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A SYSTEMATIC LITERATURE REVIEW ON MATHEMATICS MOBILE APPLICATIONS IN EDUCATION

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Abstrak: Penggunaan aplikasi seluler dalam sistem belajar mengajar saat ini merupakan bidang penelitian yang aktif. Penelitian ini merupakan Systematic Literature Review (SLR) menggunakan model PRISMA dengan mengidentifikasi berbagai literatur yang sesuai dan relevan untuk mengidentifikasi kegunaan aplikasi mobile dalam pendidikan. Pencarian data dilakukan dengan menggunakan kriteria yang ditentukan oleh penelitian dari berbagai mesin pencari seperti Google Scholar, ERIC, Scopus, Research gate dan lain-lain karena SLR dilakukan pada makalah yang diperoleh dari database tersebut. Total 77 artikel diambil; dari yang 30 yang mirip dengan tujuan makalah ini. Dari 30, hanya 15 artikel yang relevan dengan penelitian ini. Selanjutnya data dianalisis dengan menggunakan pendekatan kualitatif untuk mendeskripsikan temuan penelitian. Hasil penelitian menunjukkan bahwa telah ditemukan tiga tema utama penelitian, yaitu tujuan penelitian, populasi sasaran dan desain penelitian. Secara garis besar, hasil analisis artikel-artikel tersebut menyatakan bahwa penerapan aplikasi mobile matematika dalam pendidikan masih dalam pertimbangan di Malaysia. Temuan ini diharapkan dapat menjadi landasan bagi guru, pemerhati pendidikan, dan pembuat kebijakan pendidikan di semua tingkat pemerintahan, termasuk pemerintah daerah, negara bagian, dan federal, serta Kementerian Pendidikan, untuk mengembangkan kebijakan yang mendukung pengembangan matematika. aplikasi seluler dalam pendidikan. Temuan SLR memberikan wawasan tentang kontribusi, celah, dan peluang utama lapangan, yang menciptakan percakapan tentang bidang penelitian penting di masa depan.

Kata kunci : *Aplikasi seluler matematika, Pendidikan, pengajaran dan pembelajaran, Kegunaan*

Abstract: The usage of mobile applications in today's teaching and learning system is an active area of research. This study was a Systematic Literature Review (SLR) using the PRISMA model by identifying various appropriate and relevant kinds of literature to identify the usability of mobile applications in education. Data search was carried out using criteria determined by researches from various search engines such as Google Scholar, ERIC, Scopus, Research gate and others as SLR was performed on papers obtained from these databases. In total 77 articles were retrieved; out of which 30 were similar to the purpose of this paper. Out of 30, only 15 articles were relevant to this study. Furthermore, the data were analysed using a qualitative approach to describing the research findings. The results showed that three main research themes have been found, namely the purpose of the study, targeted population and research design.

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Outline, the analysis results of these articles stated that the implementation of mathematics mobile applications in education is still under consideration in Malaysia. These findings are expected to serve as a foundation for teachers, education observers, and education policymakers at all levels of government, including local, state, and federal governments, as well as the Ministry of Education, to develop policies that support the development of mathematics mobile applications in education. The findings of SLR provided insight into the field's primary contributions, gaps, and chances, which created a conversation about essential research areas in future

Keywords: *Mathematics mobile applications, Education, Teaching and learning, Usability*

INTRODUCTION

The objectives of this paper are to review, analyse and classify the existing work of literature which is related to learning mathematics through mobile applications. This SLR investigates research trends and identifies the similar purpose of the study, targeted population, theoretical and conceptual framework and research design of research. Table 1, shows the themes of this study.

Table 1**:** Themes of this study.

No.	Themes Of This Study
1	Purpose of the study
2	Targeted population
3	Research Design

The advancement of wireless technology in education, as well as the creation of mobile applications, has been remarkable. Many secondary school and higher education teachers have found that mobile technology in education has become one of the most important areas of research and application in recent years [1]. In addition, a wide range of multimedia applications, including mathematics mobile applications, have been developed expressly for teaching and learning [2]. Some of the possible benefits of using mobile technologies for learning include facilitating learning across contexts, contextual learning, and personalization in both personal and collaborative situations [3]. Mobile technology appears to be an effective tool for learning Mathematics because of these benefits.

LITERATURE REVIEW

Studies have proven that M-Learning can help students overcome obstacles in mathematics classes [4] [5]. M-Learning will be improved even in remote regions with the arrival of the 4IR since mobile broadband and fast and dependable internet connection will be made available. Data bundles will be made more affordable, making M-Learning more accessible in rural regions. According to

Mutambara and Bayaga [5], M-Learning shifts the focus from the teacher to the student, which can lead to deeper, more holistic learning experiences. M-Learning also provides teachers with a variety of teaching approaches, including the use of audio recording features, live polling tools, chat, online discussion forums, and group work. Learners can use M-Learning to visualise mathematical solutions, which can help them increase their knowledge and deliver thorough explanations of the specified topics.

M-Learning gives learning material everywhere and at any time. M-Learning reduces time lost by increasing the contact time between teachers and students. According to [6], mobile devices are inexpensive, may be utilised as a cognitive tool in learning tasks to solve real-world problems, and encourage reflection and collaboration during the learning process. In the epoch of technologization, mobile applications play a vital role in conducting M-Learning. When compared to textbooks, mobile applications aided students' judgments of the value of identification in learning. As a result, interactive mathematical models of Mathematics mobile applications on mobile devices that use web services could make learning more accessible to everyone [7]. Some games, for example, have been infused with instructional content and have Mathematics as their central topic. The game may appear simple, but it posed a challenge for users or students who are only learning the fundamentals of Mathematics while also having fun at once.

The Systematic Literature Review (SLR) is one form of literature review method. This method is a research method that is carried out through rigorous examination of previous studies using explicit criteria in answering research questions [8]. SLR, according to another definition, is a research activity that involves evaluating the literature using an analytic framework and interpreting the findings, often known as "defining the body of literature." [9] [10] [11]. The SLR method is characterized by the activity of seeking relevant information to identify, assess, and interpret the results of investigations about problems of concern to researchers [12]. The Preferred Reporting Item for Systematic Reviews and Meta-analysis (PRISMA) is one such paradigm. The PRISMA model is used to make a systematic, precise and reliable literature review [13]. This model defines a systematic review as a review of clearly formulated questions using systematic and explicit methods to identify, select, and critically assess relevant research results [14].

RESEARCH METHODOLOGY

This study used the Systematic Literature Review (SLR) method, which aims to collect, identify, analyse, and synthesize various studies on mathematics mobile applications in education. SLR is a literature review that is firmly attached to a set of scientific methods explicitly to avoid systematic or biased errors [15]. This study uses several stages as suggested by Peter [16] about preferred reporting items for systematic reviews and meta-analysis or PRISMA. These stages are identification, screening,

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eligibility, and inclusion. The following Figure 1 shows the methodical approach to answering this research question. Furthermore, based on the results of the data search as illustrated in the chart above, 15 articles were further analysed. The identity of the articles is summarized in Table 2.

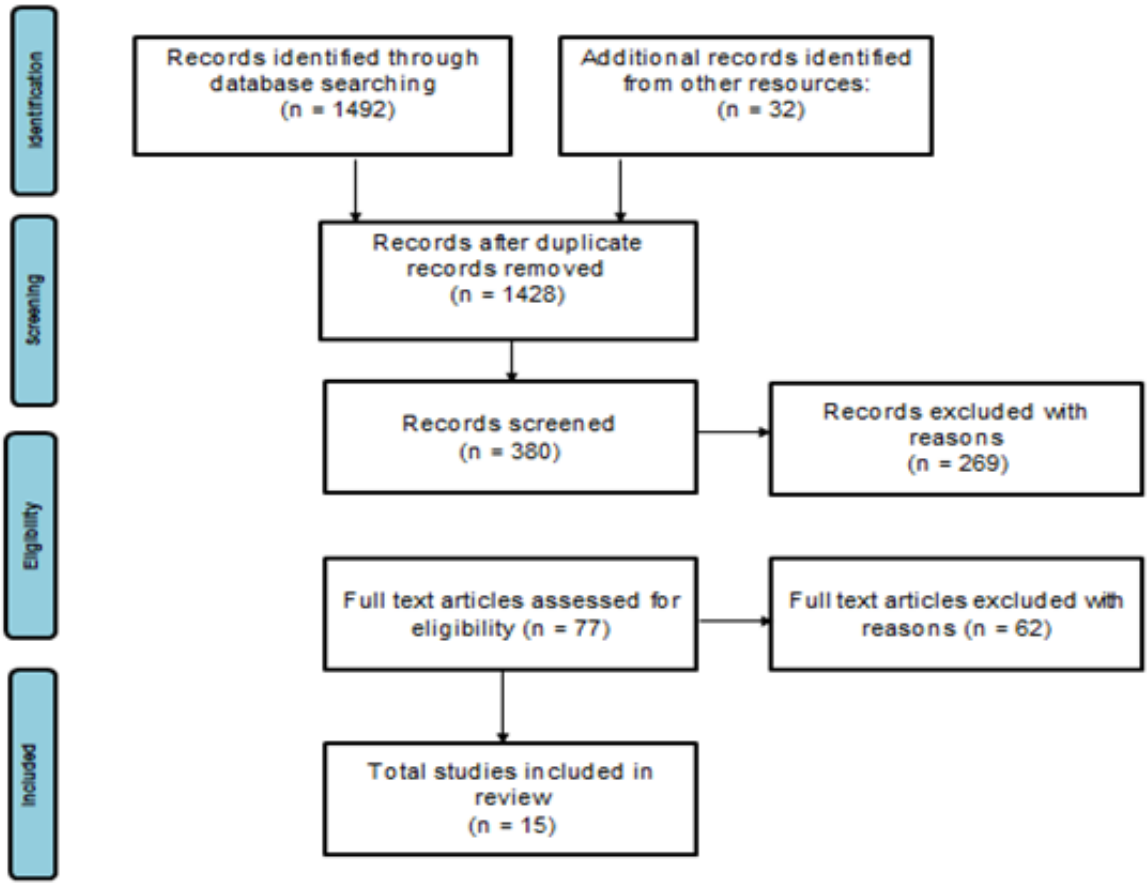

Figure 1. Research Data Search & Selection Flow

Table 2: Identity of the articles to be analyzed further.

No	Article Title	Year	Author's Name	Journal Name
1	Characterising the perceived value of mathematics educational apps in pre-service teachers [17].	2016	Handal, Boris Campbell, Chris Cavanagh, Michael Petocz, Peter	Mathematics Education Research Journal
2	Design and implementation of web-based dynamic mathematics intelligence education platform [3].	2019	Guan, H. Rao, Y. Wang, Y. Li, X. Chen, R.	Proceedings - 7th International Conference on Digital Home, ICDH 2018
3	Development and Efficiency Validation of Training Course on Smart Farm based on	2019	Sonthitham, A. Ruangsiri, K.	Proceedings of the 2019 International

No	Article Title	Year	Author's Name	Journal Name
	STEM Education: A Case Study of Abalone Mushroom [18].		Thongchaisuratkul, C.	Conference on Power, Energy and Innovations, ICPEI 2019
4	Design and implementation of the educational game to improve arithmetic abilities for children [19].	2019	Yunanto, A.A. Herumurti, D. Kuswadayan, I. Hariadi, R.R. Rochimah, S.	Proceedings of 2019 International Conference on Information and Communication Technology and Systems, ICTS 2019
5	Mobile technologies in the service of students' learning of mathematics: the example of game application A.L.E.X. in the context of a primary school in Cyprus [20].	2016	Kyriakides, A.O. Meletiou-Mavrotheris, M. Prodromou, T.	Mathematics Education Research Journal
6	Screencasts: Formative Assessment for Mathematical Thinking [21].	2016	Soto, M. Ambrose, R.	Technology, Knowledge and Learning
7	Mathematics Performance Monitoring System Using Data Analytics [22].	2021	Razak, M.S.A. Abdul-Rahman, S. Mahmud, Y.	2021 2nd International Conference on Artificial Intelligence and Data Sciences, AiDAS 2021
8	Mathematics Trails and Learning Barriers [23].	2020	Gurjanow, I. Ludwig, M.	International Perspectives on the Teaching and Learning of Mathematical Modelling
9	Mathematics trails in initial teachers´ education in Slovakia [24].	2020	Čeretková, S. Bulková, K.	19th Conference on Applied Mathematics, APLIMAT 2020 Proceedings
10	Didactic potential of using mobile technologies in the development of mathematical thinking [25].	2020	Soboleva, E.V. Chirkina, S.E. Kalugina, O.A. Shvetsov, M.Y. Kazinets, V.A. Pokaninova, E.B.	Eurasia Journal of Mathematics, Science and Technology Education
11	The Effect of Using Mobile Applications (GeoGebra and Sketchpad) on the Students' Achievement [26].	2019	Alkhateeb, Mohammad Ahmad Al-Duwairi, Ahmed	International Electronic Journal of Mathematics Education

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No	Article Title	Year	Author's Name	Journal Name
			Mohammad	
12	Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten [27].	2021	Papadakis, Stamatios	Advances in Mobile Learning Educational Research
13	The Effects of Mobile Application in Teaching High School Mathematics [28].	2018	Etcuban, Jonathan O. Pantinople, Leocineza D.	International Electronic Journal of Mathematics Education
14	Using mobile devices to enhance inquiry-based learning processes [29].	2020	Becker, Sebastian Klein, Pascal Gößling, Alexander Kuhn, Jochen	Learning and Instruction
15	Attitudes towards Using Mobile Applications in Teaching Mathematics in Open Learning Systems [30].	2018	Al-Takhyneh, Bahjat	International Journal of E-learning and Distance Education

DATA COLLECTION AND ANALYSIS

Search for data sources in this research was accessed through various electronic databases such as Google Scholar, Scopus, Research gate, ERIC, and others. There are several keywords used in data search, namely mathematics, mobile applications, education, and teaching and learning. In addition, the researchers also used several criteria in analysing data. The analysis criteria in this study were developed by the researcher by referring to the requirements previously carried out by [31] [32] [15], Kartal & Guner [33], & Williams [34]. These criteria were chosen using the SLR model equation, which stands for Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA). The articles chosen are articles published by reputable scientific journals. Table 3 shows the data collected from the articles included in this study.

Table 3: Data collected from the articles.

No.	Article Title	Purpose of the Studies	Targeted Population	Research Design
1	Characterising the perceived value of mathematics educational apps in pre-service teachers	This study validated the semantic items of three related scales aimed at characterising the perceived worth of mathematics-education-related mobile applications (apps).	Pre-service Teachers	Qualitative
2	Design and	This thesis briefly reviews the	Both Primary &	Qualitative

No.	Article Title	Purpose of the Studies	Targeted Population	Research Design
	implementation of web-based dynamic mathematics intelligence education platform	development of the web-based dynamic mathematics software; proposes that design principles of the web-based, especially a mobile internet-based, DMIEP software should be 'opening and sharing'; and provides goals to be achieved, such as seamless integration with a system or a third party application in a cross-terminal manner, good expansibility, and intelligence.	Secondary Students	
3	Development and Efficiency Validation of Training Course on Smart Farm based on STEM Education: A Case Study of Abalone Mushroom	The goal of this study is to describe the development and efficiency validation of a Smart Farm training course based on STEM education.	Teachers	Qualitative
4	Design and implementation of the educational game to improve arithmetic abilities for children	This study focuses on using a game method to establish a level automatically and varied both in games and educational material attributes.	Secondary School Students	Qualitative
5	Mobile technologies in the service of students' learning of mathematics: the example of game application A.L.E.X. in the context of a primary school in Cyprus	This article summarises the key findings of a two-year study that integrated A.L.E.X., an educational puzzle game available for iPad and Android tablet devices, into the primary school mathematics curriculum.	Primary School Students	Qualitative
6	Screencasts: Formative Assessment for Mathematical Thinking	In this study, Screencast applications on mobile devices enable teachers to collect multiple modes of communication, which students use to generate mathematical explanations.	Both Teachers & Students	Mixed Methods
7	Mathematics Performance Monitoring System Using Data Analytics	This research highlights the application of data analytics in mathematics due to its importance in IR 4.0.	Teachers	Qualitative
8	Mathematics Trails and Learning Barriers	In this study, in which ninth-graders were asked to complete a maths trail with the MathCityMap application, we observed them	Secondary School Students	Mixed Methods

No.	Article Title	Purpose of the Studies	Targeted Population	Research Design
		having trouble with measuring and handling quantities.		
9	Mathematics trails in initial teachers´ education in Slovakia	The research focuses on the Erasmus+ project Mobile Mathematical Trails in Europe (MoMaTrE), which employs the mobile application Math City Map (MCM) to approach the activity.	Pre-service Teachers	Qualitative
10	Didactic potential of using mobile technologies in the development of mathematical thinking	The research is important because it provides additional chances to improve the quality of mathematics instruction in a digital school, as well as assist young people's career orientation and self-determination through the use of mobile services and platforms.	Pre-service Teachers	Mixed Methods
11	The Effect of Using Mobile Applications (GeoGebra and Sketchpad) on the Students' Achievement	This study proposes integrating Mobile Applications in teaching geometry.	University Students	Quantitative
12	Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten	In kindergarten education, properly designed digital educational activities can become a potent educational tool for efficient and effective learning.	Pre-School Students	Mixed Methods
13	The Effects of Mobile Application in Teaching High School Mathematics	This study determined the effects of using a mobile application in teaching mathematics	Secondary School Students	Quantitative
14	Using mobile devices to enhance inquiry-based learning processes	In this approach, students use tablets to investigate motion with an application providing multiple representations of the measurement data. We	Secondary School Students	Qualitative
15	Attitudes towards Using Mobile Applications in Teaching Mathematics in Open Learning Systems.	This research examined attitudes about using mobile learning to teach math in open learning systems.	University Students	Quantitative

RESULTS AND DISCUSSION

1. Purpose of the studies

In connection with this SLR, the data analysis used in this study is content analysis. This technique is used to determine trends at the descriptive level of studies conducted on a particular subject [35]. There are three steps taken in analysing data with this technique, namely: (a) purpose analysis, (b) targeted population analysis, and (c) research design analysis. From table 3, we can conclude that the purpose of the selected articles is similar, which is to integrate mathematics mobile applications into teaching and learning systems. Some of the articles focus on certain applications while most of the articles engage the use of mobile applications in education. However, it can be concluded that education supported by mobile applications give a positive impact on learning outcomes as well as the learning atmosphere both in class and outside the classroom [7]. This outcome encourages more research on the usage of mathematics mobile applications in our education system.

2. Targeted Population

Table 4. Targeted Populations in The Studies

Pre-school students	Primary School Students	Secondary School Students	Both Primary & Secondary School Students	University Students	Pre-service Teachers	Teachers	Both Students & Teachers
n=1	n=1	n=4	n=1	n=2	n=3	n=2	n=1

The above table shows the different targeted populations of the studies. The population of each study differs according to the purpose of the study. From the 15 selected articles, one article represented preschool students, primary students, both primary and secondary students and both students and teachers populations. While two articles targeted university students and teachers groups respectively. There were three articles for pre-service teachers and four articles for secondary school students. From this data, we can conclude that there are readily available mathematics mobile applications for secondary curriculum. Therefore, in future, more articles should be focused on teachers implementing mathematics mobile applications in our teaching and learning system.

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3. Research Design

Table 5: Research Methods Used in The Studies

Qualitative Method	Quantitative Method	Mixed-Method
n=8	n=3	n=4

Table 5 provides an overview of the research methods used in the articles reviewed. There are three research methods used, namely qualitative method, quantitative method, and mix-methods methods. Eight studies used qualitative methods, 3 studies with quantitative methods and four articles used a mix-methods approach. The integration of mathematics mobile applications needs to be studied qualitatively to focus on the feelings and opinions of the targeted audience such as the data collected from observation and interviews [17]. Mixed methods research, on the other hand, is a form of study in which a researcher employs both qualitative and quantitative research methodologies. [36]. More research should be produced using the mixed-methods design to have an in-depth and useful data analysis [37].

CONCLUSION

This study is an SLR on the usage of mathematics mobile applications in education, which analyses 15 articles that have been published from the year 2016 until the year 2021 in reputable international journals and selected based on predetermined criteria. This article provides a clear picture of the SLR mathematics mobile application in education and current trends by identifying, classifying, and synthesizing research results based on research themes. There are three main themes found based on data analysis: the purpose of the study targeted population and the research design. Malaysia is widely believed to be ready to fully adopt mathematics mobile applications in teaching and learning methodologies, particularly in primary, secondary, and university education. One limitation of this review is the relatively small number of articles reviewed or analysed. This is caused by the restrictions set as criteria in capturing various Boolean searches such as “mathematics AND mobile applications AND education. A literature review must be carried out with a broader scope, both in terms of quantity and in producing more comprehensive literature review articles.

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