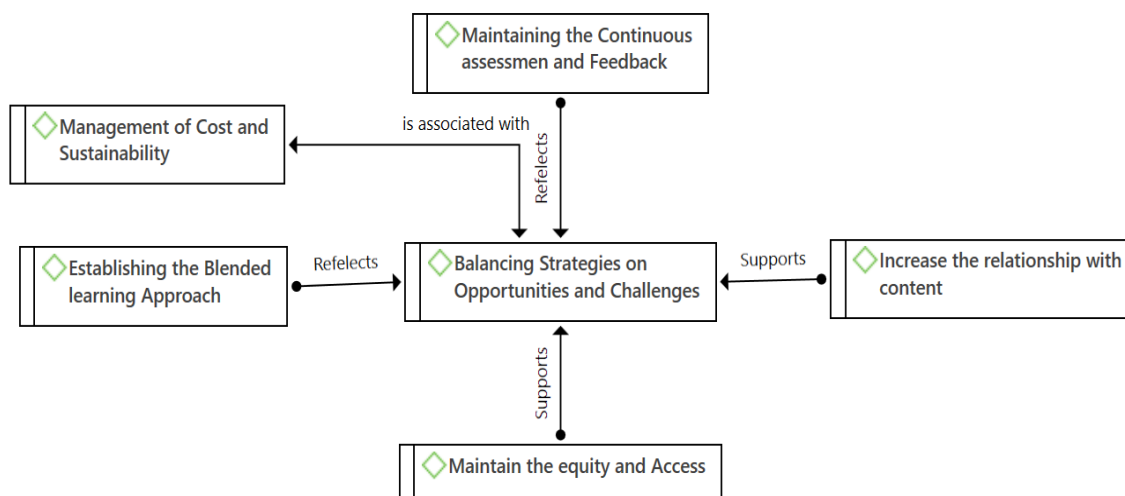


Figure 3. Balancing the Opportunity and Challenges

Increase the relationship with content

ICT should be used deliberately and with specific learning goals. For certain tasks, educators must consider whether utilizing a certain technology or resource enhances students' understanding or whether it would be better to use more traditional methods. ICT must be connected to related content to be used effectively.

Establishment of blended learning

ICT can be used with lectures, written assignments, and hands-on activities to provide students with comprehensive mathematical concepts. For example, after utilizing ICT to study a concept, students may work on related tasks without the assistance of technology to reinforce their learning.

Maintain equity and access to digital literacy

In addition to mathematical skills, teachers should also teach students how to use ICT tools safely and effectively. This means being conscious of the limits of technology and knowing when and how to utilize it. ICT is crucial in promoting equity and accessibility through digital literacy because it gives people the skills and information they need to be fully included in the digital world. By giving students from disadvantaged and marginalized groups access to possibilities, the government can control and decrease the digital divide. By providing distance learners with access to high-quality education through digital libraries, online learning environments, mobile applications, and other resources, ICT helps close the gap between urban and rural education systems. It contributes to improving digital literacy, which is required for students to participate in their studies (UNESCO, 2018; Anderson & Shattuck, 2012)

Maintaining the continuous assessment and feedback

ICT plays an important role in the management of continuous assessment and feedback in educational settings by providing real-time feedback, continuous monitoring, supporting the individual learning environment, and developing collaboration and feedback with peers and groups with a Learning Management System (LMS). It helps to create a dynamic learning platform with teachers, students and friends.

Conclusion

Teaching mathematics is a challenging but worthwhile endeavour. The learning process can be substantially improved by the opportunities that technology presents, the growth of critical and abstract thinking abilities, and interdisciplinary linkages. To guarantee that every student may gain from a top-notch mathematics education, it is necessary to address difficulties including different learner demands, mathematics anxiety, curriculum rigidity, and equity concerns. To provide a supportive and productive learning environment for every student, educators must strike a balance between these possibilities and obstacles as they continue to innovate and adapt. Although there is great promise for improving student learning, the use of ICT in mathematics teaching must be done carefully. By striking a balance between the advantages of technology and the requirement to acquire basic mathematical abilities. Teachers have the ability to establish a learning environment in which students not only thrive in mathematics but also learn how to use technology as a tool for exploration and learning. The ultimate objective is to equip students with the critical thinking and problem-solving abilities needed to flourish in a world that is changing quickly, as well as the ability to harness the power of ICT in the future. Because of the features of modern technologies, it is possible to create new approaches to education and learning, changing the conventional methods that teachers taught their students.

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