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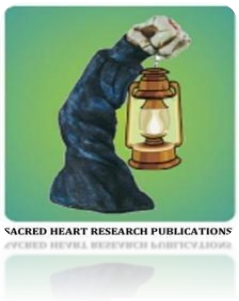

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Effective pedagogical practices of teaching mathematics: A literature review

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Abstract

Innovative pedagogical practices are the way to change the paradigm of teaching mathematics and help teachers in gaining new experiences with new ideas. Nowadays, the use of technology in the teaching process became essential for making it more interesting and easier for learners. This paper discourses a literature review which examined the role of technology in various ways as the use of GeoGebra and flipped classrooms as innovative pedagogical practices in teaching mathematics; furthermore, we identified some of the challenges faced by the teachers during the use of this technology in the teaching process. The literature was explored from Education Resource Information Center (ERIC), google scholar databases. Key terms used for searching are Pedagogical practices, Mathematics teaching, technology in mathematics, flipped classroom, GeoGebra, challenges, etc. Those studies comprised the reviews published from 1999-2022. The results of the review conclude that there is a necessity for more innovative pedagogical practices for teaching mathematics. Studies suggested that the use of technology will help students in improving students' satisfaction with better performance and increased understanding.

Keywords: Pedagogical practice, Mathematics, Technology, GeoGebra, Flipped Classroom.

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Introduction

Children of different levels have a phobia of the abstract subject of Mathematics. The reason behind this phobia may lie in the applied pedagogical practices by teachers. Traditional methods can be seen not to address the needs of learners as dominated by the theories, it is even argued that these approaches since the times of ancient Egypt and Assyria 5000 years ago have not progressed much (Abate & Cantone, 2005). Nowadays, Technology became an essential tool for better teaching. However, in spite of these technological developments, students are struggling in developing mathematical skills (Hunter & McCurry, 2013). There are a number of software such as graphics calculators, computer algebra systems, and dynamic geometry available which makes it easy for students in calculating, making accurate diagrams, and drawing graphs. It provides chances for affirmative changes to teaching and learning (Pierce & Stacey, 2010).

Concept of Effective Mathematical Pedagogy:

Mathematics teaching as a pedagogical approach became effective when it engages the learners in achieving the desired learning outcomes, those outcomes are divided into five components namely conceptual understanding (comprehension of mathematical concepts, operation, and relation), procedural understanding(skills in carrying out procedures flexibly, accurately, efficiently, and appropriately), strategic competence (ability to formulate, represent, and solve mathematical problems), adaptive disposition(capacity for logical thought, reflection, explanation, and justification) and productive disposition (habitual inclination to seeing mathematics as sensible and worthwhile, coupled with a belief in diligence and one's own efficacy). ((Anthony et al., 2009 & Kilpatrick, et al., 2001).

Anthony and Walshaw (2007) recommended 10 components and NCTM (2007) suggested some principles of pedagogical practices mentioned below in table1.

Table 1

Components of Effective Mathematics Pedagogy

Anthony and Walshaw (2007)	NCTM (2007)
An ethic of care To create a classroom which promote the needs of individual students. Arranging for learning. Building on students thinking. Worthwhile mathematical tasks.	Choosing good problems which will help the students- In exploring important mathematical concepts. Providing opportunities to students in extending their knowledge.
Assessment for learning.	Assessment.
Mathematical communication.	Assessing students' understanding by: - listening to discussions - asking students to justify their responses • Creating a variety of opportunities such as - group work and - class discussions for students to communicate mathematically.

Mathematical language.	Model appropriate mathematical language and strategies for solving a challenging mathematical problem.
Tools and representations Teachers' knowledge and learning.	Use multiple representations to foster a variety of mathematical perspectives.

With the above-mentioned principles, the teacher also needs the knowledge of technology, pedagogy, and mathematics content (TPCK) to be creative in using technology in the classroom (Mishra & Koehler, 2006).

Aim

The purpose of this review of the literature was to study the different effective pedagogical practices for teaching Mathematics, examine the role of technology in teaching mathematics, and identify the opportunities and challenges faced by teachers in the implementation of practices by the pre-service teachers.

Method

The literature was searched from Google Scholar and Education Resource Information Centre (ERIC) databases. For keeping the required literature, some key terms namely- mathematics, pedagogical practices, technology, flipped classroom, GeoGebra, challenges in teaching, etc. were used for searching the articles. The range of years for searching the literature was in English from 2003-2022. The inclusion of articles covers four phases- initially, the review was done then after the initial review, from appendixes some related references were obtained additionally. Both qualitative and quantitative research-based articles were taken which focused on the pedagogical perspectives, use of technology, the role of the flipped classroom, use of GeoGebra in the teaching of mathematics, and problems of teaching and learning mathematics within the time period 2003-2022. The exclusion of articles from the review consisted of those not published prior to 2003, those not published in English, and the comparison studies.

Results

From the review of 66 articles, 15 articles are related to flipped classrooms, 31 articles are related to the use of technology and GeoGebra and 20 articles are related to innovative approaches to teaching mathematics.

from the review, two major themes arose: flipped classroom as an innovative way to teach mathematics, and technology and GeoGebra helps in transforming the mathematics classroom, challenges, and opportunities in the implementation of new pedagogical approaches.

Flipped classroom: Approach to teaching mathematics.

The first theme found from the review was flipped classroom: A pedagogical approach to teaching mathematics. The flipped classroom has been defined by many researchers, out of them Bishop and Verleger (2013) defined that flipped classroom as composed of two parts, namely, the group interaction inside the classroom and the use of computers in learning outside the classroom which includes videos and lectures. Moreover, a wide-ranging definition of the flipped classroom has been given by Flipped

Learning Network (FLN), "it is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter". (FLN 2014).

Now a day, students are very curious to learn through the internet by which they can acquire information very quickly as compared to earlier students a few decades ago. (Cevikbas and Argun 2017). Most of the student's desire to get information digitally and want to construct their own knowledge by enjoying it within themselves. (Engelbrecht et al. 2020). Flipped classrooms offer a better learning environment to students by changing the traditional approaches with the integration of technology. It helps in developing the quality of activities and developing learning opportunities for students in mathematics. (Chen and Wen 2019). It inspires the students in improving their thinking abilities, helps in collaborative learning to achieve goals, and motivates students to think about mathematical problems before taking part in the classroom. (Mazur et al. 2015; Voigt et al. 2020). For doing hands-on activities and, applying to inquire based and problem-solving activities, teachers get extra time in flipped classrooms. (Schmidt and Ralph 2016). The benefit of flipped classes in teaching mathematics is to encourage the students to engage in activities of mathematics from cognitive, emotional, and, behavioral perspectives. (Cevikbas and Argün 2017).

Challenges to teaching mathematics in flipped classrooms:

Though there are a number of benefits of adopting flipped classrooms as innovative pedagogical practice for teaching mathematics, still there are some challenges faced by teachers are conveyed in this study. The prime difficulty is the paradigm shift which refers to the changes in the pedagogical paradigm of teaching and learning mathematics. (Cevikbas and Argün 2017; Lo and Hew 2017). Here, students may skip the outside classroom learning that is given by the teacher and come back to the classroom without watching or listening to the videos given by teachers. Another problem is mastery over the content. Teachers should have well-prepared notes, lecture videos, teaching materials, and slides for flipped teaching. (Chen 2016; Lo and Hew 2017).

It is very difficult always to find out the appropriate video or lecture for a specific concept, for this reason, teachers have to prepare their own lecture videos, which will take more time. (Cevikbas & Kaiser, 2020). Another biggest problem is the accessibility of the internet if the teacher is not that technology-friendly and if technical problems will be there then the flipped classroom practices do not work well. Teachers should have competencies in the use of technology. (Trigueros et al. 2020).

Technology helps in renovating the mathematics classroom

Under the second theme technology, GeoGebra, and mathematics software were discussed in the reviews. The literature on mathematics education (e.g., Calder et al., 2006; Jupri et al., 2015) and curriculum documents (e.g., Ministry of Education, Science and Sports, [MOESS], 2007)

steadily highlight that to incite the student's thinking process, to generalize and to exploring the concepts of mathematics, there is a necessity to use the technology. The role of ICT has become an indispensable tool that helps in making a better teaching-learning process. (Kirschner, 2001; García-Valcárcel Muñoz-Repiso, & Tejedor, 2006). NCTM (2003) stated that "technology is an important tool for mathematics in the 21st century, and all schools must ensure that all their students have access to technology".

For teaching and learning mathematics, GeoGebra is dynamic mathematics from the middle school through college level (see Hohenwarter & Preiner, 2007). It is an open software that boosts teachers' knowledge and skills in integrating technology in teaching mathematics and helps in developing students' higher-order thinking. (Wakwinji, 2011; Mainali & Key, 2012). GeoGebra helps in teaching some mathematical concepts namely algebra, calculus, statistics, vectors, and geometry. (Benning, 2021). GeoGebra has grown its popularity due to its user-friendly, easy-to-access, and cost-effective nature. (Hohenwarter et al., 2009).

The efficacy of GeoGebra in the professional development of teachers is proved by many studies (Andresen & Misfeldt, 2010; Hudson, 2012; Prodromou et al., 2015). It enhances the skills and knowledge of teachers in integrating technology with teaching mathematics (Andresen and Misfeldt, 2010). Studies found that GeoGebra helps in understanding the different patterns in mathematics and helps teachers in developing their in-depth understanding of the use of technology in teaching (Bulut and Bulut 2011).

Challenges in using technology in teaching mathematics

The use of technology in teaching has both positive and negative sides, it becomes a challenge for teachers and students (Artigue, 2002; Davies, 2011). Teachers' professional competence in using technology is the primary necessity. Ertmer, Addison, Lane, Ross, and Woods (1999) divided the barriers into two categories namely external and internal barriers in external barriers included the availability of computers, level of administrative support, internet facilities, etc., and internal barriers included the attitude and beliefs of teachers. Wachira & Keengwe, 2011 found that teachers' lacked access to mathematics-specific software due to the high cost of site licenses. "While most classrooms in the United States have technology available, alleviating the severity of external barriers, many internal barriers remain". (Ertmer, 2005; Bauer & Kenton, 2005; Afshari et al., 2009; Kaleli-Yilmaz, 2015; Washira & Keengwe, 2011). From the studies (Becker, 2000; Gray et al., 2010; Means, 2008), it has been found that as compared to elementary teachers, secondary teachers are less willing to have their students use technology and the use of technology in secondary school is lesser in mathematics than in language and social science classes. If we talk about the use of GeoGebra, Agyei et al., (2015) stated that there is a lack of awareness among teachers about the use of GeoGebra as a tool in teaching mathematics, where other barriers are- time-consuming, lack of computer literacy skills, irregular internet accessibility, frequent power cut, difficulty

in using the GeoGebra to teach topics in mathematics.

Conclusion

There is a need for innovative pedagogies to teach mathematics, by developing an integrative teaching platform that contains the use of technology, it is expected that students will improve math performance with better retention, enhanced student satisfaction, and increased confidence because the pedagogy will match their preference for active engagement with interactive technology.

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