

Developing Dynamic Number Card Game of Number Sense for First Grade Students

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Abstract. *This study aims to develop a learning media in the form of a dynamic number card game based on number sense as a media for learning mathematics for first graders. This study uses the research and development (R&D) with ADDIE model. Data collection techniques were interviews, observation, and questionnaires. The quality of the dynamic number card game was obtained from the validity and practicality test. Expert validation was carried out to evaluate the quality of media and content. The practicality test was conducted one-to-one (3 students) and in small groups (6 students working in small groups). The results showed that the dynamic number card game received a high score of validity from the expert judgment. The students also had positive responses to the practicality of the dynamic number card game in guessing and ordering numbers. The findings indicate that the dynamic number card game has the potential to be used as a medium for learning number sense for first grade students.*

Keywords: *dynamic number card game, first-grade students, number sense, research and development*

Introduction

Students still consider mathematics a difficult subject to learnt (Siregar, 2017). Mathematics learning in schools is still conventional, in the form of memorizing formulas. Teachers are still the centre of presenting information which makes the mathematics learning process tends to be monotonous (Sembiring, Hadi, & Dolk, 2008). Mathematics learning will be fun if it can be packaged well-using technology or other learning media, especially in primary school.

Among several domains in primary school, number sense becomes a central topic to be developed by first graders. Number sense is a student's grasp of numbers and number operations, as well as the ability to apply that information to make flexible mathematical decisions and build effective and efficient strategies for dealing with number-related difficulties (Anghileri, 2006; Bana, Farrell, Gleeson, Jones, McIntosh, & Swan, 1999; McIntosh, Reys, & Reys, 1992). According to Sood and Mackey (2015), number sense serves as a foundation for formally grasping mathematical concepts and abilities. Someone with good number sense usually has the ability and expertise to process numbers. This ability is not only used when performing mathematical calculations but also in everyday life. Burton (1993) further explained that someone with good number sense can use various ways and strategies to solve complex problems. From this opinion,

it is obvious that number sense has many benefits not only in learning mathematics at school but can also be used to facilitate solving problems encountered in daily life.

Students require number sense skills to solve greater and more complicated mathematical tasks (Treffers, 2001; Van Nes, 2009). Students with a strong number sense see numbers as a unified whole and employ arithmetic mental calculation procedures appropriate to the number situation. Number sense ability will make students think flexibly so they can solve mathematical problems in various conditions and situations. However, some previous studies have shown that many students did not perform well in number sense (Mutmainnah, Putra, & Syahrilfuddin, 2021; Witri, Putra, & Nurhanida, 2015; Yang & Li, 2008). Students tend to struggle to solve number tasks with flexible strategies, such as using mental arithmetic.

One of the important roles of number sense is shown in problem-solving, namely providing skills to solve a problem (Mutmainnah et al., 2021). In this case, students will have the ability to understand the relationship between the core of the problem and the calculations that must be carried out, recognize, and use various ways and strategies to solve problems, use efficient and flexible number representations, estimate various possible answers to a problem, decide whether the answers obtained are following the problems at hand, and re-checking the results of the work and the answers generated. In solving mathematical problems, someone with good number sense can use number representations that do not depend on algorithms or ordinary calculation procedures (Saleh, 2009). Therefore, it is important to support first-grade students' number sense development.

There are several studies on investigating students' number sense (Hativa, 1993; Howell & Kemp, 2010; Tjoe, 2017, 2021; Yang, 2019), and some of them focused on supporting students' number sense (Baccaglini-Frank & Maracci, 2015; Flores & Hinton, 2022; Pareto, 2014; Scalise, Daubert, & Ramani, 2020). For instance, Flores and Hinton (2022) use the concrete-representational-abstract-integrated (CRA-I) sequence to develop pre-kindergarten to six-grade students' number knowledge and understanding of addition. This study involved students working with twelve mini lessons of number sense, and the results found that the intervention impacted students' conceptual understanding and supported automaticity. Meanwhile, Scalise et al. (2020) conducted an intervention study to use numeral card games to improve low-income preschool students' number sense and functional skills. This study used a concrete number card game to increase students' numerical identification and magnitude comparison skills. Both studies developed instructional learning and media based on concrete objects, such as number card games.

In contrast to the two previous studies, Baccaglini-Frank and Maracci (2015) developed multi-touch technology for fostering preschool students' number sense. This study is based on an

examination of students' interactions with various applications as part of a series of activities focusing on the use of the iPad. Those applications have the potential to play complementary roles in the development of students' number sense (Baccaglini-Frank & Maracci, 2015). Similarly, a dynamic game called a teachable agent game developed by Pareto (2014) has achieved deeper levels of mathematical thinking and reasoning in primary and lower secondary school students. The game provides students to leverage engagement, reflection and learning mathematics concepts and reasoning. Besides, the technological game has the potential to support students' motivation to learn number sense. For instance, Jaemu, Kim, and Lee (2008) developed a web-based program to motivate students' underachieve learning number sense.

Considering the development of technology, the researchers find a potential to combine number card games and technology. The use of digital technology in learning number sense raises an issue to develop a media called a dynamic number card game. The game becomes an instrumental genesis for students' development of number sense. In addition, the dynamic number card game is developed for a mobile phone used, so it can be assessed by teachers, students, and parents easily. Thus, the present study sought answers to research questions: how is the dynamic number card game developed? And what is the validity and practicality of the dynamic number card game that has been developed?

Method

The type of research used in this study is research and development (R&D). R&D is a research method used to produce certain products, and test their effectiveness of the products (Creswell & Creswell, 2017). The R&D model used is the ADDIE (analyze; design; development; implementation and evaluation) model (Branch, 2009) (Figure 1). The ADDIE development model is applied to develop a dynamic number card game. The reason to choose the ADDIE model is its educational philosophy that deliberate learning should be student-centred, inventive, authentic, and inspiring (Branch, 2009).

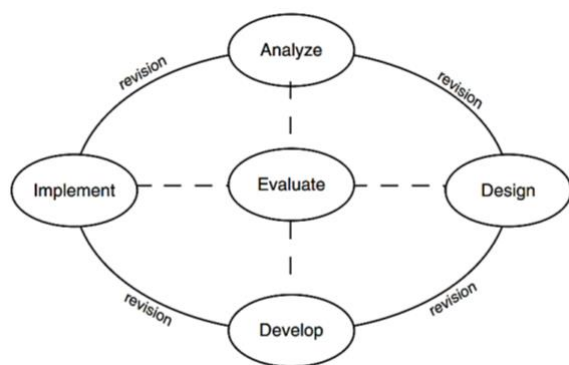


Figure 1. The diagram of ADDIE model (Branch, 2009)

The ADDIE model is a five-phase technique (Branch, 2009; Mamolo, 2019). The first stage is analysis, which aims to discover possible explanations for a performance disparity. The design phase follows to validate the expected performances and appropriate testing methodologies. The development phase's goal is to create and validate learning resources. The implementation phase is concerned with creating the learning environment and engaging students, whereas the evaluation phase is concerned with assessing the quality of the instructional products and procedures both before and after implementation (Branch, 2009). Then, in the next paragraphs, each aspect of this investigation is expounded on further.

The first step taken by the researchers was to collect information related to first-grade students' number sense ability. The first researcher observed students and interviewed the principal and the homeroom teacher of first grade. The questions asked were about the learning process in class, the learning media used, and students' number sense ability. After that, the researchers conducted an analysis of the curriculum, students' characteristics, and mathematics contents learnt by students.

The second step is designing. This stage has a very important role because at this stage the researchers begin to develop the product, including 1) Looking for various supporting reference sources related to educational games and number sense for first-grade students, 2) Make a grid of instruments as a follow-up step from previous observations and interviews, 3) Planning the manufacture of media, namely educational games to match the competencies to be achieved in learning numbers in first grade, 4) Designing educational games as number learning media to support students' number sense skills using the Canva application; 5) Design number cards as attractive as possible; 6) Look for various forms of game images related to number sense, and 7) Use the android studio application to create educational games. This product is named the dynamic number card game and was developed in the form of an application that can be operated via Android.

The third phase is development, and the researchers conduct expert validation. Validation from the experts is useful to find out whether the dynamic number card game is feasible or not to be used in learning. With the help of experts, media improvement can be carried out appropriately. Expert validators for this study consist of three experts, two are researchers in mathematics education, and one is an experience teacher in the first grade of elementary school.

The implementation stage is the stage for implementing the media design that has been developed in real situations (Cahyadi, 2019). As a further step from the development stage, at the implementation stage, the media has started to be tested on students. In small group trials, more students were involved than during one-on-one trials. In a one-on-one trial, the media was evaluated by three students. Meanwhile, small group trials were conducted on six students. During

the one-on-one trial, the first researcher showed the game to the students, let them play with it, and then asked their opinion through interviews. Meanwhile, during the small group trial, students played the game in a small group. At the end of the meeting, the students were asked to fill out a questionnaire to know the practicality of the product. All students have already able to read the questions, but the first researcher gave technical support to students who had difficulties understanding the questions.

The evaluation stage is the last step and aimed to receive feedback from students as users of the dynamic number card game. At this stage, the evaluation used is formative. Formative evaluation is an evaluation carried out at the end of every face-to-face meeting (Mohamadi, 2018; Whitworth & Wright, 2015). The small group test was conducted on six first-grade students. Tests were conducted to obtain more relevant data and to obtain corrections and suggestions regarding media products that had previously gone through several stages of revision. The researchers also conducted interviews with each student to see what the final response of students to the use of the dynamic number card game was.

Evaluation of the dynamic number card games by experts focuses on two main aspects, namely content and media. The content aspect consists of eight questions which are divided into two indicators, namely presentation and materials, and the media aspect consists of 12 questions which are divided into three indicators, namely quality, effectivity, and programming (Mamolo, 2019). Then, the criteria of the practicality of the dynamic number card game consisted of 10 questions that were adapted from the previous study conducted by Mukholifah, Tisngati, and Ardhyantama (2020) and Mamolo (2019). The percentage of experts' and students' responses is presented in Table 1 (Mamolo, 2019).

Table 1. The interpretation of validators, teachers, and students' responses to the dynamic number card game

Percentage	Category
100-81%	Very Valid/Very Good
80-61%	Valid/Good
60-41%	Moderately Valid/Fair
≤40%	Not Valid/Poor

Results and Discussion

The dynamic number card game was developed using the ADDIE model which consists of five stages. The following describes the details of the implementation from each stage.

Analyze

The analysis stage is divided into three stages, namely curriculum analysis, students' characteristics, and content analysis. The following explains the stages of analysis.

1) Curriculum Analysis

Curriculum can be interpreted in three ways: as an idea, as a practice, and as a subject of study (Green, 2022). In terms of student learning, the curriculum can be seen as a learning experience device that will be obtained by students. To understand it, the researchers analyzed the curriculum in one public elementary school in Pekanbaru, Indonesia. The school used the year 2013 Curriculum which was adapted to learning activities during the COVID-19 pandemic. Learning in first grade is carried out by grouping each subject and rearranging basic competencies and indicators to make it easier for teachers to deliver learning due to limited space for movement.

The implementation of the year 2013 Curriculum was adjusted during the COVID-19 pandemic. Literacy and numeracy learning modules were created by the government to make it easier for teachers, students, and parents to carry out online learning. However, there is still limited access for the students on using technology in learning mathematics.

Researchers conducted an analysis of basic competencies and indicators contained in the year 2013 Curriculum with the literacy and numeracy learning model so that the learning objectives were still achieved. There are two basic competencies (KD in Indonesian term) used in developing this educational game, namely KD 3.1 (sorting a group of numbers) and KD 3.3 (comparing two numbers) whose indicators have been adjusted based on the literacy and numeracy learning model.

2) Analysis of Student Characteristics

Analysis of the characteristics of students is carried out with the aim that the development of educational games can be following the way students learn. The characteristics of students in low grades (first grade until third grade) are different from students in high grades (fourth grade until sixth grade). Piaget (1976) has identified the stages of intellectual development that children go through (a) the sensory-motor stage aged 0-2 years, (b) the operational stage aged 2-6 years, (c) the concrete operational stage age 7-11 years or 12 years, and (d) the formal operational stage of age 11 or 12 years. Thus, one can know that students who are in elementary school are in the concrete operational stage at the age of 7-11 or 12 years. At this stage, children can think logically but the shortcomings in this phase without a real object, the children will have difficulty and even be unable to solve problems properly (Lubis, Widada, Herawaty, Nugroho, & Anggoro, 2021).

This opinion is according to the facts found by the researchers in the school. During distance learning and online learning, students found it very difficult to understand learning only with the teacher's explanation through google meet. Educational game media is very suitable to be used to help students understand learning. The concept of educational games gives students the experience of learning and playing at the same time (Vlachopoulos & Makri, 2017; Zirawaga, Olusanya, & Maduku, 2017). The display of attractive images and colours can help restore student focus.

3) Content Analysis

Content analysis was carried out so that the mathematics learning material on the number domain can be following the game media that will be made, and the learning objectives can be achieved. The content selected was following the analysis that had previously been carried out by the researchers, by integrating the year 2013 Curriculum with the literacy and numeracy learning model. The topics are sorting and comparing numbers. The description of the content is to sort the numbers from 1 to 10 and compare two sets of objects with the terms less, more or equal to. The two learning contents are used as a reference by researchers in developing these math learning games.

Design

The next stage after the analysis stage is the design stage. Before starting the design stage, the researchers collected materials related to learning numbers and research related to the game media that would be developed. The steps taken include:

1) Developing Instruments

The research instrument is useful for assessing the feasibility of number learning game media. The instruments used are to assess the quality of the media and its practicality from students' perspectives. The instrument to assess the quality of media consists of three aspects (quality, effectiveness, and programming) with a total of 12 questionnaires. The instrument to assess the content consists of two aspects (presentation and material) with a total of eight questionnaires. The student response instrument used for the trial consisted of 10 questionnaires (material, language, display, pictures, and buttons).

2) Product Design

The design of the product begins with creating a game concept using several applications. To make cards in the game, the researchers used Canva and android studio applications. The pictures on the cards are number sense models. The number sense components used by the researcher are dots, numerals, fingers and pictures (apple and ball). Each card contains numbers 1 to 10. There are 50 different cards (Figure 2).

Evaluation of the design stage was carried out to change the initial design of the dynamic number card game. This change was made to make the game look more attractive. The evaluation of the design stage was carried out by a focus group discussion among researchers and discussed with the programmers to help the researchers create this dynamic number card game better.

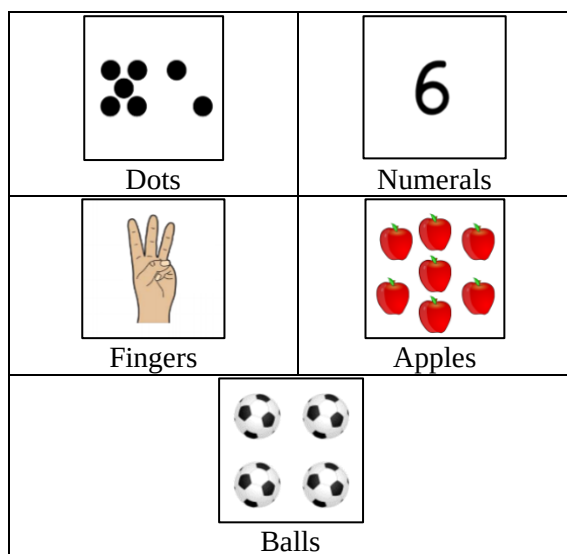


Figure 2. Some examples of number representations in the dynamic number card game

Development

In the development phase, the researchers begin to create number cards and the game. The researchers describe the step of developing the dynamic number card game as follows:

- 1) Designing the dynamic number card game
 - a) Creating number cards

Number cards were created using the Canva application. To create cards, the researchers used a logo template. The template is used to equalize the size of the card in the form of a square (Figure 3).

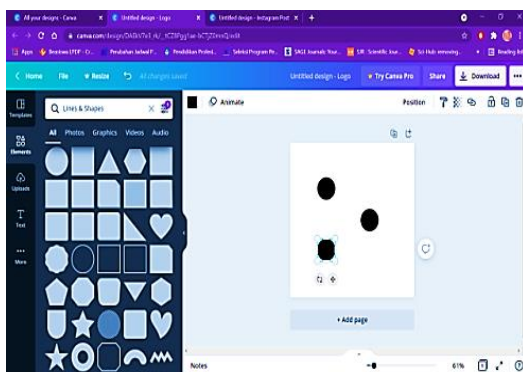


Figure 3. Making cards using canva

- b) Making a dynamic number card game

A dynamic number card game was created using the Android Studio application. Android studio is the official Integrated Development Environment (IDE) for android application development and is open source or free (Juansyah, 2015). The android studio used in making dynamic number card games is Android Studio 4.2.2 for Windows (Figure 4).

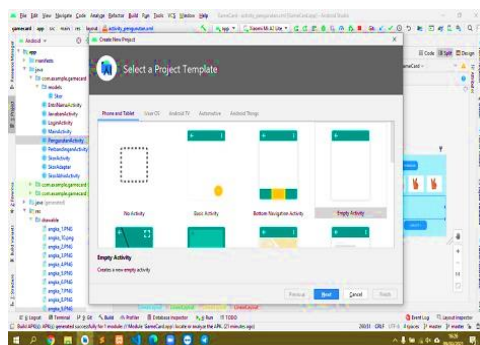


Figure 4. Starting project

c) The front page of the dynamic number card game

The game's front page is designed with blue backgrounds, colourful character images and numbers. There are two buttons, the "start" and "exit" buttons (Figure 5).



Figure 5. Front page of dynamic number card game

d) The main page of the dynamic number card game

The main page of the dynamic number card game is designed in blue with scattered colourful numbers. The selection of this design is done so that the game looks attractive and follows the theme of the game, which is about numbers (Figure 6).

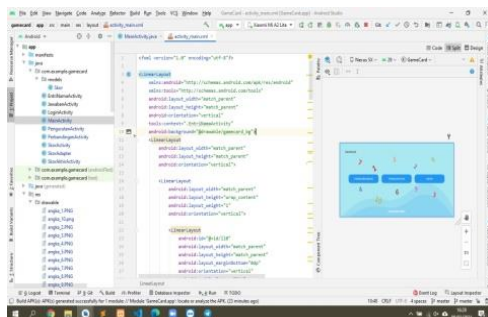


Figure 6. Making the main page

e) Menu in the dynamic number card game

There are three buttons on the main page of the dynamic number card game, namely the comparison (*perbandingan*) button, sorting (*pengurutan*) button, and score (*skor*) button (Figure 7).



Figure 7. Menu in the dynamic number card game

f) Comparison game display

At the top, there is a command about "compare the following 2 objects". There are 2 types of cards to be compared. In the middle of the card is given a space and a question mark symbol (?). At the bottom, there are three answer choices, namely "less than (*lebih kecil*)", "equal to (*sama dengan*)", and "more than (*lebih besar*)" (Figure 8). The number 1 on the 1/10 button shows the question number and the number 10 shows the total number of questions. The button will change to "continue" when someone clicks one of the answer buttons.



Figure 8. Comparison game display

g) Sorting game display

At the top, there is a command about "order from smallest to largest". Under the command questions, some cards must be sorted. The number of cards will increase according to the number of questions (Figure 9). Question numbers 1 and 2 consists of 2 cards. Question numbers 3 and 4 consists of 3 cards. Question numbers 5 and 6 consists of 4 cards. Question numbers 7 and 8 consists of 5 cards. Question numbers 9 and 10 consists of 6 cards. Each card is programmed to come out randomly. This means that players will not get the same card image every time they play, and neither will other players.



Figure 9. Sorting game display

h) Create a name for scores

After completing answering questions in the game, players will be asked to fill in their names (Figure 10). If this is done so that players can see the score they get. After entering the name and pressing the save button, the player will automatically return to the main page.

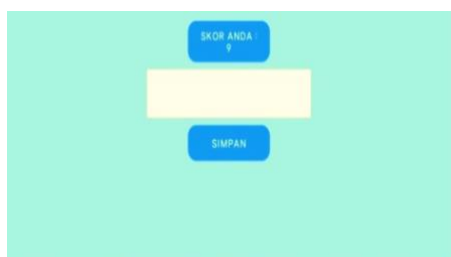


Figure 10. Create a name for scores

i) Score display

The score display is divided into two parts, the comparison score and the sorting score. The minimum score that can be obtained by the player is 0 and the maximum score is 100.

j) The “help” button

The help button contains the procedures for playing the game. The back button is for returning to the main menu.

2) Media and content validation of dynamic number card game

Expert validation aims to determine the feasibility of the developed media before testing it on students. Expert validation was carried out by three experts. They evaluated the quality of the media in terms of content and media (Table 2). The content validity focuses on the presentation and material presented in the dynamic number card game. Meanwhile, the media validity focuses on its quality, effectiveness, and programming. Overall, the quality of the dynamic number card game fulfils the very valid category. This means that the media is acceptable to be tested on first-grade students at elementary school.

Table 2. Media and content validation

	Aspects	Average Score	Category
Content	Presentation	100%	Very Valid
	Material	93.75%	Very Valid
Media	Quality	80%	Very Valid
	Effectivity	95%	Very Valid
	Programming	88%	Very Valid

Implementation

The dynamic number card game media which has been validated by experts is then tested on first-grade primary school students. The implementation phase is carried out using a one-to-one experiment. Researchers asked five questions to three students regarding the dynamic number card educational game they had played. Here is one excerpt of the interview with student A:

- R : How do you feel after playing the dynamic number card game?*
Student A : Yes, [I am] happy.
R : What do you think about this dynamic number card game?
Student A : It's nice, because [I can learn] while playing.
R : Did you find any difficulties while playing with this dynamic number card game?
Student A : No, I don't. [It is] easy to play
R : Can you answer all the questions on the dynamic number card game?
Student A : Yes, but there was a mistake because I was nervous.
R : Is it easier for you to understand the number learning material by using the dynamic number card game?
Student A : Yes, it's easier to use games than textbooks.

From the results of interviews with student A, He was very happy to be able to play while learning using the dynamic number card game. He also did not find trouble when answering the questions contained in the game. Student A also said that it was easier to understand learning materials using games than using textbooks.

The researchers also found similar results when interviewing other students. They did not have any difficulties when interacting with the game, so they can solve the problem on it. When playing with the dynamic number card game, the way they answer the questions is different. Among them, some have a strong grasp and memory. Even though they have different abilities, every student can still finish the game well and agree that learning while using the dynamic number card game is fun and interesting.

Evaluation

Small group implementation was conducted by researchers to apply the dynamic number card game. This was done because from the beginning, the purpose of the dynamic number card game was developed as a media for learning mathematics. Small group implementation was conducted on six first-grade students from a public primary school in Pekanbaru. Small group

implementation was conducted by providing students with mathematics learning materials using the dynamic number card game. The students worked in a small group of two students.

The researchers gave a questionnaire to students consisting of 10 statements. The scores obtained from the questionnaire can be seen in Table 3.

Table 3. Student response to the dynamic number card game

No	Statement	Percentage (%)	Category
1	I can easily understand the number learning material using the dynamic number card game	87.5%	Very Good
2	The language used in the dynamic number card game is clear	91.67%	Very Good
3	Dynamic number card game display very interested	87.5%	Very Good
4	I can use the buttons on the dynamic number card game	87.5%	Very Good
5	The image in the dynamic number card game is visible	83.33%	Very Good
6	The writing on the dynamic number card game can be read	91.67%	Very Good
7	The pictures in the dynamic number card game are interesting and varied	95.83%	Very Good
8	I can easily understand number learning materials with the dynamic number card game	87.5%	Very Good
9	I understand the command displayed on the dynamic number card game	91.67%	Very Good
10	The dynamic number of card games can increase my curiosity	91.67%	Very Good
The average percentage of student responses		89.58%	Very Good

Table 3 shows the results obtained from the questionnaire given by the researchers to six students. Of the six students, an average overall percentage is 89.58%. Based on the results of these calculations, it can be concluded that the dynamic number card game is in the "very good" category to be used as a medium for learning mathematics in number learning material for first-grade students.

Learning media is currently one of the important components in the implementation of learning. Trianto (2012) reveals that the success of learning is very dependent on the use of the selected learning resources or media. The selection of the right learning media helps students more quickly understand the learning delivered. Especially in the situation of distance learning and online learning as it is today where students and teachers cannot do face-to-face learning.

One type of learning media that can be used is game-based learning media. Educational games are games that are packaged to stimulate thinking power, including increasing concentration and solving problems. This educational game aims to be able to overcome learning problems by increasing interest in learning, helping the development of intelligence and improving children's abilities in the learning process (Rahman & Tresnawati, 2016).

Through the R&D approach with ADDIE model, the dynamic number card game that has been developed was valid and practical. Concerning expert validity, the game has received a very high score. This means that the game fulfils the design and content quality. This finding is also supported by the results from *one-to-one* and *small group* trials. The students have a positive attitude toward the use of dynamic number card games. As supported by the previous study conducted by Jaemu et al., (2008), a web-based program can motivate students' underachieve learning number sense. Therefore, the dynamic number card game that has been developed could have high potential to support first-grade students' number sense.

The use of technology, such as games gives students experiences of learning and playing at the same time. The display of attractive images and colours can help restore student focus. Students can think logically and the link between the object and the number, as well as order the numbers. Representing structuring objects in the game can help students to visualise and recognise numbers. It is also supported by the previous study conducted by Putra, Darmawijoyo, Putri, and den Hertog (2011) who found that the game could support students' learning numbers up to ten. Therefore, educational game media is very suitable to be used to help students understand learning.

The dynamic number card game learning media is made based on number sense because the media made using number sense can influence and build children's mathematical abilities. This is following the research conducted by Kartini and Julianto (2016) regarding the use of number sense media consisting of number rods and flashcards in kindergarten. The use of number sense media affects kindergarten students' ability to recognize number symbols.

One of the things or ways to improve students' number sense ability is to create an interesting and fun learning atmosphere (Putra, Wulandari, Alpusari, & Hermita, 2021; Simorangkir & Br Sembiring, 2018). Creating a learning environment can be done by using interesting and fun learning media as well. The use of android-based learning media is one way to create interesting and fun learning media. In the context of young learning, it is obvious that students' interaction with digital technology can be the potential to play complementary roles in students' number sense development (Baccaglini-Frank & Maracci, 2015). Besides, learning media, both digital and non-digital, provides young students to visualize abstract mathematics to be meaningful for their understanding. However, teachers have an important role to supports students' learning at an early age.

Conclusion

The dynamic number card game developed using ADDIE model was valid and practical. It has the potential to engage elementary school students in learning number sense in entertaining

and enjoyable ways. The game offers mathematical activities in number sense context-based challenges that differ from those found in school mathematics textbooks. As a result, it is debatable whether the game may be used by teachers to promote and excite students' number sense because it provides rich number sense representation. However, there is a limitation of this study including the number of number sense tasks in the dynamic number card game, and the students involved in this study are limited. Therefore, further studies need to add a variety of number sense learning materials to the dynamic number card game. Also, it is needed to conduct an experimental study to test the effectiveness of dynamic number card games to support students' number sense.

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