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Teaching Aids for Remedial Mathematics Instruction: A Systematic Review

Low W. Sheng[1*], Mohd M. Tahar[2], Siti M. Maat[3]

1-3Faculty of Education, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Abstract

Poor numeracy skills among remedial pupils remained a critical issue for Malaysia to achieve educational goals. This systematic literature review identified research trends and evidence-based practices on teaching aids to enhance remedial mathematics instruction. The review followed PRISMA model through four phases, searching WoS and Scopus databases to analyze 29 studies from 2014 to 2023 that met the inclusion criteria. The predominant focus was on Indonesia, Taiwan, Malaysia and the United States. Main ly quantitative and qualitative research designs were utilized. Findings revealed diverse teaching aids were proposed, including digital technologies such as systems, smartphone apps, games, multimedia, augmented reality, virtual reality, as well as manipulatives, number lines and instructional modules. Both digital and hands-on manipulative teaching aids have been applied in remedial mathematics interventions with promising results. Key findings indicate the effectiveness of teaching aids depends on alignment with pupils' individual needs and suitable pedagogical approaches based on local context. Implications emerge for developing new teaching aids and teacher training tailored to local remedial mathematics learners. Rigorous research is needed, particularly in the Malaysian context, to evaluate the usability of teaching aids over time. Investing in specialized teaching aids and aligned instruction will help provide quality remedial mathematics education. This review highlights promising teaching aids and gaps to build essential numeracy skills among remedial pupils in Malaysia for equitable math outcomes.

Keywords: Teaching aids, remedial, mathematics, instruction, systematic literature review.

Introduction

Quality education is essential to enable individuals and nations to build strong foundations of knowledge and skills. Thus, the fourth United Nations Sustainable Development Goal (SDG) prioritizes inclusive and equitable education for all learners to promote lifelong learning opportunities (Department of Statistics Malaysia, 2020). In alignment, Malaysia's Education Blueprint has set the goal of improving access to quality education across all schools (Ministry of Education Malaysia, 2013). A key national target is for 100% of pupils to achieve proficiency in basic literacy and numeracy skills that are fundamental for later academic and career success.

To work towards these aims, the Ministry of Education (MoE) Malaysia has implemented various remedial programs to strengthen pupils' mastery of basic literacy and numeracy, including the Special Remedial Program, 3M Program, Literacy and Numeracy (LINUS), and Primary Literacy and Numeracy (PLaN). Nevertheless, recent assessments indicate many pupils still lack competency in fundamental mathematics skills, especially in mastering the four basic mathematical operations. As per the Malaysia SDG indicator report (Department of Statistics Malaysia, 2020), 16.9% of pupils at the primary level had not achieved the minimum requirement for mathematics. This aligns with the Primary School Assessment Report in 2019 where 16.87% of pupils failed in mathematics subject (Ministry of Education Malaysia, 2019). Besides, MoE Malaysia also reported a significant increase in pupils yet to acquire basic numeracy skills after the COVID-19 pandemic (Ministry of Education Malaysia, 2021). These concerning statistics reveal the issue of pupils not mastering basic numeracy skills has reached a critical level and is crucial to be solved immediately.

One key to achieve SDG 4 and Malaysia's Education Blueprint is to close numeracy gaps among disadvantaged learners. To address this issue, innovative and evidence-based teaching aids tailored to remedial pupils' needs could be beneficial. Integrating suitable teaching aids and materials

Corresponding Author e-mail: P107234@siswa.ukm.edu.my
https://orcid.org//0000-0002-4503-9414

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into remedial mathematics instruction may provide engaging support to build mathematics skills effectively (Azhari & Safrina, 2022; Purwaningrum, Muzid, Siswono, Masriyah, & Kurniadi, 2023). To meet different remedial pupils' needs, MoE Malaysia should develop and implement a variety of effective and evidence-based mathematics teaching aids aligned with 21st-century learning. Teaching aids refer to concrete, audio, visual or visual-audio pedagogical materials used in instructional design to engage pupils actively in learning mathematics (Kapur, 2018). These teaching aids aim to improve pupils' understanding of mathematics concepts and build connections between abstract ideas and mathematics procedures (Wong & Kamisah, 2018). Integrating effective and evidence-based teaching aids into mathematics instruction can be an effective approach for Malaysia to continue working towards the SDG education targets and preparing all pupils for success in mathematics.

Nevertheless, a recent report from The Organization for Economic Cooperation and Development (OECD) indicates Malaysia is facing inadequate mathematics teaching aids problems compared to other developed nations (OECD, 2019). Although MoE Malaysia has implemented various remedial programs as mentioned above, there are limited new mathematics teaching aids proposed to enhance the instruction quality. The same teaching aids are suggested across the years such as block dienes, counters, place value charts and others. Besides, local mathematics textbooks also offer limited new remedial teaching aids, particularly leveraging 21st century digital technologies (Chew, Goh, Lim, Tan, & Leow, 2018). Ahamad and Abdul Mutalib (2015) also confirm the statement above by affirming the teaching aids provided by MoE result in pupils feeling bored and less interested in mathematics.

Addressing this issue to equip teachers and pupils with sufficient and up-to-date teaching aids aligns with Malaysia's education development goals. It also moves towards meeting the United Nation's Sustainable Development Goal of quality education for all learners. Investing more resources into the provision of evidence-based teaching aids, particularly for remedial pupils, can better support teachers in delivering engaging mathematical instruction. Closing the teaching aid gap between Malaysia and other OECD nations should be a priority. With proper resources, Malaysia's teachers can unleash the full potential of their remedial pupils. Thus, this review paper aims to identify research trends and evidence-based practices for teaching aids that enhance remedial mathematics instruction, informing recommendations for Malaysia's context. Recommendations for instruction and gaps in the literature are discussed by answering the following research questions:

i/ What are the research trends in recent studies on teaching aids for remedial mathematics instruction based on publication year, country and research design?

ii. What types of teaching aids have been proposed for remedial mathematics instruction in recent studies?

Methodology

A systematic literature review (SLR) method is utilized in this study to rigorously gather, evaluate, and synthesize studies on teaching aids for remedial mathematics. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model was followed as a guide in this review paper. The PRISMA model emphasizes detailing all stages of the review methodology such as search strategy, study selection, data collection process, and risk of bias assessment (Mohamed Shaffril, Samsuddin, & Abu Samah, 2021). Additionally, it facilitates reporting that enables readers to evaluate the appropriateness of the methods and reliability of the findings (Page, McKenzie, Bossuyt, Boutron, Hoffmann, Mulrow et al., 2021). The PRISMA model has the advantages of defining clear research questions to allow systematic research, stipulating inclusion and exclusion criteria, and investigating large scientific literature databases efficiently (Sierra-Correa & Kintz, 2015).

The PRISMA model encompasses four phases that steer the systematic review process, namely Identification, Screening, Eligibility and Inclusion. These four phases are depicted in a PRISMA flow diagram. It assists researchers in methodically identifying and synthesizing relevant research to produce a rigorous systematic literature review. Besides, this model also enables a transparent, replicable systematic search and review (Mohamed Shaffril et al., 2021). Figure 1 shows the PRISMA flow diagram in this study.

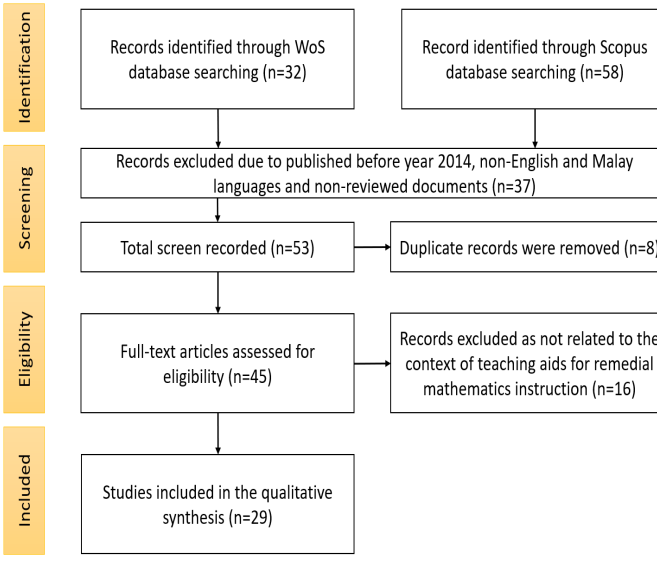

Fig. 1: PRISMA Flow Diagram.

Identification

The initial phase is identification. Basic keywords can be derived from the research questions (Kitchenham & Charters, 2007). In alignment, the present study identified three primary keywords for searching relevant articles, namely "teaching aids", "remedial" and "mathematics". As Mohamed Shaffril et al. (2021) suggest, online thesaurus tools can be leveraged to pinpoint synonyms, related terms and variations to locate more pertinent articles. For instance, alternate terms for teaching aids include teaching tools, teaching materials, instructional tools, and other related synonyms.

After identifying relevant keywords, two scholarly databases were selected to search for applicable articles: Web of Science (WoS) and Scopus. These databases complement each other in terms of impact, prestige, and scope (Joshi, 2016). WoS comprises over 74.8 million academic records, whilst Scopus indexes more than 23,452 active journal titles (Singh, Singh, Karmakar, Leta, & Mayr, 2021). Besides, these two databases also provide powerful search functionalities that enable an effective exploration of relevant articles by using advanced search strings. Thus, drawing from these two high-quality databases was deemed sufficient.

This SLR employed an advanced search strategy to enable extensive search queries. The final search strings combined keywords with Boolean operators. Table 1 presents the search string formulated for WoS and Scopus. The specified databases yielded 90 possible articles (WoS, N = 32, Scopus, N = 58) (Table 1).

Screening

The second phase is screening. This phase involves including and excluding articles based on predefined criteria to identify the relevant articles that are applicable for answering the research questions (Patino & Ferreira, 2018). This study set three inclusion criteria aligned with its aims, namely timeline publication, publication language and document type (Mohamed Shaffril et al., 2021).

The first criterion is timeline publication. This study includes articles published between 2014 to 2023. A ten-year range was selected to illustrate trends in teaching aids used for remedial mathematics. Articles before the year 2014 were excluded as they would skew results away from 21st-century teaching aid developments. The ten-year timeframe is validated by Kraus, Breier and Dasí-Rodríguez (2020), where less matured studies need longer timeline publications. Limited relevant articles will result in a lot of research questions remain unanswered. This ten-year scope enabled focusing on the current trend while yielding a substantial pool of research.

The second criterion is publication language. This study includes articles that are published in English and Malay language only, as these languages can be proficiently comprehended by the researchers. According to Linares-Espinós, Hernández, Domínguez-Escrig, Fernández-Pello, Hevia, Mayor et al. (2018), selecting articles from languages that cannot be understood will create confusion. Sources in other languages were excluded given the costs, confusion, and delays inherent in translation.

The third criterion is document type. This study includes articles that are published in the form of peer-reviewed journals, proceeding papers and book chapters only. As these documents undergo expert review before publication, they represent reliable sources from which to synthesize a quality conclusion for this study. According to Johnson and Hannessy (2019), low-quality works of literature will result in making a wrong conclusion. Conversely, grey literature such as reports, newsletters, working papers and speeches were excluded as lower-quality evidence. Besides, review articles were also excluded as this paper aims to make a new review of teaching aids for remedial mathematics instruction settings.

After applying these criteria, 37 articles were excluded for failing to fulfil the three requirements set in this phase. In total, 53 relevant articles remained (WoS, N

Table 1: Search Strings for Systematic Identification of Articles.

Database	*Search String*
WoS	TS=((“teaching aids” OR “teaching aid” OR “teaching tools” OR “teaching tool” OR “teaching material” OR “teaching materials” OR “teaching resources” OR “teaching resource” OR “instructional tools” OR “instructional tool” OR “learning tools” OR “learning material” OR “pedagogical material” OR “study aid” OR “study tools” OR “study tool”) AND (“remedial” OR “rehabilitation” OR “learning disability” OR “special needs” OR “dyscalculia”) AND (“mathematics” OR “mathematic” OR “math” OR “arithmetic” OR “calculation” OR “numeracy”))
Scopus	TITLE-ABS-KEY ((“teaching aids” OR “teaching aid” OR “teaching tools” OR “teaching tool” OR “teaching material” OR “teaching materials” OR “teaching resources” OR “teaching resource” OR “instructional tools” OR “instructional tool” OR “learning tools” OR “learning material” OR “pedagogical material” OR “study aid” OR “study tools” OR “study tool”) AND (“remedial” OR “rehabilitation” OR “learning disability” OR “special needs” OR “dyscalculia”) AND (“mathematics” OR “mathematic” OR “math” OR “arithmetic” OR “calculation” OR “numeracy”))

= 21, Scopus, N = 32). Besides, 8 duplicate papers were also removed, leaving 45 articles to be assessed in the next phase.

Eligibility

The third phase is eligibility. This phase involved manual screening, as the preceding identification and screening phases relied upon computer assistance. According to Liberati, Altman, Tetzlaf, Mulrow, Gøtzsche, Ioannidis et al. (2009), the automated screening process has a risk of including papers unrelated to the study context. Thus, researchers manually reviewed each article's full text to evaluate alignment with the focus on teaching aids for remedial mathematics instruction. Scrutinizing titles, abstracts, methods and findings sections enabled the exclusion of irrelevant articles in this phase.

After researchers reviewed the 45 papers, 29 relevant papers were confirmed and accepted for in-depth review and synthesis in this study. Researchers eliminated 16 papers due to incompatible topics and outside the scope of teaching aids for remedial mathematic instruction. These 16 papers were unsuitable for informing evidence-based recommendations to support remedial mathematics education.

Inclusion

The last phase is inclusion. This phase encompassed 29 papers that met the inclusion criteria of systematics analysis, presented in Appendix 1. These studies directly relate to teaching aids utilized or developed specifically for remedial mathematics instruction.

A spreadsheet organized key data extracted from the final set of articles, including author(s), year, country, research design, and type of teaching aids were investigated. The teaching aids were coded into eight categories, namely system, app, game, multimedia, augmented/virtual reality, manipulative, number line and module. The results summarize the publication trends of teaching aids for remedial mathematics instruction.

Findings

This section reports the findings corresponding to the two guiding research questions. It starts with the findings of publication trends by year, country and research design, followed by the main findings on types of teaching aids for remedial mathematics instruction.

Publication Trends by Year

Figure 2 illustrates the distribution of articles by year of publication. The findings revealed that the interest in this research area of teaching aids for remedial mathematics is observed to persist over time. While 2023 is still in progress, the peak year for publication was 2018 with seven articles,

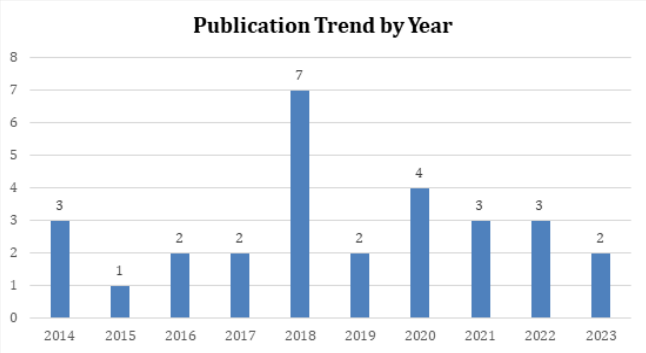

Fig. 2: Publication Trend by Year

followed by 2020 with 4, and 2014, 2021 and 2022 with three articles each. The rest of the years had two articles each, except 2015 had single paper. This growing focus on teaching aids for remedial math comes amidst concerns over persistent numeracy gaps (Figure 2).

Publication Trends by Country

Figure 3 maps the distribution across the ten represented countries. Geographically, the findings revealed that Indonesia, Taiwan, Malaysia and the United States had the highest output, with five articles each, followed by Spain (N=4). Single papers emerged from Austria, Norway, Jordan, Poland and Switzerland.

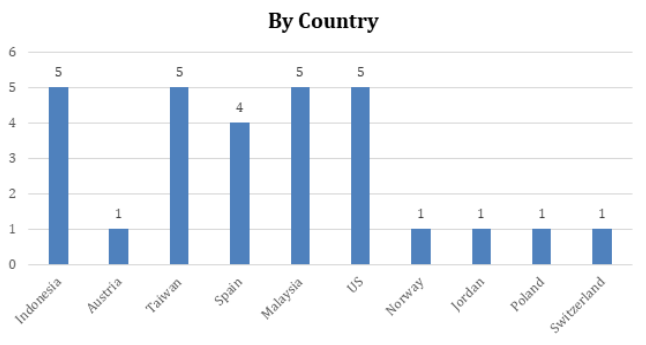

Fig. 3. Publication Trend by Country

Publication Trends by Research Design

Figure 4 illustrates the distribution by research design. Methodologically, the findings revealed that most studies employed a quantitative research design to evaluate the effectiveness of proposed teaching aids, with 13 out of 29 articles (44.8%). Next, 12 articles (41.4%) utilised a qualitative design to develop and explore the teaching aids usage for remedial mathematics instruction. Only 4 studies (13.8%) employed mixed methods research design to provide in-depth and evaluative insights about teaching aids for remedial mathematics instructions.

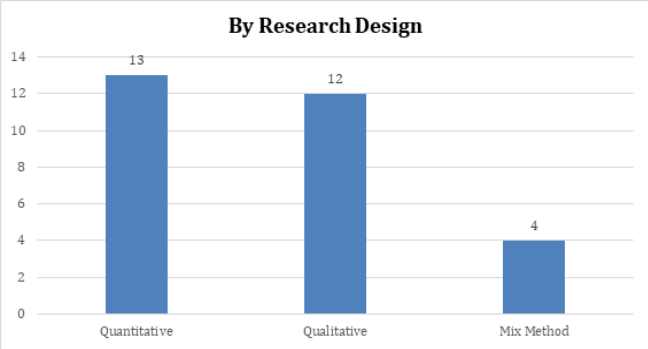

Fig. 4: Publication Trend by Research Design

Main Findings - Types of Teaching Aids for Remedial Mathematics

Figure 5 displays the distribution by type of teaching aids proposed for remedial mathematics instruction. Across the literature review process, this study identified eight types of teaching aids proposed for remedial mathematic instruction, namely system, app, game, multimedia, Augmented Reality/ Virtual Reality (AR/VR), manipulative, number line and module.

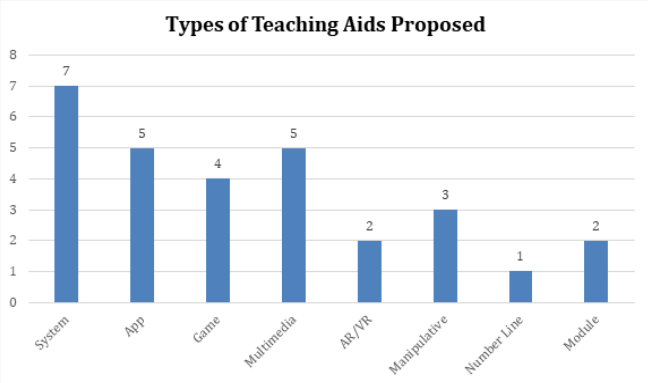

Fig. 5: Publication Trend by Types of Teaching Aids Proposed for Remedial Mathematics Instruction.

Seven articles proposed specialized systems to deliver tailored teaching materials and remedial instruction to pupils (Azhari, Yacoeb, & Irfan, 2020; Chi, Chen, & Tsai, 2014; Hsiao, Lin, Chen, & Peng, 2018; Che Abdul Rani, Rohizan, & Abd Rahman, 2014; Wang, 2014; Wen, Silverstein, Zhao, Amog, Garnett, & Azenkot, 2021; Wen, Zhao, Silverstein, & Azenkot, 2020). These systems integrated learning principles such as mastery learning and differentiated instructions to support remedial pupils' learning process effectively. Based on these principles, the systems could break mathematical concepts into incremental steps, able to assess individuals' mathematics performance, recommend suitable learning materials based on individual assessment, and provide repetitive practice to help pupils master mathematics efficiently. Different remedial pupils faced different learning problems, thus there was no one size fit all teaching aids available. The main reason these systems were successful because they could assess remedial pupils individually and proposed tailored activities and learning materials that could meet different pupils' needs. Besides, one research also proposed a system that addressed emotional aspects through adequate "brain breaks" to reduce math anxiety among pupils. This is because one of the factors remedial pupils cannot master numeracy skills well is due to math anxiety (Ramirez, Gunderson, Levine, & Beilock, 2013).

Five articles focused on mathematical smartphone applications, which represent another prevalent teaching aid in remedial mathematics learning (Chang & Yang, 2016; Mazeyanti, Fiqa Azureen, & Norshakirah, 2017; Mazeyanti, Fiqa Azureen, & Savita, 2018; Kaur, 2017; Lovskar, Home, & Linares-Pellicer, 2015). These mathematical smartphone applications were designed and developed carefully by experts in both education and computer science. These apps could be used to promote playful and engaging math practice for pupils to improve mathematics performance at their level of understanding. These apps integrated suitable learning principles, working memory, game design and instructional design to cater different needs of remedial pupils. The app's contents were tailored to provide remedial pupils with positive and engaging learning experiences, tapping into the benefits of enhancing working memory and motivation. Besides, high-quality smartphone applications can also attract pupils' interest in learning mathematics and improve their mathematical performance effectively. However, findings revealed there were limited customizable and free mathematical apps to be downloaded in the market. Additionally, inappropriate instructions with smartphone games will result in negative feedback on pupils' learning process. Thus, teachers must plan their instructions carefully and provide explicit instructions when incorporating such apps into their teaching methods.

Four articles examined interactive digital math games (Avdiu, Bekteshi, & Xhaferi, 2022; Chu, Chen, Kuo, & Yang, 2021; Mustafa, Mustafa, Zriqat, & Althebyan, 2023; Pinto, Elias, Barbot, Pinto, Mascarenhas, & Santos, 2016). These articles' findings found that digital math games could increase pupils' engagement and autonomy in their learning process by enabling interactive concept practice. This concept-effect relationship could enhance pupils' positive behaviours and improve their mathematical performance. Although the play-based learning approach appears effective, cited barriers included gaining teacher cooperation and lack of games tailored to special needs and remedial pupils. Existing e-learning materials such as online math games were not specifically designed to meet these pupils' population learning

characteristics. This resulted in different difficulties for pupils to learn mathematics effectively. Thus, researchers need to design and develop a user-friendly and free downloadable digital math game which can meet diverse remedial pupils' learning characteristics.

Five articles proposed multimedia teaching aids such as audiobooks and instructional videos to support pupils' mathematics learning (Daniela & Jurimae, 2018; De Hierro & Roldan, 2018; Kaczorowski, Hashey, & Di Cesare, 2019; Maćkowski, Brzoza, Żabka, & Spinczyk, 2018; Sugiman, Suyitno, & Pujiastuti, 2021). Multimedia teaching aids were beneficial in promoting better mathematical understanding and provided self-paced learning while increasing interest and participation from special needs and remedial pupils. Audiobooks were developed specially for blind pupils. These books could explain abstract mathematical concepts through audio and tactile without teachers' or parents' physical guidance. In addition, instructional videos allowed self-paced reviews to increase pupils' comprehension towards a certain mathematics course. Pupils could play particular videos repeatedly to increase their acceptance rate towards the course. This can be differed by the users understanding. Thus, multimedia teaching aids were effective in supporting pupils' self-directed learning especially at home or without parents' and teachers' guidance.

Two studies integrated Augmented Reality (AR) and Virtual Reality (VR) into remedial mathematics interventions (Ibrahim, Seman, Wahab, Osman, Ilyas, & Saini, 2022; Keller, Hebeisen, & Brucker-Kley, 2018). These immersive technologies boosted motivation, focus, and performance by enabling immersive digital experiences between virtual and real worlds. Pupils were more motivated to study by experiencing a different learning environment compared to traditional classroom settings. Besides, AR and VR technologies could attract pupils' interest to focus on the showed-up virtual learning content. This could support special needs and remedial pupils by avoiding loss of attention in the learning process. Nevertheless, teachers should plan their instructions with AR and VR technologies carefully to make sure the devices could work fluently and able to be played by the pupils.

Three studies also highlighted the ongoing value of hands-on manipulative teaching aids in mathematics learning (Aprinastuti, Anggadewi, Suharno, & Wiyantari, 2020; Tovazzi, Basso, & Saracini, 2020; Metikasari, Mardiyana & Triyanto, 2019). Manipulative teaching aids such as physical models could improve pupils' conceptual understanding, self-directed learning and confidence through hands-on learning. The use of manipulative teaching aids involved a multisensory math learning approach which helped pupils to understand mathematical concepts concretely. These active and concrete learning experiences improved pupils' mathematical performance effectively. Though not digital, manipulative teaching aids were still able to foster conceptual understanding and procedural fluency, which were essential in mathematical study. Nevertheless, researchers need more evidence on the use of manipulative teaching aids with remedial pupils.

The number line was tested in one article to support struggling mathematics learners (Weng & Bouck, 2019). It is a powerful visualization tool which is widely used in mathematical learning worldwide until today. The findings showed dotted number lines offered clearer support than abstract symbols of numbers for special needs pupils. Pupils could understand multiple mathematics concepts more effectively by counting the dots provided. Besides, it also helped pupils to understand the quantity of a number visually. However, complementary teaching materials and strategies were necessary to support effective learning. Number lines and explicit instruction approaches represent promising strategies, but require further research on their efficacy for remedial pupils.

Finally, two recent studies developed specialized mathematical modules to support pupils with varying learning abilities (Azhari & Safrina, 2022; Purwaningrum et al., 2023). For effective mathematics education, it was essential to provide teaching materials that were tailored to meet local cultural elements and individual needs, ensuring optimal learning outcomes. The validation process of the module involved experts in mathematics learning content, linguistics, and media. The findings also found that the development of modules and learning tools needed to be structured using a model or framework. Module and learning tools that were developed under a structured model and validated by experts had the potential to perform positively before implementation in school. Nevertheless, potential limitations include cultural inclusivity and a lack of exploration of long-term impacts.

In summary, the systematic review revealed a wide array of teaching aids proposed for remedial mathematics instruction, encompassing various forms of digital technologies, concrete manipulatives, visual tools, and mathematics modules. The evidence indicates teaching aids could be potent catalysts for enhancing remedial math outcomes, but only with deliberate selection and implementation tailored to local learners' needs. Furthermore, the use of these teaching aids must be harmonized with appropriate instructional approaches to unlock their full potential. Nevertheless, the existing evidence presents variations in terms of their effectiveness, mechanisms, and implementation among the remedial pupil population. In conclusion, selecting and applying appropriate

teaching aids require alignment with pupils' needs and the adoption of suitable instructional approaches.

Discussion

This systematic review reveals several key insights into utilizing evidence-based mathematics teaching aids to support remedial math learners. Findings show diverse teaching aids can be developed, namely systems, smartphone applications, mathematics interactive games, multimedia, AR, VR, manipulatives, number lines and modules. These teaching aids can positively improve remedial pupils' engagement, skills, motivation, and performance when tailored to their needs and aligned instructionally (Mazeyanti et al., 2018;). Thus, teachers play a significant role in choosing and develop suitable teaching aids for their remedial pupils.

This study reveals a majority of articles develop digital technologies as teaching aids. These teaching aids are the game changer in alignment with Industrial Revolution 4.0 and Society 5.0. Different types of technology teaching aids can support pupils' learning process in different ways. They are effective in developing pupils' mathematical skills, motivating pupils through entertainment value, and delivering repetition and reinforcement learning activities regardless of time and place (Avdiu et al., 2022; Azhari et al., 2020; Mazeyanti, et al., 2018). Nevertheless, traditional manipulative teaching aids and number lines retain their value by enabling hands-on understanding and concrete learning experience (Tovazzi et al., 2020; Weng & Bouck, 2019). Different types of teaching aids have different benefits to cater to different pupils' needs. Thus, both digital and hands-on manipulative teaching aids are still vital in remedial math interventions for a promising result. However, more research is needed on their applications to examine the long-term effect which abides to Malaysia remedial education culture.

A critical gap emerges in the field as most existing teaching aids are designed for the general pupil population. There are limited teaching aids tailored to address the specialized needs of special needs and remedial pupil populations available in the market (Kaur, 2017). This misalignment points to the significance of developing customized teaching aids and math content suited to meet the remedial pupils' needs. Furthermore, these teaching aids must be tailored to meet local cultural elements to ensure optimal learning outcomes (Azhari & Safrina, 2022). Malaysia is facing inadequate teaching aids problems compared to the other developed nations (OECD, 2019). Personalized and autonomy-supportive teaching aids can play a vital role in enhancing remedial pupils' self-efficacy and mathematics skills development (Baten, Vansteenkiste, De Muynck, De Poortere, & Desoete, 2019). In addition, the current systematic literature review reveals limited studies focused on the development of mathematics kits. Thus, it is highly recommended to develop a comprehensive mathematics kit that encompasses diverse teaching aids and instructional guides to facilitate well-structured remedial interventions in Malaysia.

Findings reveal different types of teaching aids are used to innovate remedial pupils' learning process, but limited teaching aids innovate the mathematical processes. Further research is warranted on delivering easy-to-understand mathematical concepts and simplifying mathematical procedures to reduce the knowledge gaps between remedial populations with their peers (Shomad, Kusmayadi, & Riyadi, 2018). Besides, remedial pupils face attention difficulties, lack of self-confidence and a negative attitude towards learning (Special Needs Education Department, 2012). Thus, this research must affiliate with an appropriate instruction approach. Explicit instruction with the demonstration of number lines and multimedia teaching aids shows promising results, but efficacy research on the remedial pupils' population is needed (Sugiman et al., 2021; Weng & Bouck, 2019). Further work is also needed on training teachers in selecting appropriate teaching aids, rather than relying solely on standard textbooks, which are insufficient to cater to remedial pupils' diverse needs (Zakelj, 2015).

Another key limitation of the review includes the dominance of non-Malaysian contexts. Thus, this study suggests a future study in Malaysia's remedial mathematics context is needed. Although there are five Malaysian studies in this review, most of them focused on the special needs population. In Malaysia's context, remedial pupils differ from special needs pupils who have their educational system (Chiang, 2018). Besides, the heavy emphasis on technology teaching aids in this review also highlights the need for more balanced blended learning (Daniela & Jurimae, 2018). This is also in alignment with limited technology teaching aids proposed in Malaysian mathematics textbooks (Chew et al., 2018). The development of more user-friendly technology-based teaching aids that are tailored to remedial pupils' needs can leverage Malaysia 21st-century learning culture.

Several implications emerge for practice and policy. Educators working with struggling math learners need targeted professional development on utilizing teaching aids customized to this population (Pinto et al., 2016). Mainstream textbooks and generic digital tools are insufficient to cater to different remedial pupils' needs. Thus, educators must have sufficient skills to choose suitable teaching aids and support with appropriate instructional approaches to deliver effective mathematics instruction in the classroom. In addition, policymakers should support the development and rigorous evaluation of remedial math curricula and teaching aids

tailored to remedial pupils' needs. Funding is also needed at the school and district level for purchasing specialized manipulatives, technologies, and instructional teaching aids to support remedial mathematics teaching and learning processes aligned with 21st-century learning proposed by the MoE.

Future research directions include developing cost-effective math kits equipped with various teaching aids. The development of a cost-effective mathematic kit that is tailored to Malaysia's remedial pupils' context will guide toward high-impact remedies at the initial stage. Besides, future research should investigate product usability alongside performance to ensure long-term usage among the remedial population. Rigorous localized longitudinal studies are needed to evaluate the long-term impacts of developed teaching aids intervention over time. This review has limitations, including the lack of experimental studies on impacts over time. Many teaching aid studies occurred outside Malaysia, reducing direct generalizability. Nonetheless, it provides an impetus for future research on designing and developing teaching aids specifically suited for Malaysia's remedial mathematics instruction context. Investing in the sustained growth of struggling pupils will provide them with the opportunities to gain skills and confidence in mathematics. It is then beneficial to reduce the issue of remedial pupils that have yet to master basic numeracy skills in Malaysia.

Conclusion

In summary, this systematic review provides valuable insights into utilizing appropriate teaching aids to enhance remedial mathematics instruction by analyzing 29 recent studies. Key findings reveal the types of teaching aids applied and their effectiveness depends strongly on targeted pupils' needs and pedagogical approaches. No single teaching aid and solution are universally effective. Thus, it is vital to develop a mathematics learning kit that encompasses various teaching aids to cater to different remedial pupils' needs in the Malaysia context.

This review reveals gaps in research on remedial mathematics teaching aids, curricula, and teacher training. Investing in remedial pupils' growth through tailored teaching aids and aligned instruction will provide meaningful opportunities to gain numeracy skills and confidence in math. Findings also indicate appropriate teaching aids show promising results, but only when they are tailored to meet targeted remedial pupils' needs. Thus, it is vital to address all misalignment issues to ensure these teaching aids can serve as catalysts in achieving Malaysia's educational goals of mathematics competency for all pupils. Continued research and investment in this remedial pupils population are critical to overcome skill gaps and improve mathematics education in Malaysia.

The analysis of research trends and evidence suggests several implications for educators, researchers, and policymakers aiming to improve numeracy outcomes. Targeted teaching aids and interventions can help remedial pupils gain math proficiency, but require customized design, strategic implementation and ongoing progress monitoring. Further research in the Malaysia remedial mathematics instruction context is needed. To conclude, efforts to build essential early numeracy skills will promote more equitable and higher-quality mathematics education for the nation.

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Appendix

Appedix 1. Systematics Analysis of 29 papers that met the inclusion criteria.

		Database				*Type of Teaching Aids*							
No	*Author(s) / Year*	*WoS*	*Scopus*	*Country*	*Design*	*System*	*App*	*Game*	*Multimedia*	*AR/VR*	*Manipulative*	*Number line*	*Module*
1	Azhari & Safrina (2022)	√		Indonesia	QN								√
2	Avdiu et al. (2022)	√		Austria	QL			√					
3	Chu et al. (2021)	√	√	Taiwan	QN			√					
4	Azhari et al. (2020)	√		Indonesia	QL	√							
5	Tovazzi et al. (2020)	√		Spain	QN						√		
6	Metikasari et al. (2019)	√	√	Indonesia	QL						√		
7	Hsiao et al. (2018)	√	√	Taiwan	QN	√							
8	Daniela & Jurimae (2018)	√		Spain	QL				√				
9	De Hierro & Roldan (2018)	√		Spain	QN				√				
10	Mazeyanti et al. (2018)	√		Malaysia	QL		√						
11	Mazeyanti et al. (2017)	√		Malaysia	QN		√						
12	Kaur (2017)	√	√	US	QL		√						
13	Chang & Yang (2016)	√	√	Taiwan	QN		√						
14	Pinto et al. (2016)	√		Spain	QL			√					
15	Lovskar et al. (2015)	√	√	Norway	QL		√						
16	Wang (2014)	√	√	Taiwan	QN	√							
17	Purwaningrum et al. (2023)		√	Indonesia	QN								√
18	Mustafa et al. (2023)		√	Jordan	QN			√					
19	Ibrahim et al. (2022)		√	Malaysia	MX					√			
20	Wen et al. (2021)		√	US	QL	√							
21	Sugiman, Suyitno & Pujiastuti (2021)		√	Malaysia	QL				√				
22	Wen et al. (2020)		√	US	QL	√							
23	Aprinastuti et al. (2020)		√	Indonesia	MX						√		
24	Weng & Bouck (2019)		√	US	QN							√	
25	Kaczorowski et al. (2018)		√	US	MX				√				
26	Maćkowski et al. (2018)		√	Poland	MX				√				
27	Keller et al. (2018)		√	Switzerland	QN					√			
28	Che Abdul Rani et al. (2014)		√	Malaysia	QL	√							
29	Chi et al. (2014)		√	Taiwan	QN	√							

QN- Quantitative; QL- Qualitative; MX- Mix Method