



# Developing construct 2 android-based education math game to improve the ICT literacy on number patterns subject

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## Abstract

This research aimed to describe the development process and results of the Construct 2 Android-based education math game on number pattern subjects to increase student's ICT literacy. This research employed the Research and Development method with a 4-D development model. The development model consisted of 4 stages: the Define stage, the Design stage, the Development stage, and the dissemination stage. Also, the researchers developed the Android-based application based on ICT literacy indicators. The application must be valid, practical, and effective. The results showed a correlation coefficient value of 0.87 and included in the valid category with very high interpretation. The level of practicality of the developed product was 83.96% based on a users' responses questionnaire. The effectiveness was determined based on the percentage of students' learning outcomes which was 83.33%. The increase in students' ICT literacy was determined based on the ICT literacy questionnaire and learning outcome tests' average N-Gain score. The average N-Gain value obtained was 0.75, with an average value for the ICT literacy questionnaire of 0.89 and the average value for the learning outcome test of 0.61. Based on these three criteria, it can be concluded that the Construct 2 android-based educational math game on the number pattern material can improve students' ICT literacy.

## INTRODUCTION

The technological development of the industrial revolution era 4.0 combines physical and digital technology through analytics, artificial intelligence, cognitive technology, and the Internet of Things (IoT). One of the fields that have been influenced is education through E-learning (electronic learning). Thus, teachers must adapt to technology to improve students' learning skills (Kayalar, 2016). Technology in learning can make students feel more enthusiastic about learning and understanding the material (Nurdyansyah & Riananda, 2016). Therefore, teachers' role is essential in the effectiveness of technology in the learning process (Kayalar, 2016).

Technology in education can be used in ICT learning (Information and Communication Technology). ICT-based understanding is expected to motivate teachers during the learning process. However, based on the results of observations conducted at schools, the use of technology in classroom learning was still not optimal. ICT is an ability that students must possess (Muawiyah et al., 2018). ICT literacy can use digital technology as a tool to access, manage, integrate, evaluate, and create (Garba, 2014). Broadly, ICT can be defined as computers, internet, telephone, radio, and audiovisual equipment (Pernia, 2008).

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ICT-based learning media can be the internet, intranet, smartphone, and CD room/flash disk (Suci et al., 2019). Smartphones are currently overgrowing and have become a trend among Indonesians. Based on Statista Research Development data, smartphone users in Indonesia reached 81.87 million people, and 92.14% of Indonesians use the Android operating system on their mobile devices. The percentage is higher than other operating systems (Department, 2020b, 2020a). For education, smartphones can bring about positive and negative impacts. One of the positive effects is that the smartphone can be used as an innovation in the classroom (Faraweh & Jusoh, 2017). Contrary, smartphones' negative impacts are the usage, the students' discipline, and misuses during the learning process (Yuni & Pieewan, 2016). To overcome the negative impacts, smartphones should be used as a medium of ICT-based learning in Android-based educational games in the classroom.

Game is an innovation of technological development evidenced by the emergence of many online games such as Mobile Legend, PUBG Mobile, Free Fire, etc. Currently, online games are used as entertainment by various groups of people (Novrialdy, 2019). Many students play online games as entertainment—however, many students play games excessively. One of the effects is decreasing students' concentration at school or home (Husna et al., 2017; Novrialdy, 2019). Games can also positively impact, for instance, solving problems, learn languages, increase concentration, focus, and improve visual abilities. The visualization in the game is more interesting than the text in the book. It can be said that games are quite useful in helping teachers explain the material if they develop the educational games.

Educational games can be used as alternative media in learning activities. The educational game can be beneficial for students to understand the learning material compared to the usual learning. Games can also help students study outside the school time (Enkasyarif & Agustia, 2017; Huizenga et al., 2019; Nugraha et al., 2018). However, games should be used following the material to be covered and the learning objectives. Also, there is information in educational games that can be useful for learning (Kidi et al., 2017; Muhtasyam, 2018; Wulandari et al., 2016). The development of educational games can be done using a variety of software. Construct 2 is one of the software that can be used to develop educational games. Construct 2 is a game developer software with 2-dimensional graphics with a drag and drop system and can be used without using programming code and published on several platforms (Rahadi et al., 2016; Yustin et al., 2016).

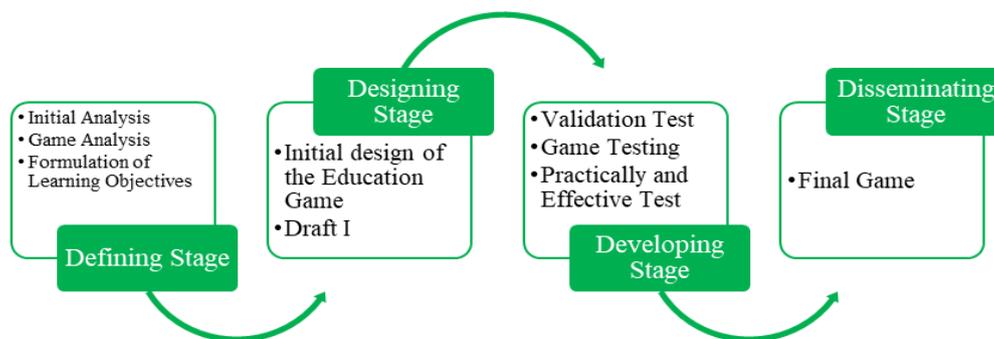
Mathematics is a subject that has an essential role in education because it underlies other sciences (Muhtasyam, 2018). One of the materials contained in mathematics is number patterns. However, some students have difficulty finding the main idea of the problem and making abstract generalizations (Handayani et al., 2015). Besides, students have a hard time determining the pattern or the  $n$ th term in a pattern of numbers. It is proven by students' incorrectly deciding the pattern of numbers (Sari et al., 2018). Therefore, a learning medium is needed to teach number patterns to students (Sulistiyawati et al., 2018).

Based on several studies, educational games' development was only focused on the material or topic being discussed. Also, educational games do not show the material discussed during the mission (Saputro et al., 2018; Yustin et al., 2016). In this development research, the educational game had been developed using the Construct 2 software adjusted to the ICT literacy indicator.

Based on the problem's background, the researchers aimed to develop a Construct 2 Android-based game on number patterns material to improve students' ICT literacy. The game's type was the platformer game, so students can learn the material by following the instruction provided. Moreover, the game was developed by following the ICT literacy indicators to understand the material and improve their ICT literacy. It is expected that the developed educational games can make mathematics learning more fun and make students comfortable to learn.

## METHODS

This research employed the Research and Development (RnD) method with the 4-D development model. The research subjects consisted of 24 students of class IX-E at SMP Nuris Jember. The development model consisted of 4 stages (Thiagarajan, 1974), as presented in Figure 1.



**Figure 1.** The Research Method Flowchart

According to Nieveen, the developed product should be tested for validity, practicality, and effectiveness (Kurnianto, 2019). Three validators assessed the validity based on three aspects: format, contents aspects, and language aspect (Yamasari, 2010). The educational game is valid if it gets a very high level of validity or higher. The practicality was determined based on the questionnaire responses and interviews. The developed educational game is practical if it meets the excellent category. Educational games' effectiveness was determined by 80% of students' learning outcomes that pass minimum mastery criteria. Also, the increase in ICT literacy is shown by the N-Gain test of learning outcomes and questionnaires before and after applying the educational game. The results of observations during the trial and the results of observations during the educational game testing are the supporting data.

**Table 1.** The Level of Media Practicality

| P-Value              | Percentage Category |
|----------------------|---------------------|
| $P > 95\%$           | Excellent           |
| $80\% < P \leq 95\%$ | High                |
| $65\% < P \leq 80\%$ | Moderate            |
| $50\% < P \leq 65\%$ | Low                 |
| $P < 50\%$           | Poor                |

**Table 2.** The Criteria of Normalized N-Gain Index (Hake, 1999)

| Normalized <i>N-Gain</i> | Interpretation |
|--------------------------|----------------|
| $g > 0,7$                | High           |
| $0,3 \leq g \leq 0,7$    | Moderate       |
| $g < 0,3$                | Low            |

## RESULTS AND DISCUSSION

The educational game was developed using Research and Develop (RnD) method with the 4-D model. The model consisted of four stages: Define stage, Design stage, Develop, and Disseminate stage. The description of the stages are as follows:

### Define Stage

This stage aims to determine the students' needs toward the educational games to be developed. This stage consisted of the initial analysis stage. The analysis resulted in the lack of students' ICT uses especially smartphones. It was also found that the students had never used educational games as a learning tool. The objective of the research was to improve students' ICT literacy skills on number pattern material.

### Design Stage

The design stage aimed to design an educational game that consisted of media selection, the selection format, the preliminary design, and the preparation of tests. The researchers chose the Android-based mathematics educational game because it became one of the attractions for students to improve their ICT literacy and make learning math attractive. The game was developed using the Construct 2 software. The android game was developed in the .apk format. It can be downloaded via Google Play Store, making it easier to access and install the game.

The mathematics education game's initial design contained the concept following the ICT literacy indicators and game assets needed. The following is the modified ICT literacy indicator from the Educational Testing Service (ETS) (Panel, 2002).

**Table 3.** ICT Literacy Indicator

| ICT Literacy Component | Definition  | Indicator   |
|------------------------|---|---|
| Access                 | Knowing about and knowing how to collect and/or retrieve information.                                 | 1. Open the educational game on the smartphone.<br>2. Press the play, tutorial, and info button.  |
| Manage                 | Applying an existing organizational or classification scheme.   | 3. Press the start button and the navigation button.  |
| Integrate              | Interpreting and representing information related to the ability to summarize, compare, and contrast. | Playing the education game.<br>- Collect the circles of known number pattern<br>- Continue the number pattern terms in the sequence.<br>- Determines the term of the unknown number pattern |
| Evaluate               | Evaluate the quality, relevance, usefulness, or efficiency of the information.                        | Answer the question at each level and determine the nth term formula.   |
| Create                 | Generating information by adapting, applying, designing, inventing, or authoring information.         | Using information that has been obtained from the educational game.   |

The developed education game is a platformer game with one type of action game where the character has to jump to pass obstacles. At levels 1 to 5, students are designed to collect a

predetermined number pattern and continue to the next unknown number pattern. After determining the pattern of numbers in each level, questions related to the previous level will appear. Then, at level 6 (the final level), the students are asked to draw up an incomplete image pattern then determine the n-th formula.



Figure 2. Main Menu Display



Figure 3. Tutorial Menu Display



Figure 4. Menu Level Display



Figure 5. Game Display



Figure 6. Question Display

The pretest and the posttest developed in the study focused on the number pattern material. The developed tests consisted of 5 description questions. The tests had been adjusted to the modified ICT literacy indicators.

### Develop Stage

The development stage was carried out by conducting expert validation and testing. The experts' validation produced a valid educational game and deserved to be tested. The trial was conducted to determine the practicality, effectiveness, and improvement of students' ICT literacy.

### Disseminate Stage

The dissemination was the last stage after the educational game met the validity, practicality, and effectiveness requirements. The game was distributed through Google Play Store. The Google Play Store was selected because of its accessibility.

### The Validity

Three aspects determined the validity: format, contents, and language. Based on the validator's assessment, the correlation coefficient ( $\alpha$ ) was 0.87, which indicated that this educational game

was valid within the excellent category. Learning media with excellent validity criteria is suitable for the learning process (Murtikusuma et al., 2019; Mareta et al., 2019).

### The Practicality

The practicality data were obtained from the questionnaire responses. Educational games are practical if the average percentage of user responses shows a good or excellent category. The results obtained were 83.96%, indicating that the educational game was included in the "good" category. Here are the criteria and the results of the questionnaire.

**Table 4.** The Questionnaire Responses

| No | Indicators   | Percentage of the Students Response of Each Category (%) |       |          |                   |
|----|--|--|-------|----------|-------------------|
|    |  | Strongly Agree   | Agree | Disagree | Strongly Disagree |
| 1  | I can open the education game "Monster Jump" easily  | 62,50  | 37,50 | 0,00     | 0,00              |
| 2  | I was happy to study by using the education game "Monster Jump."                             | 45,83  | 50,00 | 4,17     | 0,00              |
| 3  | I wasn't feeling bored studying the lesson by using this education game, "Monster Jump."     | 45,83  | 54,17 | 0,00     | 0,00              |
| 4  | I was motivated to learn mathematics after using the education game "Monster Jump."          | 20,83  | 66,67 | 12,50    | 0,00              |
| 5  | I was motivated to learn pattern number subjects by using the education game "Monster Jump." | 37,50  | 50,00 | 8,33     | 4,17              |

Based on Table 4, the students felt motivated to learn math using the developed educational game. Therefore, technology as a learning medium affects the learning outcome and students' learning interest. The data obtained through user response questionnaires and interviews proved that the educational game was practical to use (Murtikusuma et al., 2019; Kurnianto, 2019).

### The Effectiveness

The effectiveness of educational games was determined by the test results measuring students' understanding of the material. The test results obtained a completeness percentage of 83.33% from 24 students with the minimum competency criteria of 75. This percentage shows that the developed educational games can improve students' learning outcomes (Saputro et al., 2018; Yustin et al., 2016).

### ICT Literacy Improvement

The improvement of students' ICT literacy was determined by the N-Gain test on learning outcomes and ICT literacy questionnaires before and after using the developed educational game. The results of the ICT literacy questionnaire and learning outcome tests showed an increase. The N-Gain analysis results were 0.61 and 0.89, so that the average N-Gain value was 0.75. It can be concluded that the developed educational games can improve students' ICT literacy skills.

**Table 5.** The Average N-Gain Value of the Test and Questionnaire

| Average | Before | After | N-Gain |
|---------|--------|-------|--------|
|---------|--------|-------|--------|

|                   |      |      |      |
|-------------------|------|------|------|
| ICT literacy      | 0,35 | 3,6  | 0,89 |
| Test results      | 1,99 | 3,21 | 0,61 |
| Average of N-Gain |      |      | 0,75 |

**Table 6.** The N-Gain on Each ICT Literacy Component

| Components | Before | After | N-Gain |
|------------|--------|-------|--------|
| Access     | 0,44   | 4,00  | 1,00   |
| Manage     | 0,33   | 3,83  | 0,95   |
| Integrate  | 0,50   | 3,83  | 0,95   |
| Evaluate   | 0,16   | 3,33  | 0,83   |
| Create     | 0,33   | 3,00  | 0,73   |

Table 6 shows the increase in every ICT literacy aspect before and after using the developed educational games. Moreover, each aspect's N-Gain value is included in the high category because of  $g > 0.7$ . It can be said that the educational game can improve students' ICT literacy. The educational game helped students understand number pattern material and improve their ICT literacy. Students can use educational games as a medium for learning number pattern material in a fun way to encourage their participation in learning (Gros, 2007).

Table 6 shows an increase in every aspect of ICT literacy, namely access, manage, integrate, evaluate, and create. The improvement of ICT literacy can be influenced by the students' ability to use the technology and increase their knowledge (Adetimirin, 2012; Santos, 2019). Most students can easily open and access the instructions of the game. It means that students know how to collect information before proceeding to the next stage (Mustika, 2013).

Mathematic educational games with number pattern material can make students more interested and know more about the material than before playing educational games (Huizenga et al., 2019). It can facilitate students in understanding the abstract idea (Sulistiyawati et al., 2018). Students can interpret different information obtained at each level of the game, especially on the various displayed number patterns. At each level of the game, the students gain information about number patterns. In the box, there are several known and abstract number pattern terms. Students complete the number pattern by choosing a number pattern that has been provided. If they choose the wrong choice, the character's health will decrease. When the health runs out, the students have to repeat the level. The repetition process can make students better understand the material. Moreover, playing educational games, knowing the buttons' use, and combining the information obtained can promote ICT literacy. Thus, it can be interpreted that knowledge can help improve students' ICT literacy (Adetimirin, 2012).

After completing each level, a multiple choices question will appear containing the number pattern material at the levels that have been completed. Besides, at level 6, the students are asked to look for the  $n$ th term formula for a specific number pattern. Before looking for the  $n$ th term, the students must first complete the pictures to form a pattern. After completing the pattern, students are required to fill in the blank spots that have been provided. They will assess or evaluate the usefulness of the information they get to work on the problems. It means that using knowledge and information interactively requires a person to recognize and determine what is not known; identify, locate, and access the appropriate resources; evaluate the quality, relevance, and value of such information and its source; and organize knowledge information (Kim et al., 2014).

Students take a learning outcome test after completing the educational game. The learning outcome test consisted of five description questions adjusted to the material in the educational game. Some students had difficulty working on number pattern questions (Sari et al., 2018). This difficulty was shown by the use of incorrect formulas or not writing the formula. The test results obtained a completeness percentage of 83.33% of 24 students with a minimum completeness criteria of 75. The percentage showed that there was an increase in the ICT literacy aspect. Students' ICT literacy skills can be trained and improved using technology. Students' ICT literacy can also affect learning test results. Based on Yustin et al., using educational games in mathematics learning can improve learning outcomes by 32% compared to students who do regular learning by only 28% (Yustin et al., 2016). Another study conducted by Saputro et al. also showed a moderate increase in students' learning outcomes as indicated by the N-Gain value of 0.49 (Saputro et al., 2018). Therefore, ICT literacy can help students learn more effectively and help them find knowledge related to the information they want to learn (Ghavifekr & Rosdy, 2015).

## CONCLUSIONS

Based on the data analysis, it can be concluded that the Construct 2 Android-based educational game on number pattern material can improve students' ICT literacy skills. The validity of the developed educational game was 0.87 which is included in the valid category with excellent interpretation. The practicality of the developed educational games obtained 83, 96%, which is included in the good category. The effectiveness of the developed educational games, determined by the percentage of students' test results, was 83.33% (24 students). Based on the analysis, the test results and the ICT literacy questionnaire's N-Gain values before and after implementing the educational game were 0.61 and 0.89, with an average N-Gain of 0.75. Therefore, it can be concluded that the developed educational game can improve students' ICT literacy.

The researchers suggest those who will develop a game to decrease and resolve the bug better. For the next research, it is recommended to develop various types of games in other mathematics material so that the students are interested and can increase ICT literacy.

## AUTHOR CONTRIBUTIONS STATEMENT

AF represents data collection and instrument design. then assisted by NA and DD in compiling the article.

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