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An Exploration of Technology Enhanced Learning & Teaching Aids in Mathematics Education

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Abstract

The use of technology to support training would seem to be of utmost relevance given the recent shift to online instruction and/or mixed online/face-to-face (hybrid) modes of teaching made necessary by the unique coronavirus epidemic. Very few thorough meta-analytical studies have concentrated on the roles of instructional technology in support of specific learning goals, even though effective technology integration in mathematics classrooms requires recognition of students' needs and instructional goals that technology could fulfil. This study investigates the latest technological interventions in mathematics education and assesses the degree to which they use the pedagogical approaches and educational opportunities provided by the technology. A literature review was conducted to address this, and a classification is presented that categorises the types of technology as well as the educational underpinnings of the interventions that use those technologies. The findings of the article will help to improve mathematics education, guide teaching, and enhance our knowledge of learning in a technologically advanced world.

Keywords: *Technology Enhanced Learning, Technological Interventions, Teaching Aids, Mathematics Education.*

Introduction

Technology has undeniably revolutionised how we live, work, and enjoy. It is no surprise that it has started to make its presence felt in the field of education as well. Technology in education should not be limited to using computers, tablets, and smartphones to access the internet and attend online classes. It is possible to use various computer software, educational apps, and other web-based programmes as educational support systems. By utilising technology, teachers can design effective collaborative learning experiences that encourage creative problem-solving and adaptable thinking.

The possible uses of technology in education have been made even more prominent by the recent shift to online and hybrid modes of instruction, which were rendered necessary by the novel coronavirus pandemic. This influx of technology was the need of the hour during the pandemic and one of its positive outcomes is that educators as well as students have become increasingly aware and conversant with technology in education. As the pandemic recedes, more and more educational institutions are reverting to traditional offline classrooms. There is a distinct possibility that the use of technology may also be reduced. It would be a shame if this were to happen because what is needed is a much-increased use of technology in education. With educators and students having already accepted the concept during the pandemic, it is the right time to push for a multifold increase in the use of technology-based interventions and teaching aids in mathematics education.

Mathematics education is one field where the use of technology has shown encouraging results (Ran, H. et al, 2022). Numerous meta-analyses have examined the effects of various forms of technology on mathematical success, including Dynamic Geometry (Chan & Leung, 2014), Intelligent Tutoring Systems (Steenbergen-Hu & Cooper, 2013), Digital Game-Based Learning (Byun & Joung, 2018), and Collaborative Scripts (Radkowitsch et al., 2020). A meta-analysis (Ran, H. et al, 2022) found that technology had a statistically significant impact on students' mathematical performance.

Since interventions with technology have repeatedly been shown to improve students' cognitive results in mathematics, there is a crying need to incorporate technological interventions and teaching aids on a much larger scale. This article proposes to present a variety of available and proven technology-enhanced learning and teaching aids in mathematics education to a wider audience. It can help increase the understanding of the kinds of teaching and learning of mathematics that technology has the potential to enhance. Also, it will be helpful for improving mathematics education and deepening our understanding of learning in a technologically advanced environment.

Aspects of Designing an Effective Computer-Based Intervention Programme for Students

With the thoughtful blending of both content-specific and content-neutral technology, instructors and students can build learning together in real-world contexts that improve mathematics learning. To reap the benefits of technology for mathematics teaching and learning, it must be used appropriately through deliberate design and integration into mathematics classrooms (Reiser, 2017).

Teacher's Perspective

Teachers need the right content as well as pedagogical and technological expertise to effectively integrate the use of digital tools into the classroom (Mishra and Koehler 2006). Proper technical resources, technical support, and user manuals for digital content should be available (Gaffney 2010; Hanson and Carlson 2005). Teachers are more likely to use new materials that can easily be aligned to the syllabus and fit into the crowded mandatory curriculum (Cuban 2001; Smarkola 2007). Digital tools should support teachers' individual teaching methods and strategies (Cuban 2001).

Students' Perspective

All students must have access to and be able to use the technological resources required to obtain digital learning materials. Age-appropriate, cognitively, and pedagogically relevant content should be included in the digital curriculum to meet the requirements of each student (Molnár and Csapó 2019; Hanson and Carlson 2005). Instructions must be broken down into manageable chunks. Before receiving guidance in the classroom, students should have the chance to practise the prerequisite skills, and then afterward, they should have the chance to practise the targeted skills (Molnár and Csapó 2019). Only those facts and images that won't distract students from the lesson should be used in the content presentation in elementary schools (Mayer 2014; Seo and Woo 2010).

Technology Enhanced Learning in Mathematics Education

There are countless uses for digital media because of the popularisation of technical media within the so-called "multimedia." In the past, these media included instructional movies, radio, and TV. Technology-enhanced learning, however, is now more closely linked to the use of computer-based technologies, which involve smart gadgets. The use of multimedia resources in the classroom offers ways to motivate students, engage students, and improve the learning atmosphere.

Some of the available technology-enhanced learning techniques along with their brief description are listed below:

AbsurdMath http://www.learningwave.com/abmath/

A collection of interactive games for solving mathematical puzzles is called AbsurdMath. The game series AbsurdMath is made to help people solve mathematical puzzles. It provides a

stimulating setting for learning and contemplation. The player moves through missions in a strange world where knowledge and ability in mathematics are the keys to success. There are areas and clues concealed on many of the pages.

Algebra Arrows Applet

The Algebra Arrows applet was created to give students the opportunity to create and use sequences of operations on numbers and algebraic formulas. As a result, it helps students develop the understanding that a function is an input-output chain of operations that represents a dependency relationship (Doorman et al. 2012).

Cover-up Strategy Applet

The Cover-up strategy applet was made to answer one-variable equations of the form f(x) = c through global substitution by selecting an expression's component with the mouse and determining its value (Wenger 1987).

Balance Model Applet

An applet called Balance Model offers equations and the associated simulated dynamic models which can be used to solve the equations. It has equations with the variable present on both sides i.e., of the form f(x) = g(x).

Balance Strategy Applet

The Balance Strategy applet is used to solve linear equations in one variable with the form f(x) = g(x) by performing the same operations on both sides of the equations, without using models in the solution procedures. This method was created with the Balance Model applet. This applet is to be used after the Balance Model applet because of a design choice that offers an abstraction of it.

Moodle (http://moodle. org/)

A learning platform called Moodle makes it simpler for educational institutions to manage educational content around the globe (Sabharwal et al., 2018). It is an open-source learning platform that is extensively used and accepted. It also enables contact and feedback between students and instructors, as well as aids teachers in developing top-notch online study materials.

Webmath https://www.webmath.com/index.html

A maths-help website called Webmath produces solutions to specific maths questions and issues that are entered by a user at any given time. When a web user enters their maths issue and clicks "solve," the maths answers are generated and displayed in real-time. Webmath provides the student with the solutions as well as explanations of how they were arrived at.

Digital Mathematics Environment (DME) http://www.dwo.nl/site/index_en.html

Digital Mathematics Environment (DME) is a digital learning and assessment environment for mathematics in secondary and higher education. The use of interactive instructional techniques and feedback is the highlight of this environment. The modules that have been chosen for the students can be worked on at any moment, and they can get feedback on their responses. The requirements of the class can be met by teachers by modifying modules and activities in light of the students' work.

Explain Everything https://explaineverything.com/

Explain Everything is an online digital whiteboard. Explain Everything can be used on a variety of devices and viewed from any location. It functions as a presentation tool with user-editable audio and graphic elements. The digital whiteboard can be used on almost any device because it is accessible as an app for the iPad, Android, Chromebook, and browsers. In essence, the software functions as a presentation tool. Imagine PowerPoint but with much more advanced tools designed especially for instructors working with a class.

The Maths Learning Center https://www.mathlearningcenter.org/

The Maths Learning Center offers online maths applications based on the visual models used in Bridges in Mathematics. There are various types of apps. The site's student-centred methodology prioritises conceptual comprehension, visual models, and classroom debate. Rich tasks with numerous entry points help students develop their problem-solving abilities, fluency, and understanding of mathematics. All students have the chance to establish a positive maths identity thanks to open-ended questions and pupil choice.

GeoGebra http://geogebra.org/

GeoGebra is an interactive maths programme for all educational levels that combines geometry, algebra, spreadsheets, diagramming, statistics, and calculus into a single engine.

Additionally, GeoGebra provides an online platform with more than a million free teaching materials developed by their multilingual community. These resources are readily shareable through their collaboration tool GeoGebra Classroom, where student progress can be followed in real time.

Constraints in Integrating Technology into the Teaching of Mathematics

Despite the benefits of incorporating technology into maths learning processes, educators still face some challenges when putting ICT into practice. Reduced teaching time in the classroom, inadequate technological application training, poor technical support, restricted resources for students at home, and a lack of pedagogical expertise on how to incorporate ICT into teaching are some of the challenges educators encounter (Afolake & Shittu, 2005; Keong et al., 2005).

The primary barrier to educators using technology in their instruction is the restricted time for teaching mathematics in the classroom (Keong et al., 2005). The necessity to set up the tools before beginning the learning process is one of these time constraints. This could involve projectors, screens, computers, and other devices that require time to set up because teachers aren't used to using them (Rohani, 2011).

Teachers complain about inadequate training in using technology to simplify the teaching of mathematics. The required training addresses how to incorporate ICT into maths instruction. According to a survey, 59.5% of teachers said they needed different kinds of training in ICT apps to choose the right ones for maths teaching and learning (Abramo-vich, 2014; Afolake & Shittu, 2005). To be effective in practice, training should be given on a regular basis and should address the needs of maths educators.

Another barrier for educators is a lack of technical assistance for integrating ICT into maths instruction. The availability of few computers for pupils, broken equipment that takes a very long time to be repaired, scheduling procedures for computer laboratories, and educators' low computer proficiency are some issues with technical support. These factors were cited as substantial restraints by 39.2% of educators and minor constraints by 46.4% of educators. The regularity with which educators incorporated ICT into their instruction, however, was significantly impacted by the technical support component.

Limited technological resources while teachers or students are at home is another issue that becomes a barrier to the application of ICT in the teaching of mathematics. In a research study, 78.4% of teachers acknowledged that their kids lack good access to the tools they need for

learning at home. Learning through technological applications will be restricted to the classroom for students without access to computers or the Internet (Keong et al., 2005; Ruthven et al., 2009). The creation of maths teaching resources will also be hampered for educators without access to the required technology (Zakaria & Khalid, 2016).

Along with the issue that makes using technology in the classroom difficult, and the considerations, there are also a few minor restrictions that prevent teachers from integrating technology into their maths instruction. These include a lack of computer software, a school's lack of interest in integrating technology, and difficulties getting to ICT skill-training sessions (Afolake & Shittu, 2005; Palmer, 2003). These several variables can make ICT deployment in mathematics teaching less effective and result in a lack of support from educators.

Conclusion

The adoption of technology in mathematics education can yield many benefits. Specialised digital-based interventions could help students, teachers, and researchers in different ways. They can help shorten training sessions and lighten the burden on teachers while also allowing for individualised instruction for each student. (Mitchell & Savill-Smith, 2004; Butterworth & Laurillard, 2010).

Technology can help learners to better visualise the questions in mathematics. It can make the connection to abstract concepts easier. For instance, "zooming into a 1-10 number line to find decimal numbers (Butterworth & Laurillard, 2010). Students commonly experience significant declines in their motivation for mathematics during the middle school years. Using technology has been one strategy used by researchers to stimulate students' interests and increase their perception of mathematical proficiency (Star, J.R. et al, 2014). Technology can assist in reducing the number of directions by using visually appealing animations and graphics, as well as cartoon characters, to enhance learning motivation (Cezarotto; Battaiola, 2016; Seo & Woo, 2010). For students who struggle to persevere and frequently struggle in traditional classroom settings, virtual environments allow private feedback that can be very helpful (Butterworth & Laurillard, 2010).

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