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PAPER

Redesigning of Mobile Content to Enhance Learning Activities Preparation by Preschool Experts

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ABSTRACT

Mobile content provision at the preschool stage has grown after the post-pandemic Covid-19. Preschool teachers face varying degrees of mobile technology literacy to prepare learning activities that enhance children's understanding and acquisition of knowledge and skills. Nevertheless, these teachers have minimal exposure and input to mobile content elements that can enhance learning. This study aims to redesign the mobile content model by redefining the required elements to improve learning activities preparation for preschoolers' basic problem-solving skills in mathematics. This case study involves seven preschool experts whose data was collected using the Nominal Group Technique approach. Then, Interpretive Structural Modelling was applied to develop the model through a voting process. The technique was used to rank the data from the experts before running the voting session. The findings revealed eleven principal elements for the mobile content model that can be divided into three content execution streams. The results offer several implications and benefits to the mobile learning arena, particularly in early childhood education, due to its potential to enhance engagement, interaction, and personalized learning experiences for young learners. These outcomes provide insights into the best practices, strategies, and pedagogical approaches that can optimize the use of mobile devices in early childhood education, hence, promoting effective learning outcomes.

KEYWORDS

mobile technology, nominal group technique (NGT), learning activities, preschool expert, interpretive structural modeling (ISM), maths

1 INTRODUCTION

There has been a significant transformation in learning norms using digital technology during the times of pandemic [1]. Online learning offers the best option to replace face-to-face physical classroom interactions between students and instructors when countries were forced to close the education sector to curtail the COVID-19

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pandemic beginning in December 2019 [2], [3], [4]. Preschool education was also impacted by the pandemic, culminating in the cessation of face-to-face instruction and classroom learning. Even when the restriction has been lifted, like other institutions, preschools today integrate various online learning resources, including mobile learning, as an alternative to face-to-face learning.

Preschool learning offers early experiences for children aged four to six to fundamental education. It is children's most crucial early educational experience [5]. The main issue in addressing preschool's learning concerns and challenges is the relevancy of the teachers' teaching and learning approaches [6] to match the children's abilities. Preschool teachers need to facilitate effective teaching and learning. The selection of teaching strategies, teaching resources, and assessments that are the primary tasks of teachers should be emphasized frequently [7], [8], [9]. Preschool children need support during the learning process to acquire the targeted learning outcomes. Hence, preschool teachers are highly encouraged to provide children with interactive and engaging learning sessions.

In Malaysia, numerous initiatives by the government have been executed to date, including allocating funds to support and maximize the usage of Information and Communication Technology (ICT), specifically in education [10]. In this regard, local educators should first be aware of the latest issues and trends in the use of ICT to ensure the effectiveness of the incorporation in their context of teaching and learning. Particularly in early childhood education, the topics and trends comprise the safety and health of the children, preschools' infrastructure, and educators' competencies in integrating ICT as teaching aids and as a medium of communication and collaboration with parents.

Tzimiris et al. [11] assert that many teachers have willingly participated in distance education, irrespective of their prior training or experience in ICT. The teachers felt the need to adapt to distance education during the COVID-19 pandemic because they need to experience to be students learning online. In addition, even when they have limited or no experience with online teaching, they must learn to choose effective media, strategies, models, and learning methods to enhance the effectiveness of teaching and learning [12]. According to Intan Nur Syuhada and Zamri [13], online learning relies heavily on suitable internet technologies and achievements so that the learning process can be implemented smoothly, allowing students to access all information about their studies. Constructively integrating ICT in education and preparing suitable teacher candidates to use ICT in classrooms is vital to their professional development. The technology, without a doubt, can enhance the teaching and learning experience, promote student engagement and collaboration, and provide access to various educational resources and opportunities [12] if it is designed correctly.

This study argues for the necessity to plan and implement strategies to meet children's learning needs for effective learning. Recognizing that children learn through repetition and imitation, interactive learning apps in the context of mobile learning can make the learning process more effective [14]. The techniques are vital for a child's development because interactive games contain audio and video, allowing children to process a word they hear and repeat the words to be used at the right time while speaking. Thus, interactive learning apps can be used repeatedly to ensure children's learning is more effective.

Therefore, this study aims to redesign a mobile content model by gauging preschool experts' viewpoints on the required elements to enhance learning activities preparation. The principal elements for a mobile content model and learning activities are determined using Interpretive Structural Modelling (ISM) software to leverage the experts' practical experience and knowledge of mobile learning for preschool. The results should help preschool instructors or content developers create and provide learning activities accessible via mobile devices such as smartphones or tablets. This model can assist preschool teachers in providing their children with dynamic and exciting learning experiences and facilitating access to learning resources anytime.

2 LITERATURE REVIEW

Technology is the most crucial element of the teaching and learning process now. The use of mobile technology in preschool education has become widespread in various areas of education and learning and has been shown to improve the effectiveness of teaching and learning [15]. This development has led to the emergence of various techniques and technologies that are student-centered. Among the popular methods available in learning technology are game-based mobile learning, such as audio, scan card images and animations, problem-solving-based learning, and question-based learning. Play is a crucial aspect of early childhood education and has various benefits, including cognitive, social, emotional, and physical development [16]. Play theories generally emphasize the importance of play in children's learning, socialization, and overall development.

Technology has reinforced gamification through components and techniques that provide students with all the necessary supplies leading to positive learning outcomes [17]. Findings from a study on preschool children's imaginary companions offer insight into the who, how, and type of interaction children like to have in gamification. During the phenomenological research, forty-six Turkish children aged between 48 and 60 months provided six themes and 24 categories of their imaginary companions. The companions were male in terms of gender, clothing, and accessories in terms of appearance characteristics and happiness in terms of mood characteristics [18]. Considering the thinking status of their imaginary companions, the children concentrated on entertainment/game, communication skills in terms of liked/admired features, and hostile behavior, the disliked/unadmirable characteristics. From these findings, addressing imaginary companions in children's lives in different dimensions can contribute to redesigning a custom-made mobile content model.

Mobile technology is a method capable of producing practical learning approaches to improve the quality of learning [19], [20], [21]. Mobile learning can change students' views and fears about a previously challenging course [22]. In addition, mobile learning can enhance curiosity and diverse and exciting delivery methods [23] and is suitable as a learning material. Mobile learning is also independent, interactive, and able to connect with all members in the classroom [24], and enable collaborative learning [25], coaching and counseling activities [26]. Mobile learning is used at all levels as a powerful tool for living and learning, including preschool education [27]. This mobile learning activity can also occur in the home environment where parents can be directly involved. Mobile learning can foster the knowledge and experiences of this age and support specific assessment areas, namely early literacy skills, early math skills, cognitive skills, social-emotional skills, and motor skills, as well as cater to children with special needs.

A review on the effects of mobile applications on children's math learning provides insights into four features of mobile applications that impact math learning [28]. This research contributes to understanding the implications for educators and app designers in facilitating compelling math learning experiences. The advancement of mobile learning using learning apps for preschoolers revolutionizes early childhood education. Papadakis et al. [29] found that when combined with developmentally appropriate software in the children's daily routines, computers and especially tablets may substantially contribute to early childhood students' comprehension of numbers. These apps provide many advantages, including promoting cognitive, emotional, social, motor, language, creativity, and imagination skills in preschoolers.

However, the use of software for smart mobile devices, which has grown in popularity, has become a hotly debated issue in education and child development [30]. There needs to be more evidence about the real value and suitability of educational apps. The study to examine whether self-proclaimed educational apps for Greek preschoolers have been designed according to developmentally appropriate standards to contribute to children's social, emotional, and cognitive development in formal and informal learning environments revealed unsettling findings. Most of the apps were drill-and-practice-style, based on a low level of thinking skills, which promotes rote learning; hence, they were unable to contribute to a deeper conceptual understanding of certain concepts.

Papadakis conducted a literature review of empirical studies on applying four coding apps to support young children's learning of computational thinking and computational fluency [31]. The results show that all apps positively affect the development of children's computational thinking. None of the apps can ultimately support the development of computational fluency, though *ScratchJr*, with a "sandbox" approach, can better help students express themselves. The study also affirms the responsibility of educators or teachers in introducing young children to computational thinking and computational fluency using touchscreen technology.

In a more recent study, Papadakis et al. [32] investigated the app choices made by Greek parents and their impact on young children's smart mobile usage at home. The study involved 325 parents of kindergarten children. The findings revealed that parents in Greece utilize mobile devices to support their children's learning at home. However, parents also need to learn about the developmental appropriateness of apps and require further guidance. The study highlights the prevalence and significance of interactive touchscreen devices in the lives of young children. In identifying and comparing the mediation strategies between two countries, Greece and Turkey, for the digital games played by children, significant differences were placed in the mediation strategies [33]. The study concluded that parents playing digital games with their children during the pandemic showed substantial differences in the mediation strategy.

On the other hand, Nikolopoulou [34] identifies teachers' perceived barriers to using mobile learning. The challenges are related to scarcity or limited resources, training opportunities, and the lack of funding. At the same time, there are critical concerns regarding the constraint of hands-on experiences, children's concentration, and cyber safety issues. Studies related to learning the Malay language based on technology-driven games in preschool show that they are less likely to be preferred by teachers due to the constraints [35]. Regardless, teachers often need help with learning applications, especially mobile ones. Teachers need more confidence in using and producing multimedia content for teaching. Therefore, experts' viewpoints on the required elements for effective mobile learning activity preparation are necessary so that teachers can confidently use game-based mobile applications to provide interactive and fun learning for children.

In addition, a systematic literature review on mobile for preschoolers has highlighted some gaps in the area [36]. The obvious one is framework development. Numerous mobile applications in the market are designed and developed using various methods for preschoolers. While the multiple techniques used may have advantages and disadvantages, here it calls for redesigning existing models based on experts' viewpoints to assist researchers and developers in creating mobile learning applications for preschoolers.

Overall, this study justifies the need for collaborative efforts by all parties to redesign the existing mobile content and activities and form a model. The study provides a more systematic way for preschool teachers to formulate and build a better application based on expert consensus. As a result, the redesigned model should consist of elements that can enhance preschoolers' learning of basic mathematical skills. The redesigned model should also guide teachers with suitable methods and required features to engage the children in learning the subject via mobile devices.

3 METHODOLOGY

One fundamental concept in designing the mobile content model is utilizing ISM (Interpretive Structural Modelling) software to leverage the practical experience and expert knowledge. ISM is an interactive learning process designed to break down complex systems into multiple subsystems and construct a hierarchical structure model that facilitates understanding and analysis [37]. ISM is a methodology for dealing with complex issues and has been applied in various domains, including content modeling. It enables experts to transform unclear and poorly articulated mental models into well-defined models useful for different purposes, such as developing content management systems. The following are the required steps to design a comprehensive mobile content model using ISM software.

1. Identify the Ecosystem: Determine all existing content that the mobile application will encompass.
2. Analyse Requirements: Determine the specific types of content needed and their characteristics.
3. Define Content Structure: Structure the content at a granular level, identifying the relationships and elements forming the hierarchical model.
4. Leverage ISM Software: Utilise ISM software to facilitate the breakdown of complex systems into subsystems, taking advantage of practical experience and expert knowledge.

In designing the mobile content model, the software uses experts' practical experience and knowledge to dismantle complex systems into multiple subsystems and simultaneously build a hierarchical structure model. Warfield [38] defines ISM as a computer-aided learning process that allows individuals or group users to develop structures that show relationships between predetermined elements according to selected contextual relationships. It can also be seen as a management decision-making tool that connects individual or group ideas to facilitate a deep understanding of complex circumstances through a map of the relationships between the many elements involved in complex decision-making [39]. ISM is interpretive because it requires judgment on whether there is a relationship between the elements and, if so, how they should be connected. This method is structural because the overall structure can be generated using the relationships between the elements. Finally, it is a modeling technique because the graphic model can depict the overall design and the relationships between the elements.

3.1 The study expert panel

In this study, ISM is used to help a panel of experts reach a consensus on the relationships between elements in redesigning a preschool mobile content model. Seven experts were identified and invited to collaborate in an online workshop facilitated by the researchers to redesign the model (Table 1).

Table 1. The study experts' criteria

Expert	Degree	Expertise	Experience (Year)
P1	Doctor of Philosophy	Curriculum Development	10
P2	Doctor of Philosophy	Early Childhood Education & Pedagogy	15
P3	Doctor of Philosophy	Technology in Education	12
P4	Doctor of Philosophy	Early Childhood Education & Pedagogy	10
P5	Master's degree	Mathematics Education	12
P6	Master's degree	Early Childhood Education	11
P7	Master's degree	Early Childhood Education	12

The selection of panels is made by identifying local experts with extensive experience in the context of the studies. Findings from the selected panel include experts in early childhood education, preschool teachers, math instructors, ICT, and assessment experts—all experts have more than five years of preschool teaching experience.

Four Ph.D. holders and three master's degrees are labeled P1 to P7. P1 is a curriculum development specialist with a Doctor of Philosophy degree, serves as a lecturer at public universities, and has ten years of experience in related fields. P2 graduated with a Doctor of Philosophy and specialized in early childhood education and pedagogy. He works at the Public University as a lecturer and has ten years of work experience. P3 is a specialist with a master's degree specialising in early childhood education, a child development specialist for ten years and served as a teacher. P4 is a lecturer with ten years of experience. He has a Ph.D. Early Childhood Education and Pedagogy.

P5 is a math teacher with more than ten years of experience. His input is specifically needed for the subject matter of the developed mobile content. Finally, P6 and P7 have master's degrees and extensive early childhood education experience to ensure valid and credible input regarding the principal elements for designing preschoolers' basic mathematics mobile content. The experts' viewpoints towards elements were gathered via responses that were rated using a five-point Likert scale ranging from 1 (Strongly disagree); 2 (Disagree); 3 (Agree); 4 (Agree); and 5 (Strongly Agree).

3.2 Interpretive structural modelling procedures

This study performed six steps of Interpretive Structural Modelling (ISM) procedures.

Step 1. Identify elements related to the problem or issue. In this study, the researchers identified the elements based on problem statements, literature reviews, and needs analysis. The formed elements were included in the questionnaire and distributed to the experts for voting. The notion is to identify the priority position of the model elements in the study. Table 2 analyses the seven experts involved in NGT and ISM sessions conducted through online workshops.

Table 2. Analysis of findings using the NGT approach

Item	Expert							Score	%	Ranking
	P1	P2	P3	P4	P5	P6	P7			
1	5	5	4	5	4	5	5	33	96	1
2	5	5	4	5	4	4	5	32	91	13
3	5	5	4	5	4	5	5	33	96	1
4	4	5	4	5	4	5	5	32	91	13
5	5	5	4	5	4	5	5	33	91	13
6	5	5	4	5	4	5	5	33	91	20
7	5	5	4	5	4	5	5	33	93	9
8	5	5	4	5	4	4	5	32	93	9
9	5	5	4	5	4	5	5	33	91	13
10	5	5	4	5	4	5	5	33	96	1
11	5	4	4	5	4	5	5	32	89	13

Step 2. Define the phrases of relationships and contextual relationships concerning how learning activities (elements) should relate to each other.

Step 3. Develop a matrix of structural self-interaction (SSIM) of content elements that indicate the connection between elements. ISM software is used to assist the process. The software will display the pair of features to allow the experts to vote on the relationship before presenting the elements. The process is repeated until all elements are paired for the connection.

Step 4. Generate ISM model. The software runs the process after the pair of elements has successfully been carried out. The software acquires a model based on intelligent comparison of teams and transitive logic. Transitive Logic is for any three parts (A, B, C) with a given relationship when:

A has a relationship with B (written $A \rightarrow B$),
and B has a relationship with C (written $B \rightarrow C$),
then A has a relationship with C (written $A \rightarrow C$ or $A \rightarrow B \rightarrow C$).

Step 5. Review the model to examine conceptual inconsistencies and make necessary adjustments.

Step 6. Present the final model after the necessary modifications are made.

4 FINDINGS

The results of the evaluation show that all experts, by consensus, agreed with the mobile learning model to solve rudimentary mathematical problems of tasks. The developed model and evaluation of the mobile learning content framework are to solve basic preschool-level mathematical problems. It is implemented as a guide for preschool teachers in preparing and assigning basic math problem-solving skill activities to their kids.

The expert voting process that has been implemented and carried out has resulted in a prototype learning model that develops a model of the mobile framework of the essential mathematical solution kindergarten. Figures 1 and 2 display the main components of the learning model of the content of the mobile framework of the crucial mathematical solutions of the resulting nurseries.

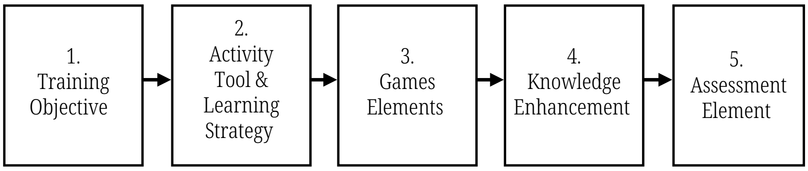

Fig. 1. Primary model for mobile content development

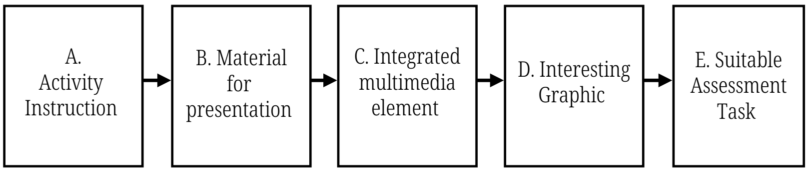

Fig. 2. Learning activity for mobile content

4.1 Findings from step 2

The decision analysis in the second step of the ISM, i.e., identifying the type of ISM to be constructed, determined the connecting and contextual phrases to be arranged in ISM. The findings showed that phrases that fit the context of the study were:

Phrase of unity/relationship/liaison: *"The element … MUST BE run BEFORE the element…"*

Contextual phrase: *"In carrying out teaching using mobile based, elements …"*

The phrases were chosen as an ISM procedural phrase to identify the relationship from the perspective of the importance of content elements built from the context. The experts also agreed with the connecting phrase.

4.2 Findings from steps 3 and 4

The findings from the third and fourth steps are the most critical. The experts have agreed upon and approved the development of content elements for the mobile content models. The findings show the relationship of elements using intelligent pairing techniques with the help of ISM software. These steps are processed by the software, which technologically performs mathematical calculations. In these steps, the facilitator plays a role in clarifying the situation or interpreting the meaning of the problem presented by the ISM. Based on the questions of the paired elements proposed by the ISM software, the experts reached a consensus for each element presented. The findings of this stage form a graphical illustration produced as a computer output (Figure 3). The digraphs that make up the model are for mobile content model preparation of learning activities for math preschool.

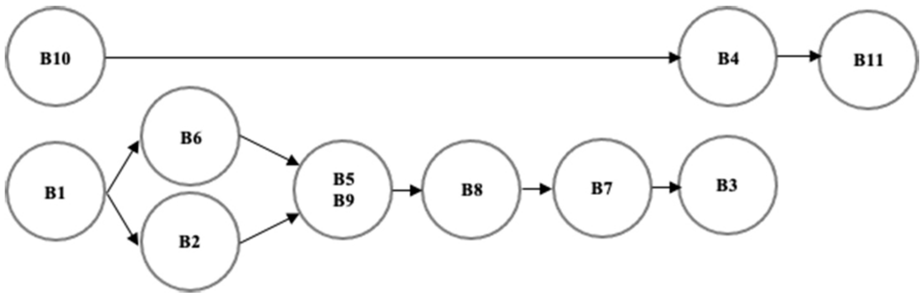

Fig. 3. Mobile content model preparation of learning activities for preschools

Table 3. Symbols for elements of content

Element	Content
B1	Define topics, objectives, and learning outcomes for the children to understand better.
B2	Provide quality teaching materials (video, text, audio, and easy-to-understand images) to teach solving basic mathematical problems.
B3	Ensure the instructional videos are short and interesting to the children.
B4	Ensure the introduction of exciting videos and course images using 3D images.
B5	Determine interesting animation content videos.
B6	Provide basic visuals that support the delivery process.
B7	Provide suitable activity materials such as flashcards.
B8	Use problem-solving-based learning.
B9	Ensure that the content has various interesting sound elements.
B10	Offer problem-based learning.
B11	Use teacher-centered learning activities.

4.3 Findings from steps 5 and 6

The final stage findings of the discussion and structural amendments showed that the experts agreed to maintain the design of the modules without any modifications. Before the decision, the facilitator described and interpreted the relationship structure between the developed content's elements. The experts confirmed the resulting model as elements B4, B3, B5, and B9. The driving power is the force that drives other elements or activities to achieve the goals themselves [40]. The power of dependence, on the other hand, is the power that depends on other forces to achieve goals.

Based on Figure 3, the results show that the model can be divided into three content execution streams. The first stream indicates that the B10 element (Ensuring learning material is based on the problem of pupils suitable for understanding pupil learning) is at the highest level, and the driving power is higher apart from the elements B4, B9, and B11.

On the other hand, the second and third streams indicate that element B1 (determining the topic, objectives, and learning outcomes for students to understand the purpose of learning better) is at the highest level. The driving power is higher apart from the elements B6, B2, B5, B9, B8, B7, B3, B4, and B11. B11 (Giving pupils space to encourage interaction among pupils and teachers) is placed at the lowest position of the model. The figure also shows that element B2 has the highest dependency power.

5 DISCUSSION

The result presented eleven required elements to redesign preschool math learning activities prepared for the mobile content model (Figure 3 and explanation in Table 3). The elements could be divided into three streams of implementation. The first stream shows the role of B10 to ensure the material is used appropriately before B4, B9, B10, and B11 are carried out. The findings coincide with the study of Derus and Wan Muna Ruzzana [35] on game-based learning applications for Bahasa Melayu teaching. Based on the design and content aspects of the application that have been developed, the selection of content-type applications in the material preparation activities is appropriate and easy to read, recorded as the highest mean value. Therefore, there is no denying that the type of quality teaching materials plays a central role in a developed mobile learning model. As depicted in Figure 1, the second and third streams show that element 1 (determining the topic, objectives, and learning outcomes for students to understand the purpose of learning better) is at the highest in this content model.

The data align with the study by Ahmad Nasir and Noralina [23], where the primary strategy of collaborative learning implementation is an open learning platform to identify learning outcomes for each student task or project. This finding is closely related to a study by Salmah Jan [41] that developing content in software should start with an explanation of the main topic and course learning outcomes. There are three elements at the lowest level in the content model streams. The earliest elements must be carried out before the other elements because they depend on them. The features provide comment spaces to encourage interaction among pupils and teachers.

The last element needs to be implemented after B4, B3, B7, B8, B9, B5, B2, B10, and B1. The finding is identical to that by Md. Yusoff et al. [42] and Subramaniam et al. [43]. It was identified that using 3D-shaped materials on applications such as language games and mathematical basics helps pupils answer complex questions or poorly understood topics. Teachers, as tutors, can provide additional guidance and explanations to help preschoolers understand the learned subject or topic. At the same time, it can encourage interaction between participating children. The research also provides insight into the impact of mobile apps on children's learning and for educators and app designers. It highlights four mobile app features that impact math learning for preschoolers to transform early childhood learning of the subject. The input offers various advantages, including promoting cognitive, emotional, social, motor, language, creativity, and imagination skills in preschoolers.

Nevertheless, it is essential to note that the study data gathered through this voting is based on the feedback and expertise of the selected experts. The experts' credibility in the field is well-established and appropriate for the study, and their viewpoints reflect the local education needs and context. This context-dependent criterion confined the findings to countries with similar early educational backgrounds, like Malaysia. By employing ISM software, developers and content teams can effectively structure the mobile content model, ensuring a clear understanding of requirements and facilitating the development of content management systems or other content technologies; integrating ISM software can provide valuable insights and enhance the development of a mobile content model.

6 CONCLUSION

The study contributes to understanding mobile applications' implications in preschool children's math learning. It highlights the advantages of mobile learning applications for preschoolers in acquiring a wide range of skills. The development of mobile content models for math preschool activities preparation emphasizes the importance of quality teaching materials and clear learning outcomes. The eleven principal elements should be included in redesigning the mobile content models. These elements ensure that the redesigned models help achieve meaningful learning and deliver a satisfying learning and teaching experience for teachers and preschoolers. The Nominal Group Technique helps bring together various individuals' viewpoints to reach a consensus in prioritising the relevant issues and techniques to be combined in the ISM process.

The development of mobile content models for preschool teachers' math learning preparation using a consensus of experts through the Interpretive Structural Modelling (ISM) process has assisted and solved problems in developing structures, frameworks, and models. This study will serve as a reference and recommendation for mathematics instructors and content developers to formulate learning models using mobile learning as a teaching platform. Particularly after the pandemic, alternative teaching and learning approaches like the use of mobile should take center stage in Malaysian education and cater to more personalised needs, even preschoolers.

Though mobile learning is well-established in the Western, it is still considered green in the context of preschool education in Malaysia. Hence, the study findings are confined to preschools that employ the Malaysian early education standard curriculum to prepare syllabuses and learning activities. Future studies are recommended to explore in-depth and design activities and assessments fundamental to creating an educational application. In addition, future work can also look to identify the needs of teachers in using and designing game applications in the form of teaching materials to ensure that they are fully prepared with the necessary pedagogical approaches in planning and implementing teaching and learning to produce satisfaction and meaningful learning experiences for kindergarten pupils.

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