Pegem Journal of Education and Instruction, Vol. 14, No. 4 , 2024 (pp. 267 -278)

RESEARCH ARTICLE WWW.PEGEGOG.NET

Developing Digital Android-Based Snakes and Ladders for Elementary Students in Learning Mathematics on Flat Shapes in Indonesia and Taiwan

Mulyani[1], Nurul Istiq'faroh[2*], Ricky Setiawan[3], Mikko Lin Tien-Hsiang[4]

[1,2]Universitas Negeri Surabaya, Sidoarjo Indonesia,

[3]Universitas Negeri Surabaya, Surabaya Indonesia

[4]Yu Da University of Science and Technology, 0935167683, Taipei Taiwan

Abstract

During the Covid-19 epidemic, technology plays a critical role in the learning process. There is a demand for learning media that can help students study online, particularly in mathematics. This study aims to create android-based digital snakes and ladders learning medium that can be used during the learning process. The product of this research is an Android-based snakes and ladders game developed using the Android Studio application. This application was developed as a learning media for third-grade students in learning mathematics on flat shape material. This study used Analyze, Design, Develop, Implement, and Evaluate (ADDIE) model. The topic was selected after conducting interviews at two different schools as part of a needs analysis. Interviews and questionnaires served as the data collection and verification instruments. Media and material specialists were used to validate the instruments. Qualitative and quantitative data analysis techniques were used. The qualitative technique was used to analyze the results of the interviews, and the quantitative technique was used to analyze the validation instrument. Based on quantitative data, media expert validation received a score of 92.04% in the highest feasible category, while material expert validation received a score of 84.09%. The student response test scored 92.3% at the implementation stage. As a result, the digital snakes and ladders game developed for Android is appropriate for usage by third-grade elementary school students.

Keywords: Android, Mathematics, Snakes and Ladders.

Introduction

Education is crucial to the advancement of technology in the current period (Kirschner & De Bruyckere, 2017). Technology helps to facilitate more innovative teaching techniques (Sung et al., 2016). Rapidly developing technology and information have had a positive effect on education. The use of modern technology can help to support learning (Allah & Bashir, 2015). The existence of science and technology will substantially assist teachers in selecting numerous new learning models and media, making the learning process easier for students and teachers (Sumantri et al., 2018). Technological advancements had created many new tools that made it easier for teachers to choose media for learning activities and convey learning materials so students could understand them (Chiu & Mok, 2017). Thus, 21st-century learning requires technology.

The 21st century is characterized by information and communication technology's rapid development and effect on various disciplines, including education. Education in the 21st century emphasizes learning that allows students to explore their curiosity, develops skills that will benefit their future lives, and allows students to collaborate in problem-solving. According to Rotherham and Willingham 2006), a student's success depends on their capacity to master 21st-century abilities, thus students must learn to do so. Creativity, critical thinking, communication, cooperation, invention, and problem-solving are 21st-century abilities (Anagün, 2018; Fadel & Trilling, 2009; Gleason, 2018; Istiq'faroh et al., 2020). The 21st century requires new skills, including creativity and invention, communication and teamwork, critical thinking, and ICT (capacity to use technology) (National

Corresponding Author e-mail: nurulistiqfaroh@unesa.ac.id

https://orcid.org/0000-0003-3717-5616

How to cite this ar ticle: Mulyani, Istiq'faroh N, Setiawan R, Tien-Hsiang ML (2024). Developing Digital Android-Based Snakes and Ladders for Elementary Students in Learning Mathematics on Flat Shapes in Indonesia and Taiwan. Pegem Journal of Education and Instruction, Vol. 14, No. 4, 2024, 267-278

Source of support: Nil

Conflict of interest: None

DOI: 10.47750/pegegog.14.04.23

Received: 07.02.2024

Accepted : 23.05.2024 **Publised :** 01.09.2024

Education Association, 2010). Mathematics is considered a fundamental science that plays a significant part in advancing science and technology since it allows for the development of rational, logical, and systematic thinking. Accordingly, mathematics education in schools aims to provide students with information and critical thinking abilities for solving mathematical issues (Karlimah, 2018; Rachmadtullah et al., 2018).

Mathematics is a discipline that studies patterns and relationships in thinking, with organizational strategies, analysis, synthesis, and tools to solve abstract and practical problems (Schoenfeld & Sloane, 2016). Mathematics is a discipline that studies abstract structures and interrelated patterns (Brumbaugh et al., 2005; Polly et al., 2015). In essence, mathematics is about learning concepts, the structure of concepts, and finding relationships between ideas and their structures. According to McGrath & van Bergen (McGrath & Van Bergen, 2015), the characteristics of mathematics learning in primary school include: students learn to move from concrete to more abstract stages, and they can use symbols and formal representations that naturally develop from the concrete stage, form logical, critical, creative, accurate and disciplined attitudes. Some students experience difficulties in learning mathematics, especially primary school students, particularly during the COVID-19 pandemic.

The outbreak of the COVID-19 pandemic worldwide has changed almost every aspect of life, including education, and Indonesia is no exception to this change (Rasmitadila et al., 2020; Tanu Wijaya, 2020). In education, students from elementary school to university level cannot attend school for learning (Viner et al., 2020; Wijaya, Ying, et al., 2020). Generally, technology in education can be used as an effective learning medium to improve students' mathematical abilities (Al-Mashaqbeh, 2016; Chotimah et al., 2018; Lin et al., 2020; Wijaya, Murni, et al., 2020). Technology can also make students more interested and enthusiastic about learning mathematics than traditional teaching methods (Miguel-Revilla et al., 2020; Mushipe & Ogbonnaya, 2019)2006. Several studies have shown that technology-based learning media can improve students' learning abilities and achievements (Chatmaneerungcharoen, 2019; Hernawati & Jailani, 2019; Sukaesih et al., 2019)aligned with professional development on teacher's technological pedagogical content knowledge (TPACK. With technology in the learning process, students have the potential to become more active and confident when learning specific topics (Rohaeti et al., 2019).

Currently, technology-based learning media may help teachers in guiding students in discovering basic concepts and core learning (Badraeni et al., 2020; CunHua et al., 2019). Distance learning is becoming more feasible as technology advances (Oner, 2020; Redmond & Lock, 2019). The Chinese government has enabled students to engage in remote learning through the use of dynamic mathematical software known as Hawgent (Peters et al., 2020; Zhu & Liu, 2020). Hawgent is a mathematical program developed in Guangzhou to address the needs of educational practitioners and academics. The Hawgent program is used in mathematics education to help students understand basic knowledge and build their skills (Tanu Wijaya et al., 2020). Since the COVID-19 pandemic, Brazil has also introduced distance learning (Council State Department of Education Rio de Janeiro, 2020). Carius investigated mathematics learning in Brazil using the 'Educa em Casa' platform as a mathematics-based learning media (Carius, 2020). Furthermore, Basilaila and Kvavadze (2020) discovered that since COVID-19 was implemented on April 8, 2020, Georgia has been undertaking online learning through Zoom, Slack, Google Meet, and EduPage.

The current situation has certainly posed a challenge and raised many concerns for teachers, particularly regarding how to deliver materials, design effective, engaging, and meaningful learning, and ensure that all students learn from a distance (Mailizar et al., 2020; Purwanto et al., 2020; Rasmitadila et al., 2020; Syah, 2020). The impact of Covid-19 on education is also felt in Indonesia. In Indonesia, "large-scale social restrictions" were adopted in March 2020 due to the increasing number of people infected with COVID-19. This was followed by other regulations such as working from home for employees, praying from home, and learning from home for students from early childhood education to higher education (Rasmitadila et al., 2020). Several researchers have carried out several solutions for developing technology-based learning media to facilitate mathematics.

Education stakeholders should recognize the potential of mobile technology as a source of learning for students (T. Chao et al., 2011). The development of mobile learning can improve the effectiveness and efficiency of student learning. Through smartphones, students can learn anywhere and anytime while engaging in social media activities or entertainment (Garcia-Peréz et al., 2015). Mobile learning technology can make learning easier for students (Portelli & Eldred, 2016). Mobile learning has practical characteristics and can be taken anywhere (Kennewell & Beauchamp, 2007). The operating system used is one consideration in developing smartphones into mobile learning media. Data from gs.statcounter.com stated that from January to December 2015, Android was the dominant operating system in smartphone circulation in Indonesia with a market share of 68.75%, followed by

Blackberry OS with a market share of 8.73% (Statcounter, 2015).

Simorangkir & Sembiring (2018) conducted research to develop Lectora Inspire-based learning media for mathematics learning in elementary schools. The results showed that 95.57% of students responded positively to Lectora Inspire, and 89.56% of teachers responded very well. Gusteti, Rifandi, Manda & Putri (2021) developed 3D animated video-based learning media for mathematics learning in elementary schools. The research result showed that the validation of the media was 3.33 and 3.67, respectively. These results indicate that the developed 3D animated video is very valid for elementary school students in mathematics learning. Similarly, Lauc, Jagodić & Bistrović (2020) stated in their research that multimedia increases student learning motivation in Croatia.

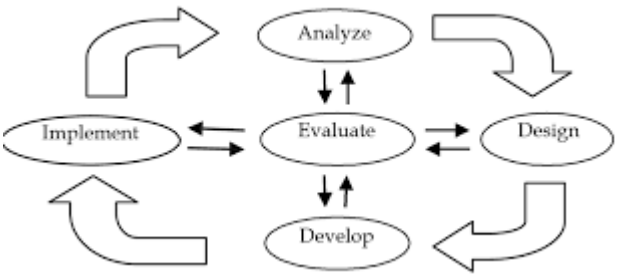
Experts claimed students like snakes and ladders media (Pallaro et al., 2015; Sianipar et al., 2021). Syawaludin, Rachman & Khaerunnisa (2020) developed a snakes and ladders game for elementary social studies. The snakes and ladders game was valid and practical, improving primary school students social studies interest and learning. 92% of respondents liked the snakes and ladders game. Husna (2020) added that the snakes and ladders game could promote eye health. The game covered healthy eyes, eye workouts, refractive issues, correct reading, eye tiredness, and eye health care professionals. Media professionals validated 91% of the developed media, health promotion specialists 82%, and eye health experts 46%. However, android-based snakes and ladders for elementary math learning have not been produced. Thus, during the COVID-19 epidemic, this project seeks to create an android-based snakes and ladders math learning media for third graders.

Both Indonesia and Taiwan are becoming more technologically dependent in various aspects of life, including education. Given the widespread use of smartphones and gadgets in both countries, creating mathematics learning tools aligned with technology trends can increase students' interest and participation. Thus, this study was conducted in both Indonesia and Taiwan. Research questions: Is the developed android-based snakes and ladders learning media feasible for third-grade elementary school students in learning mathematics on flat shape material? What are the student and teacher responses to the developed snakes and ladders media? Therefore, the objective of this study is to develop an Android-based snakes and ladders learning media to teach flat shape concepts in third-grade elementary school mathematics. This study also tries to find out teachers' and students' responses after implementation of media.

Method

The method used in this research is development research. According to Seels and Richey (1994), development research is a systematic study of designing, developing, evaluating educational programs and learning products, and meeting the internal consistency and effectiveness criteria of using the program or product. Furthermore, Akker explained that development research is usually conducted to develop curricula, media and technology, learning and teaching, and teacher education (van den Akker, 1999). The research model used is the ADDIE model. This ADDIE model has five stages: analysis, design, development, implementation, and evaluation (Chang, 2006). The ADDIE development model aims to improve the effectiveness and efficiency of education or training by understanding initial needs until adequate products are developed (Allen, 2006)knowledge, and expertise. Revisiting traditional training models and processes is important as a means of moving forward. Although there are many system models, almost all are based on the generic analysis, design, develop, implement, and evaluate (ADDIE. This research is carried out to develop a product in the form of a digital snakes and ladders game as a learning media for third-grade elementary school mathematics. The Android-based snakes and ladders media in learning mathematics on flat shape concepts help students in visualizing concepts, reinforcing understanding, and adding excitement to mathematics learning. The following is the ADDIE development model flowchart.

The procedure of the ADDIE model consists of Analyze, Design, Develop, Implement, and Evaluate. The learning system included in it relates to the processing and selection of content (learning resources), the arrangement of learning strategies, and also consists of the selection and development of media to be used, and the evaluation of goal achievement (Branch, 2009). However, in this study, the researcher only used 4 stages. The fifth stage was not conducted because the researcher had difficulty accessing the school due to the lockdown in Indonesia. Data collection techniques were



Flowchart 1: ADDIE Development Model

carried out using interviews and questionnaires. Interviews were used to analyze the initial needs of the product being developed. The questionnaire was used to measure the quality of the media being developed. The questionnaire will be given to subject matter experts and media experts. The data analysis techniques used in this study are qualitative and quantitative. Qualitative data sources come from preliminary studies that include described interviews. Meanwhile, quantitative data was obtained from expert assessments in subject matter and media converted into quantitative data.

Participants

The participants in the implementation phase of this research were students and teachers in third-grade elementary schools in Sidoarjo, East Java, Indonesia and in Miaoli, Taiwan. There were 30 students from Taiwan, consisting of 15 males and females and 34 students consisting of 12 boys and 18 girls from Indonesia, with a female teacher aged 38 years old. The students and teacher were selected to test their response to the developed learning media, a digital snake ladder game based on Android.

Indonesia and Taiwan were selected in the curriculum dimension due to the similar objective in mathematics education: developing conceptual understanding and mathematical thinking skills. However, differences were found in the content depth, learning priorities, and teaching approaches. Taiwan emphasized competitiveness and in-depth understanding, while Indonesia on practical applications. In this context, the research identified the implementation of Android-based digital snakes and ladders in mathematics education within both nations.

Instruments

This development research was validated by experts using a questionnaire as an instrument. The experts who assessed the Android-based digital snake ladder game were media and material experts. The assessment criteria table for media experts was adopted from Allesi & Trollip (2001) (Table 1).

Next is presented a table of assessment instrument grids by material experts adopted from Erikson (1977). (Table 2)

Table 1: Grid Instrument Validation by Media Experts

No	*Aspect*	*Indicator*
1	Layouts	Design Excitement
2	Text	Selection of font type and font size
		Color selection and writing location
		language use
3	Videos	Video Composition
		Video Excitement
		Video Quality
4	Animation	Amination Compatibility
		Amination's attractiveness
5	Audios	Suitability
		Accuracy
6	Games	Ease of Use
		Attractiveness
7	Programming	Sound Placement Accuracy
		Ease of Use
		Clarity of Instructions
		Flexibility of Use
		Meaningfulness
8	Navigation	Navigation function precision
		Quality with users
9	Packaging	Packaging attractiveness
		Compatibility of packaging with contents

Table 2: Grid of Validation Instruments by Media Experts

No	*Aspect*	*Indicator*
1	Quality of learning materials	The material is in accordance with competency standards and essential competencies
		Material according to learning indicators
		Presentation of interesting material for students
		Presentation of material in accordance with the cognitive development of students
		The material presented is in accordance with everyday life
		The tasks given in the material are in accordance with the learning objectives
2	Quality of learning design	Information is available such as competencies that must be mastered by students, table of contents, and bibliography

No	Aspect	Indicator
		Encouraging student interaction with learning resources
		Encourage student curiosity
		Encourage students to construct their knowledge
		The description of the material follows the flow of thought from simple to complex

Result and Discussions

An android-based snake and ladder game was developed using the ADDIE research and development model. The following is an explanation of the development results that the researcher has conducted. Analysis Stage (Analysis) In the needs analysis, the researcher interviewed two third-grade teachers from different schools in Indonesia and Taiwan. The first interview was conducted on January 20, 2022, with a third-grade teacher in an elementary school in Indonesia. The teacher used applications such as Google Classroom, Google Forms, Quizizz, and Kinemaster to support distance learning activities. However, online learning resulted in less than optimal material delivery by the teacher, leading to inadequate understanding by the students. One of the challenging topics for students was the concept of the perimeter of 2D shapes and its application to word problems.

The second interview was conducted on January 30, 2022, with a third-grade teacher in an elementary school in Taiwan. Several factors hindered the teacher's ability to deliver online learning effectively, such as a) the limited devices available to students for online learning, b) socio-economic factors, where most students came from middle to lower-income families, c) environmental factors, where the school and home environments were not conducive to online learning, and e) students' understanding of numerical concepts, especially the topic of the perimeter of 2D shapes and its application to word problems. Therefore, this study aims to develop an android-based digital snake and ladder game as a media to support mathematics learning in elementary schools.

Design Stage (Design) The next stage in the ADDIE model is the design stage. The learning media is designed and developed in this stage based on the previous analysis results. The development of this product utilizes Android Studio software. The result of this product development is an Android application in APK format. The device specifications for running this application are Android Ice Cream Sandwich (4.0) operating systemThe Android-based digital snake and ladder game media has several displays, including the home screen, a menu with learning objectives and competencies, a menu for materials with learning videos, and an evaluation menu with snake and ladder game quiz questions. The front screen uses the Kraashregular font with a font size of 23. The digital snake and ladder game for evaluation consists of levels 1 to 4. Levels 1 to 3 consist of 15 questions, while level 4 contains 30 questions. Clicking the dice moves the player according to its number. At each step, a multiple-choice question will appear to be answered by the player. The design results for the Android-based snake and ladder game media are as follows.

a. The initial display

Fig. 1: Initial design of digital snake ladder

Figure 2. Menu display on digital snake ladder

\b. Evaluation display

Fig. 3: Evaluation display on digital snake ladder

Fig. 4: Digital display of game end

Table 3: Validation Results of Android-Based Digital Snakes and Ladders Game on Media Experts

No	*Aspect*	*Indicator*	*Score*	*Criteria*
1	Layouts	Design Excitement	4	Very good
2	Text	Selection of font type and font size	4	Very good
		Color selection and writing location	4	Very good
		language use	4	Very good
3	Videos	Video Composition	3	Good
		Video Excitement	4	Very good
		Video Quality	4	Very good
4	Animation	Amination Compatibility	3	Good
		Amination's attractiveness	3	Good
5	audios	suitability	4	Very good
		Accuracy	4	Very good
6	Games	Ease of Use	3	Good
		attractiveness	4	Very good
7	Programming	Sound Placement Accuracy	4	Very good
		Ease of Use	4	Very good
		Clarity of Instructions	3	Good
		Flexibility of Use	4	Very good
		Meaningfulness	4	Very good
8	Navigation	Navigation function precision	4	Very good
		Quality with users	3	Good
9	Packaging	Packaging attractiveness	3	Good
		Compatibility of packaging with contents	4	Very good
Total				81
Percentage				92,04%
Criteria				very feasible

Next, a table of assessment instrument grids by material experts is presented, adopted from Erikson (1977). Android-based digital snakes and ladders media that has been completed, proceed to the next stage, namely the validation stage with several experts. The purpose of the validation activity is to test the feasibility of the media before later being tested in the field. The validation is focused on three aspects, namely media validation and material validation. The following will present the validation results of the Android-based digital snakes and ladders game to media experts.

The assessment by media experts on the Android-based digital snakes and ladders game has resulted in a validity and quality rating of "very feasible" with a percentage score of 92.04%. The validation process will proceed to the next stage, which is validation by subject matter experts (Table 4) .

The assessment result by media experts for the Android-based digital snake ladder game obtained a "very good" level of validity and quality. The overall score obtained was 37 with a percentage of 84.09%, categorized as very feasible.

In the implementation stage, a response test was carried out for the product that had been validated by experts. The response test was conducted to determine the response of third-grade elementary school students to the Android-based digital snake ladder game. The purpose of this response test was to find out the students' opinions on the developed digital snake ladder game. The response test was carried out on Friday, April 8, 2022, with 64 third-grade students from two elementary schools in Indonesia and Taiwan as respondents. Data from this activity were obtained from response questionnaires filled out by students after they tried using the digital snake ladder game (Table 5).

Based on the results of the student response test, it can be seen that the overall score obtained is 2083 out of the ideal score of 2550 with a percentage of 81.68%. It can be concluded that the results of the student response test to the Android-based digital snake ladder game fall into the very feasible category. The obtained score was mostly close to ideal one, meaning that media was categorized as effective and accepted.

The rapid development of technology has a significant impact on human life. This is marked by the emergence of various technological products that can make it easier for humans to carry out activities. The smartphone is one of the specialized products that is now widely used and has penetrated the world market. Around 1.7 billion smartphones are used worldwide, while the total world population is 6 billion (Shudong & Higgins, 2005). The potential for developing applications adds to the number of people using smartphones (Demidowich et al., 2012), opening up opportunities for this technology to support activities in the education world, one of which is mobile learning (T. Chao et al., 2011).

Android was developed by a company called Android, Inc. In 2005, as part of a strategy to enter the mobile space, Google purchased Android and took over its development (W.-M. Lee, 2012). Android provides an open platform for developers to create applications (G.-Y. Lee et al., 2013) the battery resources of such a system are inadequate as it has to trace the location of the moving target in real time and consumes a large amount of battery power while communicating with GPS satellites and mobile phone base stations. In addition, the systems cannot infer the mental state of the targets or detect their alcohol consumption levels, which may be necessary for the prevention of a repeat crime. The purpose of this study is to connect the Ubiquitous System Network (USN. Android is a mobile device platform that provides ease of development for users as expected (Ichwan et al., 2013). The Android system that supports application development is expected to produce representative mobile learning-based learning media (W.-M. Lee, 2012).

Table 4: Validation Results of Android-Based Digital Snakes and Ladders Game by Subject Matter Experts

No	*Aspect*	*Indicator*	*Score*	*Criteria*
1	Quality of learning materials	The material is in accordance with competency standards and basic competencies	4	Very good
		Material according to learning indicators	3	Good
		Presentation of interesting material for students	3	Good
		Presentation of material in accordance with the cognitive development of students	4	Very good
		The material presented is in accordance with everyday life	3	Good
		The tasks given in the material are in accordance with the learning objectives	3	Good
2	Quality of learning design	Information is available such as competencies that must be mastered by students, table of contents, and bibliography	3	Good
		Encouraging student interaction with learning resources	4	Very good
		Encourage student curiosity	3	Good
		Encourage students to construct their own knowledge	4	Very good
		The description of the material follows the flow of thought from simple to complex	3	Good
Total				37
Percentage				84,09%
Criteria				very feasible

Table 5. Student Response Test for Android-based Digital Snake Ladder Game

No	*Rated Aspect*	*Proper Score*	*Gain Score*	*Percentage*
1	The material in the digital ladder snake is clear and easy to understand	170	139	81,76%
2	The material contained in the digital ladder snake is complete	170	129	75,88%
3	The language used is easy to understand	170	133	78,23%
4	Writing in digital snakes and ladders is easy to read	170	148	87,05%
5	Menu selection in the digital ladder snake is easy to do	170	131	77,05%
6	The colors in the digital ladder snake are appropriate	170	127	74,70%
7	The screen display in digital ladder snake is interesting	170	144	84,70%
8	The image contained in the digital ladder snake is clear	170	141	82,94%
9	The layout of the text and images is not confusing	170	126	74,11%
10	Interesting animation used	170	149	87,64%
11	Animation in digital snakes and ladders according to the material	170	129	75,88%
12	The buttons in the digital ladder snake are easy to use	170	143	84,11%
13	The instructions in the digital ladder snake are easy to understand	170	136	80%
14	Digital Snakes and Ladders is easy to use	170	154	90,58%
15	I am interested in using this digital ladder snake	170	154	90,58%
Total		2550	2083	81,68%

Based on the study results, the product developed is an Android-based snake and ladder game using Android Studio application. This application was developed as a learning media for third-grade students in mathematics subjects. The home page is the first page users see when they enter the application. This learning media contains descriptions of the learning objectives and competencies, lesson materials, instructional videos, and exercises that can be accessed through an Android-based smartphone. The home page is a splash screen that shows a background image and the title of the application (Yormala & Setiawati, 2016). The menu comprises four sub-menus: learning objectives and competencies, learning goals, materials, and evaluation. The learning objectives and competencies menu describes the curriculum that will be implemented in mathematics learning. The learning goals menu explains the achievement indicators integrated with the third-grade curriculum. The materials menu presents instructional videos that contain mathematics lesson materials. Finally, a snake and ladder game with mathematics questions is presented in the evaluation section. In this final activity, students can learn while playing the digital snake and ladder game.

Android-based snake and ladder game development has been validated by two experts, namely media and material experts. The assessment result by media expert for this Android-based digital snake and ladder game received a "very feasible" level of validity and quality with a percentage of 92.04%. Similarly, the assessment result by material expert for Android-based snake and ladder media received a "very feasible" level of validity and quality with a percentage of 84.09%. Furthermore, in the implementation phase, the Android-based snake and ladder game was tested on third-grade elementary school students to determine their response. The results of the student response test showed an overall score of 277 out of the ideal score of 300 with a percentage of 92.3%. It can be concluded that the student response test result to the Android-based snake and ladder game falls into the "very feasible" category. It is hoped that with this Android-based snake and ladder game, students can easily learn anywhere they are.

Previously, several studies have been conducted on the development of mobile learning using Android as its platform. For example, Brata & Brata (2020) conducted a study on the development of Javanese language learning application based on mobile learning using Android. The results of this study showed that the development of mobile learning applications can improve students' learning outcomes and provide easy access to learning materials. In addition, a study conducted by Sun and Jiang (2015) on developing digital textbooks equipped with multimedia features, interactive controls, and e-annotations for elementary school students can be a solution for future learning. Another study also showed results that are consistent with this study (Syafmen et al., 2023). They developed a mobile learning application based on Android for numeracy literacy for junior high school students, and the results showed that the application

can improve students' learning outcomes. Overall, previous studies have shown that the development of Android-based mobile learning can benefit the education world, such as improving the effectiveness and efficiency of student learning, facilitating access to learning materials, and improving student motivation and learning outcomes.

Therefore, to enhance students' academic experience, it is necessary to utilize the educational affordances of game-based learning platforms such as the snake and ladder app as an appropriate approach for today's students. This game-based learning platform can also facilitate understanding abstract subjects (Cheng et al., 2023). Papadakis (2021) states that learning activities that can be integrated into digital applications should be well-designed so that students can interact with educators and their peers and provide fast and relevant feedback throughout the teaching session. The Android-Based Digital Snakes and Ladders media can be downloaded by using Android platform. Students start the game, enter the level or topic that they want to learn. They answer mathematics questions to play on the game. The correct answers allow the player to play on while wrong answers limit movement. The main objective is to reach the end of the game, while learning the concept of flat shapes interactively. Teachers who want to use the Android-based snake ladder app for fun learning should remember that lessons should be well-planned to ensure learners achieve the desired outcomes. Thus, using digital games in the classroom, as described in this study, has inspired students' knowledge in interactive learning.

Conclusion

Technology plays a vital role in learning in the digital era. Android-based digital snakes and ladders was developed as a mathematics learning solution for third grade elementary school. The feasibility scores from media experts (92.04%) and material experts (84.09%) show a high level of feasibility. The student response test produced a score of 92.3% in the very appropriate category. The technological elements in Android snakes and ladders are expected to attract students' interest in learning mathematics. However, further research is needed to explore learning design, influence on learning achievement, and teacher training. It is recommended that institutions support the use of fun and innovative game-based learning.

References

Al-Mashaqbeh, I. F. (2016). IPad in Elementary School Math Learning Setting. *International Journal of Emerging Technologies in Learning (IJET)*, *11*(02), 48. https://doi.org/10.3991/ijet.v11i02.5053

Allah, A., & Bashir, R. (2015). The role of using eductainment in learning EFL vocabulary. *Journal of Science and Technology : In Humanities*, *16*(4), 1–17. https://search.emarefa.net/detail/BIM-645476

Allen, W. C. (2006). Overview and Evolution of the ADDIE Training System. *Advances in Developing Human Resources*, *8*(4), 430–441. https://doi.org/10.1177/1523422306292942

Anagün, Ş. S. (2018). Teachers' Perceptions about the Relationship between 21st Century Skills and Managing Constructivist Learning Environments. *International Journal of Instruction*, *11*(4), 825–840. https://doi.org/10.12973/iji.2018.11452a

Argareta Simorangkir, F. M., & Kariani Br Sembiring, R. (2018). Effectiveness of Helped Mathematical Learning Media of Lectora Inspire on The Number Sense Ability of Fifth Grade Students of Elementary School in Substrate Materials. *Budapest International Research and Critics Institute (BIRCI-Journal) : Humanities and Social Sciences*, *1*(3), 352–358. https://doi.org/10.33258/birci.v1i3.59

Badraeni, N., Pamungkas, R. A., Hidayat, W., Rohaeti, E. E., & Wijaya, T. T. (2020). Analisis Kesulitan Siswa Berdasarkan Kemampuan Pemahaman Matematik Dalam Mengerjakan Soal Pada Materi Bangun Ruang Sisi Datar. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *4*(1), 247–253. https://j-cup.org/index.php/cendekia/article/download/195/134/

Basilaia, G., & Kvavadze, D. (2020). Transition to Online Education in Schools during a SARS-CoV-2 Coronavirus (COVID-19) Pandemic in Georgia. *Pedagogical Research*, *5*(4). https://doi.org/10.29333/pr/7937

Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer US. https://doi.org/10.1007/978-0-387-09506-6

Brata, K. C., & Brata, A. H. (2020). User experience improvement of japanese language mobile learning application through mental model and A/B testing. *International Journal of Electrical and Computer Engineering (IJECE)*, *10*(3), 2659. https://doi.org/10.11591/ijece.v10i3.pp2659-2667

Brumbaugh, D. K., Moch, P. L., & Wilkinson, M. (2005). *Mathematics Content for Elementary Teachers*. Routledge. https://www.routledge.com/Mathematics-Content-for-Elementary-Teachers/Brumbaugh-Moch-Wilkinson/p/book/9780805842470

Carius, A. C. (2020). Teaching Practices in Mathematics During COVID-19 Pandemic: Challenges for Technological Inclusion in a Rural Brazilian School. *American Scientific Research Journal for Engineering, Technology, and Sciences*, *72*(1), 35–43. https://asrjetsjournal.org/index.php/American_Scientific_Journal/article/view/6230/2232

Chang, S. L. (2006). The Systematic Design of Instruction. *Educational Technology Research and Development*, *54*(4), 417–420. https://doi.org/10.1007/s11423-006-9606-0

Chatmaneerungcharoen, S. (2019). Improving Thai Science Teachers' TPACK through an Innovative Continuing Professional Development Program. *Journal of Physics: Conference Series*, *1340*(1), 012017. https://doi.org/10.1088/1742-6596/1340/1/012017

Cheng, Y.-P., Lai, C.-F., Chen, Y.-T., Wang, W.-S., Huang, Y.-M., & Wu, T.-T. (2023). Enhancing student's computational thinking

skills with student-generated questions strategy in a game-based learning platform. *Computers & Education*, *200*, 104794. https://doi.org/10.1016/j.compedu.2023.104794

Chiu, T. K. F., & Mok, I. A. C. (2017). Learner expertise and mathematics different order thinking skills in multimedia learning. *Computers & Education*, *107*, 147–164. https://doi.org/10.1016/j.compedu.2017.01.008

Chotimah, S., Bernard, M., & Wulandari, S. M. (2018). Contextual approach using VBA learning media to improve students' mathematical displacement and disposition ability. *Journal of Physics: Conference Series*, *948*, 012025. https://doi.org/10.1088/1742-6596/948/1/012025

Council State Department of Education Rio de Janeiro. (2020). *Guides the institutions that are part of the System State School of the State of Rio de Janeiro on the development of non-classroom school activities, in exceptionality and temporality, as long as the isolation measures provided by the authorities in prev* (Issue 376). Department of Education Rio de Janeiro.

CunHua, L., Ying, Z., Qunzhuang, O., & Wijaya, T. T. (2019). Mathematics Course Design Based On Six Questions Cognitive Theory Using Hawgent Dynamic Mathematic Software. *Journal on Education*, *2*(1), 36–44. https://doi.org/10.31004/joe.v2i1.266

Demidowich, A. P., Lu, K., Tamler, R., & Bloomgarden, Z. (2012). An evaluation of diabetes self-management applications for Android smartphones. *Journal of Telemedicine and Telecare*, *18*(4), 235–238. https://doi.org/10.1258/jtt.2012.111002

Erikson, E. H. (1977). *Childhood and Society*. Paladin Grafton Books.

Fadel, C., & Trilling, B. (2009). *21st Century Skills: Learning for Life in Our Times*. Wiley Imprint.

Garcia-Peréz, M., Garcia-Nunez, J. A., Pelaez-Samaniego, M. R., Kruger, C. E., Fuchs, M. R., & Flora, G. E. (2015). Sustainability, business models, and techno-economic analysis of biomass pyrolysis technologies. In *Innovative Solutions in Fluid-Particle Systems and Renewable Energy Management* (pp. 298–342). IGI Global. https://doi.org/10.4018/978-1-4666-8711-0.ch010

Gleason, N. W. (2018). *Higher Education in the Era of the Fourth Industrial Revolution*. Springer Singapore. https://doi.org/10.1007/978-981-13-0194-0_1

Hernawati, K., & Jailani. (2019). Mathematics mobile learning with TPACK framework. *Journal of Physics: Conference Series*, *1321*(2), 022126. https://doi.org/10.1088/1742-6596/1321/2/022126

Husna, H. N., & Ardi, A. K. (2020). Snake and Ladder Game for Eye Health Promotion: A Development Research. *The Proceedings of the 2nd Bakti Tunas Husada-Health Science International Conference (BTH-HSIC 2019)*. https://doi.org/10.2991/ahsr.k.200523.061

Ichwan, M., Husada, M. G., & Rasyid, M. I. A. (2013). Pembangunan Prototipe Sistem Pengendalian Peralatan Listrik Pada Platform Android. *Jurnal Informatika*, *4*(1), 13–25. https://lib.itenas.ac.id/kti/wp-content/uploads/2013/10/Jurnal-No1Vol4-2.pdf

Istiq'faroh, N., Suhardi, S., & Mustadi, A. (2020). Improving elementary school students' creativity and writing skills through digital comics. *İlköğretim Online*, *19*(2), 426–435. https://doi.org/10.17051/ilkonline.2020.689661

Karlimah. (2018). Elementary school students' mathematical intelligence based on mathematics learning using classical music of the baroque era as the backsound. *SHS Web of Conferences*, *42*, 00112. https://doi.org/10.1051/shsconf/20184200112

Kennewell, S., & Beauchamp, G. (2007). The features of interactive whiteboards and their influence on learning. *Learning, Media and Technology*, *32*(3), 227–241. https://doi.org/10.1080/17439880701511073

Kirschner, P. A., & De Bruyckere, P. (2017). The myths of the digital native and the multitasker. *Teaching and Teacher Education*, *67*, 135–142. https://doi.org/10.1016/j.tate.2017.06.001

Lauc, T., Jagodić, G. K., & Bistrović, J. (2020). Effects of Multimedia Instructional Message on Motivation and Academic Performance of Elementary School Students in Croatia. *International Journal of Instruction*, *13*(4), 491–508. https://doi.org/10.29333/iji.2020.13431a

Lee, G.-Y., Yun, N.-Y., Lee, S.-C., & Park, S.-H. (2013). A Smart Electronic Tagging System Based on Context Awareness and Machine-to-Machine Interworking. *International Journal of Distributed Sensor Networks*, *9*(10), 392083. https://doi.org/10.1155/2013/392083

Lee, W.-M. (2012). *Beginning Android Application Development*. Wiley Publishing Inc.

Lin, S., Zhou, Y., & Wijaya, T. T. (2020). Using hawgent dynamic mathematics software in teaching arithmetic operation. *International Journal of Education and Learning*, *2*(1), 25–31. https://doi.org/10.31763/ijele.v2i1.97

Mailizar, M., Almanthari, A., Maulina, S., & Bruce, S. (2020). Secondary School Mathematics Teachers' Views on E-learning Implementation Barriers during the COVID-19 Pandemic: The Case of Indonesia. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(7), em1860. https://doi.org/10.29333/ejmste/8240

McGrath, K. F., & Van Bergen, P. (2015). Who, when, why and to what end? Students at risk of negative student–teacher relationships and their outcomes. *Educational Research Review*, *14*, 1–17. https://doi.org/10.1016/j.edurev.2014.12.001

Miguel-Revilla, D., Martínez-Ferreira, J. M., & Sánchez-Agustí, M. (2020). Assessing the digital competence of educators in social studies: An analysis in initial teacher training using the TPACK-21 model. *Australasian Journal of Educational Technology*, *36*(2), 1–12. https://doi.org/10.14742/ajet.5281

Mushipe, M., & Ogbonnaya, U. I. (2019). Geogebra and Grade 9 Learners' Achievement in Linear Functions. *International Journal of Emerging Technologies in Learning (IJET)*, *14*(08), 206. https://doi.org/10.3991/ijet.v14i08.9581

National Education Association. (2010). *Preparing 21st Century Students for a Global Society : An Educator's Guide to the "Four Cs."* https://www.aledoisd.org/cms/lib/TX02205721/Centricity/Domain/2020/Preparing21C_Learners.pdf

Oner, D. (2020). A virtual internship for developing technological pedagogical content knowledge. *Australasian Journal of Educational Technology*, *36*(2), 27–42. https://doi.org/10.14742/ajet.5192

Pallaro, E., Subramanian, N., Abdulrahman, M. D., & Liu, C. (2015). Sustainable production and consumption in the automotive sector: Integrated review framework and research directions. *Sustainable Production and Consumption*, *4*, 47–61. https://doi.org/10.1016/j.spc.2015.07.002

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2021). Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten. *Advances in Mobile Learning Educational Research*, *1*(1), 5–18. https://doi.org/10.25082/AMLER.2021.01.002

Peters, M. A., Wang, H., Ogunniran, M. O., Huang, Y., Green, B., Chunga, J. O., Quainoo, E. A., Ren, Z., Hollings, S., Mou, C., Khomera, S. W., Zhang, M., Zhou, S., Laimeche, A., Zheng, W., Xu, R., Jackson, L., & Hayes, S. (2020). China's Internationalized Higher Education During Covid-19: Collective Student Autoethnography. *Postdigital Science and Education*, *2*(3), 968–988. https://doi.org/10.1007/s42438-020-00128-1

Polly, D., McGee, J., Wang, C., Martin, C., Lambert, R., & Pugalee, D. K. (2015). Linking professional development, teacher outcomes, and student achievement: The case of a learner-centered mathematics program for elementary school teachers. *International Journal of Educational Research*, *72*, 26–37. https://doi.org/10.1016/j.ijer.2015.04.002

Portelli, P., & Eldred, C. (2016). A quality review of smartphone applications for the management of pain. *British Journal of Pain*, *10*(3), 135–140. https://doi.org/10.1177/2049463716638700

Purwanto, A., Asbari, M., Fahlevi, M., Mufid, A., Agistiawati, E., Cahyono, Y., & Suryani, P. (2020). Impact of work from home (WFH) on Indonesian teachers performance during the covid-19 pandemic: An exploratory study. *International Journal of Advanced Science and Technology*, *29*(5), 6235–6244.

Rachmadtullah, R., MS, Z., & Syarif Sumantri, M. (2018). Development of computer-based interactive multimedia : study on learning in elementary education. *International Journal of Engineering & Technology*, *7*(4), 2035. https://doi.org/10.14419/ijet.v7i4.16384

Rasmitadila, R., Aliyyah, R. R., Rachmadtullah, R., Samsudin, A., Syaodih, E., Nurtanto, M., & Tambunan, A. R. S. (2020). The Perceptions of Primary School Teachers of Online Learning during the COVID-19 Pandemic Period: A Case Study in Indonesia. *Journal of Ethnic and Cultural Studies*, *7*(2), 90–109. https://doi.org/10.29333/ejecs/388

Redmond, P., & Lock, J. (2019). Secondary pre-service teachers' perceptions of technological pedagogical content knowledge (TPACK): What do they really think? *Australasian Journal of Educational Technology*, *35*(3). https://doi.org/10.14742/ajet.4214

Rohaeti, E. E., Bernard, M., & Primandhika, R. B. (2019). Developing Interactive Learning Media For School Level Mathematics Through Open-Ended Approach Aided by Visual Basic Application For Excel. *Journal on Mathematics Education*, *10*(1), 59–68. https://doi.org/10.22342/jme.10.1.5391.59-68

Rotherham, A. J., & Willingham, D. (2006). 21st Century Skills: The Challenges Ahead. *Teaching for the 21st Century*, *67*(1), 16–21.

Schoenfeld, A. H., & Sloane, A. H. (2016). *Mathematical thinking and problem solving*. Routledge.

Seels, B. B., & Richey, R. C. (1994). *Instructional Technology: The Definition and Domains of the Field*. Association for Educational Communications and Technology.

Shudong, W., & Higgins, M. (2005). Limitations of Mobile Phone Learning. *IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'05)*, 179–181. https://doi.org/10.1109/WMTE.2005.43

Sianipar, N. J., Nur, R., & Ruslan, D. (2021). Development Of Learning Media For The Game Of Snakes And Ladders To Increase Students Learning Interest In The Ppkn Subject For Class III SD Negeri 024776 Binjai. *Sensei International Journal of Education and Linguistic*, *1*(2), 375–388. https://doi.org/10.53768/sijel.v1i2.34

Statcounter. (2015). *Top 8 Mobile Operating System In Indonesia*. Browser Market Share Worldwide. http://gs.statcounter.com/#mobile_os-IDmonthly-201501-201508-bar

Sukaesih, S., Ridlo, S., & Saptono, S. (2019). Development of biology teaching management textbooks based on competency and conservation to maximize Pedagogical and Content Knowledge (PCK) the prospective teachers. *Journal of Physics: Conference Series*, *1321*(3), 032114. https://doi.org/10.1088/1742-6596/1321/3/032114

Sumantri, M. S., Prayuningtyas, A. W., Rachmadtullah, R., & Magdalena, I. (2018). The Roles of Teacher-Training Programs and Student Teachers' Self-Regulation in Developing Competence in Teaching Science. *Advanced Science Letters*, *24*(10), 7077–7081. https://doi.org/10.1166/asl.2018.12412

Sun, Z., & Jiang, Y. (2015). How the young generation uses digital textbooks via mobile learning terminals: Measurement of elementary school students in China. *British Journal of Educational Technology*, *46*(5), 961–964. https://doi.org/10.1111/bjet.12299

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, *94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Syafmen, W., Novferma, N., Kamid, Romundza, F., & Lase, A. G. (2023). Analysis of Mathematic Literacy Ability of Junior High School Student Using Android-Based Mobile Learning Media in the Time Covid-19 Pandemic. In *Advances in Social Science, Education and Humanities Research* (pp. 345–353). https://doi.org/10.2991/978-2-38476-012-1_44

Syah, R. H. (2020). Dampak Covid-19 pada Pendidikan di Indonesia: Sekolah, Keterampilan, dan Proses Pembelajaran. *SALAM: Jurnal Sosial Dan Budaya Syar-I*, *7*(5), 395–402. https://doi.org/10.15408/sjsbs.v7i5.15314

Syawaluddin, A., Afriani Rachman, S., & Khaerunnisa. (2020). Developing Snake Ladder Game Learning Media to Increase Students' Interest and Learning Outcomes on Social Studies in Elementary School. *Simulation & Gaming*, *51*(4), 432–442. https://doi.org/10.1177/1046878120921902

T. Chao, J., R. Parker, K., & Fontana, A. (2011). Developing an Interactive Social Media Based Learning Environment. *Issues in Informing Science and Information Technology*, *8*, 323–334. https://doi.org/10.28945/1421

Tanu Wijaya, T. (2020). How chinese students learn mathematics during the coronavirus pandemic. *IJERI: International Journal of Educational Research and Innovation*, *15*, 1–16. https://doi.org/10.46661/ijeri.4950

Tanu Wijaya, T., Ying, Z., & Purnama, A. (2020). Using Hawgent Dynamic Mathematic Software in Teaching Trigonometry. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(10), 215. https://doi.org/10.3991/ijet.v15i10.13099

Trollip, S. R., & Alessi, S. M. (2001). *Multimedia for learning: methods and development* (3rd editio). Pearson Education.

Ultra Gusteti, M., Rifandi, R., Gustya Manda, T., & Putri, M. (2021). The development of 3D animated video for mathematics learning in elementary schools. *Journal of Physics: Conference Series*, *1940*(1), 012098. https://doi.org/10.1088/1742-6596/1940/1/012098

van den Akker, J. (1999). Principles and Methods of Development Research. In *Design Approaches and Tools in Education and Training* (pp. 1–14). Springer Netherlands. https://doi.org/10.1007/978-94-011-4255-7_1

Viner, R. M., Russell, S. J., Croker, H., Packer, J., Ward, J., Stansfield, C., Mytton, O., Bonell, C., & Booy, R. (2020). School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *The Lancet Child & Adolescent Health*, *4*(5), 397–404. https://doi.org/10.1016/S2352-4642(20)30095-X

Wijaya, T. T., Murni, S., Purnama, A., & Tanuwijaya, H. (2020). Pengembangan Media Pembelajaran Berbasis Tpack Menggunakan Hawgent Dynamic Mathematics Software. *Creative of Learning Students Elementary Education*, *3*(3), 205–214. https://doi.org/https://doi.org/10.22460/jpmi.v1i3.205-214

Wijaya, T. T., Ying, Z., & Suan, L. (2020). Gender and Self Regulated Learning During COVID-19 Pandemic in Indonesia. *Jurnal Basicedu*, *4*(3), 725–732. https://doi.org/10.31004/basicedu.v4i3.422

Yormala, W., & Setiawati, K. (2016). Perancangan Aplikasi Kamus Geografi Berbasis Android. *Jurnal TEKNOIF*, *4*(1), 48–56. https://teknoif.itp.ac.id/index.php/teknoif/article/view/351/694

Zhu, X., & Liu, J. (2020). Education in and After Covid 19: I mmediate Responses and Long-Term Visions. *Postdigital Science and Education*, *2*(3), 695–699. https://doi.org/10.1007/s42438-020-00126-3