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Teaching Aids in Mathematical Problem Solving: A Systematic Literature Review

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Abstract

Teaching aids (TA) has been widely recognized as an effective tool in improving instructional quality and facilitating students' achievements. The purpose of this systematic literature review (SLR) aims to focus on the use of TA in enhancing students' achievements in Mathematics, .Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework proposed by Moher et al. (2015), this review systematically identifies, evaluate and synthesizes relevant studies. A comprehensive search was conducted across academic databases including Scopus and Science Direct. The data were analyzed quantitatively to describe the research's findings and trends. The review identified two primary research themes: (a) the role of TA in mathematical problem solving; and (b) the impact on students' achievement in Mathematics. The findings indicate that the use of TA in Mathematics education in Malaysia is currently at a moderate level and is ineffective at fostering students' achievement in Mathematic Education. These insights highlight the need for more interactive and engaging teaching strategies. The results of this study provide valuable implications for educators, students, schools, and policymakers, particularly the

Ministry of Education, in designing and implementing more effective Mathematics learning approaches.

Keywords: Teaching Aids, Mathematical Problem-Solving, Percentage Topic

Introduction

Education 4.0 is an eras where education built in digital and technology including aspect teaching. Education 4.0 in mathematics refers to the intergrations of innovatives technologies in teaching methods towards learning and teaching experience. Students acquire mathematical knowledge as well as problem-solving abilities through educational programs that form the basis of global curricula according to Muhammad Hafizi & Kamarudin (2020) . Students face challenges in mathematical problem-solving despite increased recognition of problem-solving in education as teaching methods accepted over the past decades because students view mathematics as difficult and uninteresting with many different topics (Rani Ravendran & Yusoff Daud, 2019. Research indicates that teaching aids in mathematics education offer potential benefits for understanding mathematical ideas and student involvement which leads to improved problem-solving performance. The diverse collection of educational resources including physical materials and visual elements and tech-based assets makes up teaching aids because these tools enable students to understand challenging mathematical concepts through hands-on experiences. According to Mahlaba, (2020), the discipline of mathematics education conducts a comprehensive investigation into the mathematical problem-solving skills of students in terms of reaction to various teaching aids. Teachers face a challenge when selecting their teaching methods because new instructional methods continue to emerge to meet student needs (Mohamad Fikray et al., 2022). The development of innovative teaching methods in class creates mixed prospects since student responses to such techniques affect learning outcome effectiveness.

Mathematics education benefits from teaching aids because these tools helps for creating learning environments based on student participation (Pokhrel & Sharma, 2024) . Teaching aids adjust their content to fit student-specific needs because students answer questions in different ways (Frezza et al., 2023) . Teaching aids enable students to physically engage with mathematical concepts which leads to improved conceptual understanding of fundamental concepts and better problem-solving skills for new situations (Rivai et al., 2021). The effectiveness of teaching aids in mathematics education depends on various aspects which encompass both the selection of teaching tools and their integration method as well as the student characteristics. For the National Council of Teachers of Mathematics educational technology accessibility has made a substantial positive impact on mathematics instruction and learning (Foku et al., 2023). Learning technology itself does not automatically lead to better educational results since how this technology is blended with educational content alongside teacher delivery methods directly determines its effectiveness.

Literature Review

The rising tech-acceptance among mathematics teachers and students introduces modern recommended practices to mathematics education (Hagan et al., 2020). Educational organizations must implement technology into their teaching models because they must train students for the twenty-first century through modern technologies since educators

predict learning challenges without technological adoption. Worldwide nations now place the integration of information and communication technology in education at the forefront because this fundamental innovation shapes the preparation of future students for their inherited information society (Hagan et al., 2020).

Students acquire better conceptual knowledge and improve their problem-solving capabilities and become more actively involved in their learning when technology integrates mathematics education. The present-day role of technology in mathematical education consists of providing students with interactive exploration tools that increase their understanding of concepts. Student learning of complicated mathematical ideas becomes more accessible through Geogebra software due to its ability to demonstrate mathematical structures as visible and touchable elements (Seidu & Senior, 2020). Technology helps students face complex challenges and enables them to build work-related experience that sharpens their problem-solving abilities before entering the workforce.

Students can actively explore concepts through the use of technology in mathematics education, which enhances their comprehension and helps them build their problem-solving skills. To ensure that all students can benefit from tech-enhanced learning resources, however, the promising benefits of technology in mathematics education must be exceeded by addressing problems like the technological gap, inadequate teacher preparation, and equitable access (Ariani & Marleni, 2023). Technology may negatively impact learning processes, especially in early math classrooms where students require hands-on experiences. The degree to which technological tools and resources improve mathematics teaching methods depends on numerical fluency. According to Mukhtar & Rosli (2022) student learning experiences gained through experience will endure for an extended period. Effective technology deployment requires dedicated teachers who correctly integrate it to enhance education quality for every student (Hamzah & Hidayat, 2022).

Objectives

This systematic literature review study was conducted to answer several research objectives as follows:

1. To identify the role of Teaching Aids in mathematical problem solving.
2. To identify the impact of Teaching Aids on students' achievement in Mathematics.

Methodology

For this study, a comprehensive review of prior research on teaching aids in mathematics education was carried out. Scopus and Science Direct was one of the connected databases that was systematically ran from September 2019 to December 2024. Khan (2003) principles, which have been useful for researchers to critically assess, evaluate, and synthesize complicated ideas, were used in this literature study to construct an organized and systematic review. The phases involved in carrying out a systematic literature review are depicted in Figure 1.

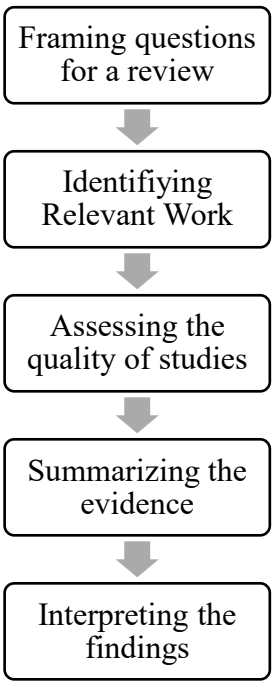

Figure 1 Phase in Systhematics Review

Phase 1: Framing Questions for A Review

The development of the review questions for this study involved looking for relevant topics and issues pointed out by earlier research. To identify prior systematic reviews about the roles of teaching aids, especially in mathematics education, and their effect on students, the researcher began searched any relevant literature. As the results, this study was pointed out two themes which are:

1. The roles of Teaching Aids in Mathematics Problem Solving.
2. The impact of Teaching Aids on students' achievement in Mathematics.

Phase 2 : Identifying Relevant Work

Identifying relevant studies during the preliminary search and evaluating their acceptability using inclusion and exclusion criteria were the primary procedures in this phase. Dissertations, conference proceedings, and book chapters were excluded as "grey literature" to maintain inclusivity, which may have limits in terms of publishing bias (Bernard, Borokhovski, & Tamim, 2014). The search for this study was restricted to peer-reviewed and full-text publications. "Teaching aids in mathematics education," "Student achievements in mathematics education," "Effect of teaching aids in mathematics problem solving," and "Using teaching aids in the mathematics problem solving" were among the keywords used in the researcher's initial search, which was carried out over a month using Scopus and ScienceDirect. In the initial search, the title and the abstract were the two primary elements that the researcher took into consideration.

Phase 3 : Assessing The Quality of Studies

A study selection technique was used to find relevant research to be included in order to ensure the quality of this review. Relevant primary research studies were identified using inclusion and exclusion criteria, and those which fulfilled these requirements were given

priority for inclusion in this research. As a result, the chosen studies had to fulfill the following requirements for inclusion.

1. Publish studies from 2019-2024.
2. Used research methodologies.
3. Studies that evaluated Teaching Aids in Mathematical Problem Solving.

In addition, exclusion criteria were used to identifying articles that were not relevant and should not be included in this study. The following exclusion criteria were applied:

1. The articles were not published from 2019-2024.
2. The studies did not used methodologies.
3. The articles did not evaluate Teaching Aids in Mathematical Problem Solving.

The review questions form the basis for the three (3) inclusion and exclusion criteria used in this study. These criteria were seen to be important since they established the validity and scope of the findings of the systematic review. These criteria were applied throughout the selection process, from the first evaluation to the final phase of identifying the studies.

Phase 4 : Summarizing The Evidence

Scopus and ScienceDirect were used as the literature databases in this review to find pertinent studies. Several key terms, including “mathematics problem solving,” “mathematics education,” and “teaching tools” were used by the researcher during their research. Through these databases, a total of 1684 studies published between 2019-2024 were retrieved, with 1000 from Scopus and 684 from ScienceDirect. After excluding non-English texts and non journal sources, 1232 results remained. Subsequently, 902 results were removed due to incomplete access to full-text. Finally, researchers identified 7 publications, and the entire content of these articles was thoroughly assessed. The search process is visually depicted in the PRISMA flowchart shown in Figure 2.

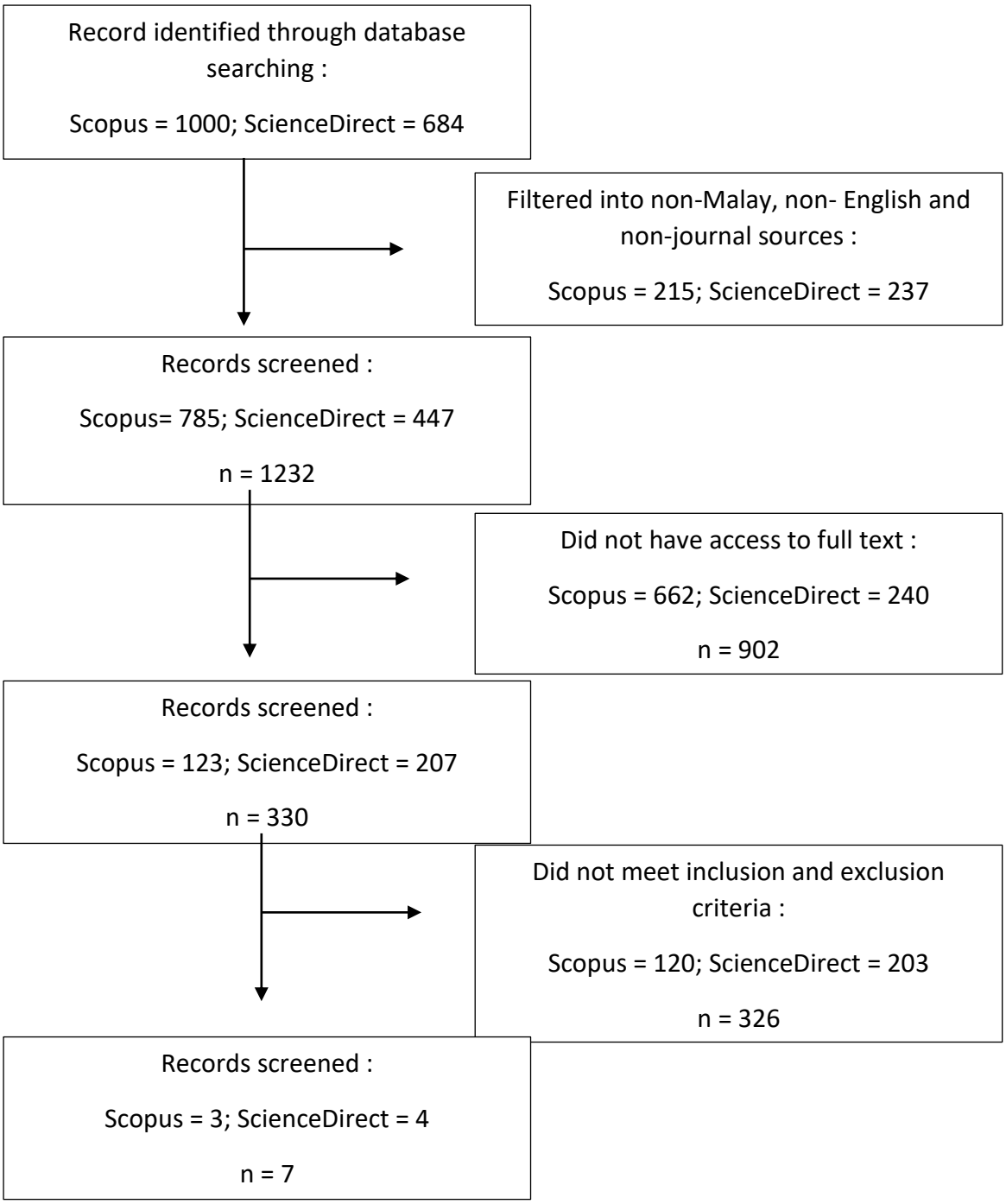

Figure 2 Prisma Flowchart

Phase 5 : Interpreting The Findings

The reserachers utilized content analysis as a method to study the outcomes. The researchers sorted previous studies into three categories based on the methodologies; quantitative, qualitative and mixed methods to identify patterns. The researchers conducted an assessment of studies published between 2019 until 2024, which focus on the roles of teaching aids in problem solving for mathematics education and the impact on students achievements. Initially, 330 were identified, but only 7 studies met the inclusion and exclusion criteria towards

Table 2
Number of study based on methods

Methods	Number of studies
Quantitative	4
Qualitative	3
Mixed Methods	1

Result

There are 7 articles that have been selected and reviewed two themes after implementing the review process using PRISMA (2020) protocol. The two themes are : (1) The Role of Teaching Aids in Mathematics and (2) The Impact of Students' Achievements in Mathematics. Table 3 is the summary of the reviewed studies.

Table 3
Summary of reviewed Studies

No	Authors	The Role of Teaching Aids in Mathematics Problem Solving	The Impact of Students' Achievements in Mathematics
1	Demetriou et al., (2019)	Virtual and Augmented Reality (VR/AR) applications were used as teaching aids to improve interactivity and interest in mathematics problem solving.	The results indicate that the implementation of new technologies in education of virtual and augmented reality improve interactivity and student interest in mathematics education, contributing to more efficient learning and understanding of mathematical concepts when compared to traditional teaching methods.
2	Kaitera & Harmoinen, (2022)	Problem-solving Keys (visual tools) were used to improved students' engagement, understanding and efficiency in mathematics problem solving.	Improved engagement, understanding, and efficiency; Supports concrete understanding of mathematical concepts
3	Kortenkamp et al., (2024)	The Fingu app uses Artifact Centric Activity Theory to analyze learning processes. The Fingu app supports subtising and part whole relations learning.	The app Fingu supports understanding of part-whole relations in children. Learning about part-whole relationships may enhance mathematical achievement. Design principles can impact user experience and learning outcomes
4	Ching & Mohammad Nasri, (2022)	The Quizz application utilized a gamification to improved student achievement levels.	Treatment group scored higher in post-test than control group. Significantly difference in scores indicates effective learning approach.
5	Lestiana & Wanita (2019)	Bar Model were designed for learning activities in problem solving.	The Bar Model helps students systematically solve percentage problems. Bar model support

			students' understanding of percentage.
6	Shah (2022)	Bar model (diagram) on whiteboard were used as teaching ais during lessons.	Bar model Visualization Technique have significant effect on students' achievement in word problem solving skills.
7	Anak Singga & Zakaria (2020)	Bar Model were used as teaching aids for problem solving in fraction.	Students showed a positive increase in problem solving skills post intervention. Mastery of fraction word problems improved significant after using the Bar Model.

Discussion

Multiple teaching aids used in mathematics instruction are fundamental for maximizing student involvement and grasping abilities and academic success. Studies conducted by Demitriadou et al. (2019) demonstrate how VR or AR applications enhance interactivity and interest in mathematics learning. These technology solutions develop full-dip immersion platforms where students better understand mathematical subjects as well as find them more interesting. Problem-solving keys serve as visual tools to help students understand mathematical concepts more clearly and achieve better student performance according to Kaitera and Harmoinen (2022). The research by Kortenkamp et al. (2024) describes how the Fingu app utilizes Artifact Centric Activity Theory to support learning processes through subtising and part-whole relations that students need for understanding mathematical concepts. Research by Ching and Mohammad Nasri (2022) proved that gamification using Quizz application leads to improved student achievement results. The Bar Model serves as a problem-solving tool in mathematics according to Lestiana and Wanita (2019), Shah (2022) and Anak Singga and Zakaria (2020) that enhances students' mathematical understanding and abilities.

Such educational tools produce advanced results in student mathematics achievement levels. Studying with VR or AR applications demonstrates increased learning performance according to Demitriadou et al. (2019) than traditional educational methods. Kaitera and Harmoinen (2022) recorded better student focus combined with improved appreciation and time efficiency from students who utilized problem-solving keys. The Fingu app according to Kortenkamp et al. (2024) helps children develop better part-whole relational skills that might translate into improved math achievement. Research by Ching and Mohammad Nasri (2022) demonstrates how gamification techniques enhanced exam scores because post-test data showed higher results among the treated students. The research conducted by Lestiana and Wanita (2019), Shah (2022) along with Anak Singga and Zakaria (2020) confirm that bar models help students solve problems better and master advanced mathematical concepts with increased effectiveness.

In conclusion, the analyzed research demonstrates that creative teaching resources establish vital functions for mathematics education. A combination of VR/AR applications together with visual tools and digital apps and gamification and the Bar Model helps develop better learning spaces which produce lasting effects. The aids support student engagement while improving student understanding and produce major positive impacts on mathematical achievement

results. These resources allow teachers to deliver enhanced interactive student learning that leads to better educational achievements for students.

Conclusion

The systematic review demonstrates that different educational tools play essential roles and create important effects in teaching mathematics. Virtual and Augmented Reality (VR orAR) applications together with problem-solving keys serve as visual tools while Fingu app along with the Bar Model for problem-solving and Quizz gamification produce more engaging and effective learning environments. The innovative teaching aids drive enhanced student learning while simultaneously boosting their mathematical results. All reviewed research concludes that employing these tools enables interactive efficient learning activities which produce better educational results for students. The implementation of advanced teaching aids by educators results in both enhanced mathematics education quality and better academic accomplishments of students.

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