

The Development of the Educational Game to Improve Logical/ Mathematical Intelligence

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The purpose of this study was to examine the educational games to improve logical/mathematical intelligence for early childhood education. In this study, logical/mathematical intelligence included the aspects of symbolic thinking, problem-solving, and logical thinking. The educational games were designed to stimulate children to think analytically or to have a higher-order thinking. This study used the ADDIE model. The results indicated that the games were valid and very feasible to use with an average score of 0.88. Additionally, the results of the practicality test of educational games were good. Also, the result indicated that the games had 87% for the effectiveness. Based on the results of the study on three aspects (symbolic thinking, problem-solving, and logical thinking), symbolic thinking and problem solving can be improved independently only with the help of audio, but for the logical thinking aspect, teacher assistance was needed to complete the game.

Keywords: ADDIE model, educational games, think logically

INTRODUCTION

Early childhood education is one of the efforts to develop and improve children's intelligence optimally. According to Roza et al. (2020), early childhood with the period from birth to eight years old is a group of children who need a maximum stimulation in the process of growth and development. During this stage, children are exceedingly influenced by the environment and the people that surround them. At the formal level, one of the forms of early childhood education to develop and improve children's

intelligence optimally is kindergarten. All children are intelligent, but sometimes parents/educators may not optimally facilitate them so that children's intelligence does not increase rapidly. Therefore, kindergarten education plays an important role in developing the full potential of children to the fullest.

Every child is gifted with his or her intelligence. However, there are those who have different intelligences, some tend to have high intelligence in certain aspects while some are low in other areas. This is influenced by stimulation from an early age. Optimally increasing children's intelligence will make them have high quality intelligence. The intelligence includes logical/mathematical intelligence, verbal linguistics, spatial, musical, kinesthetic, interpersonal, intrapersonal, naturalist and spiritual ones. According to Booth and O'Brien (2008), intelligence is powerful tools that can help children achieve their educational goals more effectively. Therefore, children's learning should be able to improve all children's intelligence so that children are able to adjust to the social environment well.

One of the intelligences that is important to be improved in early childhood is logical/mathematical intelligence because it can affect other intelligences. Logical/mathematical intelligence is the ability to recognize numbers/numbers well and have a logical and natural thinking pattern. Children who have a high level of intelligence in logical/mathematical matters will be sensitive to numbers and can easily solve problems in everyday life by thinking logically. Learning mathematics should be started from basic mathematical concepts such as the introduction of big-small, long-short, high-low, many-a little concepts, the introduction of numbers and a number of objects that match the numbers, problem solving, and logical and scientific thinking. To develop children's logical/mathematical intelligence in the early stage, one of the ways is through educational games. In this study, the educational games are digital ones that are digitally designed for educational purposes and are packaged in the form of a game that challenges children to think logically and creatively in solving problems.

The use of educational games in early childhood education such as smartphone technology is very suitable because it is in accordance with the principles of early childhood learning, namely playing while they are learning and learning while they are playing. According to Priyanto et al.(2014), *Smartphone* technology can be used as an innovative medium in kindergartens to transmit education through learning methods that are concise, interesting, interactive, and accessible at any time. The use of technology in teaching children in the early ages can be done through playing. Therefore, technology can be used as a medium for children's play that has elements of education or knowledge so that it can increase children's intelligence. Digitally educational games may become interesting solutions and improve children's logical/mathematical intelligence as they are designed to improve children's problem-solving skills and to think logically in a digital form that can be accessed via *cellphones*. The content of the educational games provides learning for improving overall logical/mathematical intelligence. This study aimed to produce educational games to improve logical/mathematical intelligence for early childhood education.

METHOD

This type of the methods used in this study was the research and development (R&D) research. According to Sugiyono (2012) research and development is the one that is used to produce certain products and to test the effectiveness of the products. The products are not always in the forms of objects (hardware), such as books, machines, modules, teaching aids, etc. but can also be in the forms of software, such as learning models, application programs. The development in this research was about software in the form of application programs which were made by using the adobe flash applications that can be run on the android applications, notebooks, and PCs. The development procedure in this study followed the sequences including analysis, design, development, implementation, and evaluation (ADDIE) model proposed by Branch (2009).

This game was made by using a PC Processor Core i-5, 8 Gygabite Ram specifications and 1 Terabite hard drive, and using Adobe Photoshop CS6 software, Corel Draw x7. Games that had been made would be developed and installed on an Android smartphone or tablet that can be used for early childhood learning. Educational games consist of 5 games including symbolic thinking games such as counting games

and recognizing numbers. In addition, children’s problem-solving abilities are stimulated through games of matching pictures and guessing for pictures with activities to find food for animals, where they live and look for the benefits of these animals. In the aspect of logical thinking, it is stimulated through a game of looking for a cause and effect and of guessing patterns by looking for causes and effects of a problem in the game and of finding the appropriate patterns in the form of a pet.

Analysis, the main activity at this stage was to analyze the importance of product development. Product development began with a lack of learning that had been applied mainly to improve children’s reading skills. Problems can occur due to the lack of facilities to develop reading skills that are attractive to children. This analysis was carried out by gathering information and identifying to make a product that would be developed according to the needs in terms of observation and interviews.

Design, this activity was a systematic process that was started from setting learning objectives, designing learning tools, designing learning activities, and designing learning outcome evaluation tools. This stage was a conceptual design that underlies the subsequent development process. Product design was carried out in accordance with the concepts and objectives of developing educational games to improve mathematical logic intelligence.

Development, this stage was started by realizing the design into a product that is ready to be implemented and making instruments to measure the product performance. The product to be developed would be examined by the developers to find out whether the product can be used properly and all components can run as expected. Then the product was consulted with experts, lecturers and teachers before it was tested. The suggestions and input obtained were revisions or improvements to the product that was being developed.

Application, the implementation stage was carried out by preparing educational game development products after being revised according to expert directions and test results. Then teachers evaluated educational game development to determine the feasibility of developing educational games when it was used by children and children’s responses after playing the game. The results of the assessment and teacher responses were followed up at the evaluation stage.

Evaluation, this stage carried out evaluation activities to measure the achievement of development goals. Evaluation results were used to provide feedback to users or children. Revisions were made according to evaluation results or unmet needs. Data collection techniques in this study used instruments in development research. The instrument was one of the tools for data collection. The data in the development of this research were a questionnaire. The questionnaire was used to obtain data on the validity, effectiveness, and practicality of the educational game (Sugiyono, 2015).

Validity analysis, the data collected from this study were the result of the validation of the educational game. The validity analysis used the V Aiken validation by using the following formula:

$$V = \Sigma s / [n(c - 1)]$$

Information:

s = r – lo; lo = lowest validity score (in this case = 1); c = highest validity score (in this case = 4)

r = Numbers given by the validator

The results of Aiken V’s calculations range from 0 to 1. After Aiken V’s calculation results, the media eligibility criteria are grouped: 0,76 - 1 = Very qualified; 0,51-0,75 = Worth; 0,26 -0,50 Worth less; <0,25 = Not eligible.

Practicality analysis, the data of user practicality test by filling out the questionnaire for principals and teachers and calculated by using the following formula.

$\text{Percentage of Practicality} = \text{Ideal score} / \text{Maximum score} \times 100\%$
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After the percentage was obtained, the grouping was done according to the practicality assessment criteria: 76% - 100% = Very practical; 51% - 75% = Practical; 26% - 50% = Practically less; 0% - 25% = Not practical

The effectiveness analysis was obtained by counting the children who did the activities. The data were analyzed by using the percentage technique proposed by Sugiono (2018) as follows:

$\text{Percentage of Effectivity} = \text{Ideal score} / \text{Maximum score} \times 100\%$

To find out the effectiveness of educational games, it can be adjusted to the criteria in the following table:

TABLE 1
THE EFFECTIVENESS CRITERIA OF EDUCATIONAL GAME

Criteria	Level of Success	Percentage
Undeveloped	Not Successful	1-25
Start to develop	Less Successful	26-50
Develop according to expectation	Successful	51-75
Very well-developed	Very Successful	76-100

RESULTS AND DISCUSSION

Analysis

In the analysis stage, the method used by the researchers was by observing teaching and learning activities at the research site and by interviewing teachers. Observations and interviews were carried out to determine the curriculum used, learning activities and the use of instructional media, especially logical/mathematical intelligence. The initial stage in analyzing product needs was to analyze the curriculum used at the research site. The purpose of analyzing the curriculum was to look at the direction of the development of the educational game. The analysis was carried out on the curriculum used, learning activities and the use of learning media by collecting information. In this development research, only the development of early childhood educational games was carried out in kindergarten. It was found that several indicators, especially logical mathematics, were still monotonous and did not stimulate children's logical thinking and analysis. Some examples include numeracy learning which only focuses on counting pictures without full illustrations, pairing objects by drawing lines and by using pictorial stories instead of stimulating children's problem solving. The results of this analysis were used as a description for preparing games based education so that it can produce a game that is suitable for children.

Design

The design process was the phase of educational games based on children ages. At this stage, an instrument was designed to measure the validity of the educational games that is being developed. Determining indicators, sub-themes and materials to be included in the game is an important thing. The theme determines how the game is shaped and designed. It also determines the achievement of learning objectives. The sub-themes used in the game are pets. Audio design in educational games is in the form of voice instructions and responses which help children to understand questions in the game. Visual design is a description that is designed according to the initial design of the educational game. The game application is based on audio and visual designs that have been designed with the pet sub-themes. Educational games were made by using Adobe Flash Pro CS6 and according to game content or storyboards. Games that have

been made would be developed and installed on an Android smartphone or tablet that can be used for early childhood learning.

Development

This stage aimed to produce a valid, practical, and effective educational game to improve logical/mathematical intelligence in kindergarten. The product that would be developed was checked by the developers to see if the product is working properly and that all the components work as expected. Educational game to improve logical/mathematical intelligence was developed by using a flash application that can run on the Android, Windows (XP, Vista, 7, 8) Operating System, and a PC or laptop to include prepared materials and videos. The results of validation by experts indicated that there were some improvements such as replacing the terms of some games according to the children's understanding and adding a manual for use and an explanation of the navigation function in the game.

Implementation

This stage was carried out by preparing the product of the game that has been declared eligible by experts and tests. The educational game was also assessed by kindergarten teachers including the practicality test which indicates that the level of practicality of the media used by the teachers. This activity was carried out to determine the extent of benefits and ease of use by the teachers. Based on the 13 aspects in the practicality test done by teachers and school principals, the average percentage of practicality for each aspect of the assessment was 92%. Practicality test results indicated that the game was very practical.

Evaluation

The results of evaluation were obtained based on the assessment sheet of experts and classroom teacher questionnaires on educational game to improve logical/mathematical intelligence for early childhood education. Based on the expert's recommendations, the materials have sufficient, eligible, and valid item validity, but it needs revisions in some areas. Additionally, the results of the media experts indicated that the game has sufficient and valid item validity, but it needs revisions in some parts. Then, based on the recommendations, revisions were made in terms of materials and media revisions. The educational games consist of 5 areas: symbolic thinking games including counting games and recognizing numbers with counting the number of pets in educational games. In addition, children's problem-solving abilities are stimulated through games of matching pictures and guessing for pictures with activities to find food for animals, where they live and look for the uses / benefits of these animals. In the aspect of logical thinking, it is stimulated through a game of looking for cause and effect and guessing patterns by looking for causes and effects of a problem in the game and finding the appropriate pattern in the form of a pet.

Children in their early ages are individuals who are in the process of rapid growth and development. According to Sujiono (2011), early childhood is an individual who is undergoing a process of rapid development and that is fundamental to the next life. Each child has her or his own and unique characteristics according to his or her age stage. Therefore, the treatment or teaching given must also pay attention to and consider the characteristics and stages of its development.

Children in their early ages have characteristics that make them not the same with teenagers and adults. At this time, children have a curiosity about what is around them. According to Suryana (2013), the uniqueness of early childhood has the characteristics such as a) children are egocentric; b) children have curiosity (c) they are unique; d) children are rich in imagination and fantasy; e) children have a short concentration power. This is what distinguishes early childhood with the others. Additionally, according to Khairi (2018), the characteristics of early childhood are: unique, egocentric, active and energetic, strong curiosity and enthusiasm for many things, explorative and adventurous, spontaneous, happy and rich in fantasy; still easily frustrated, there is still a lack of consideration in doing something, short attention span, passionate to learn and learn a lot from experience, show more interest in friends. Therefore, the learning of early childhood should be able to facilitate the development of the child so that the child's intelligence is optimally stimulated.

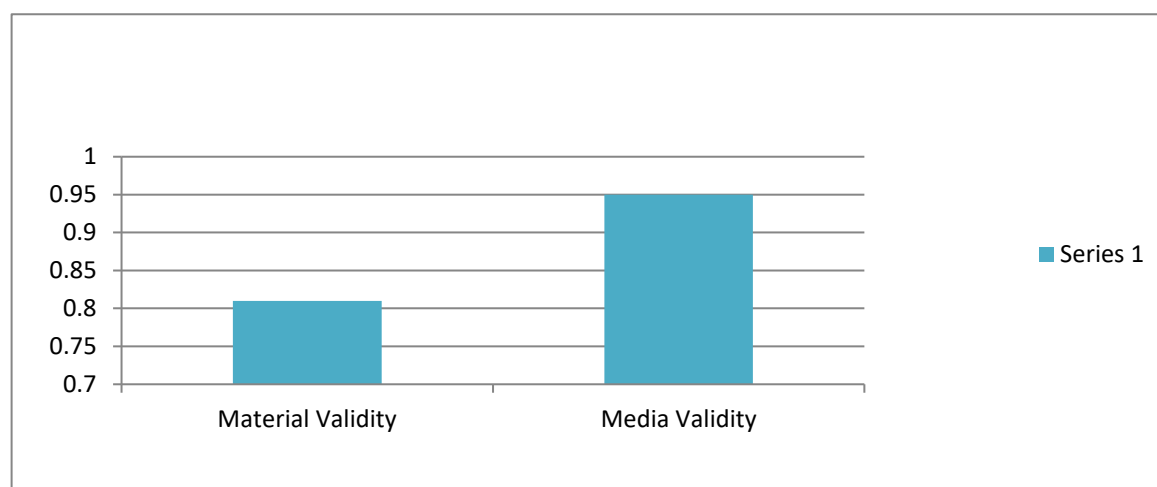
In the context of the early childhood education, logical/mathematical intelligence is an important thing to improve because it can affect other intelligences. According to Nurtiani and Sheilisa (2017), logical/mathematical intelligence is the ability to handle relevance / argumentation and recognize patterns and sequences. Logical/mathematical intelligence is not only about numbers but patterns and sequences are also part of logical/mathematical intelligence. Wajannati (2016) argues that logical/mathematical intelligence is related to a person's ability to easily understand numbers and think logically and scientifically. Thinking logically and scientifically is important in improving children's analytical mindset in early childhood.

Numbers, problem solving, and logical thinking are some things that cannot be separated from logical/mathematical intelligence. According to Gardner (2011) mathematicians underline the importance of numbers as the basis for mathematical development. Additionally, Setiawan and Aprianti (2018) logical/mathematical intelligence in early childhood education is developed through recognizing several numbers, several patterns, calculations, measurements, geometry, and classification.

To improve logical/mathematical intelligence for early childhood education, educational games can be one of the alternatives which are designed and developed to achieve goals in increasing and developing children's intelligence, especially as a medium of learning. In the meantime, the existence of smartphones or digital technology is very attractive to children so that the use of technology will provide and facilitate children in learning through games that have educational / educational elements. The use of educational games is able to give children the opportunity to solve problems creatively and scientifically.

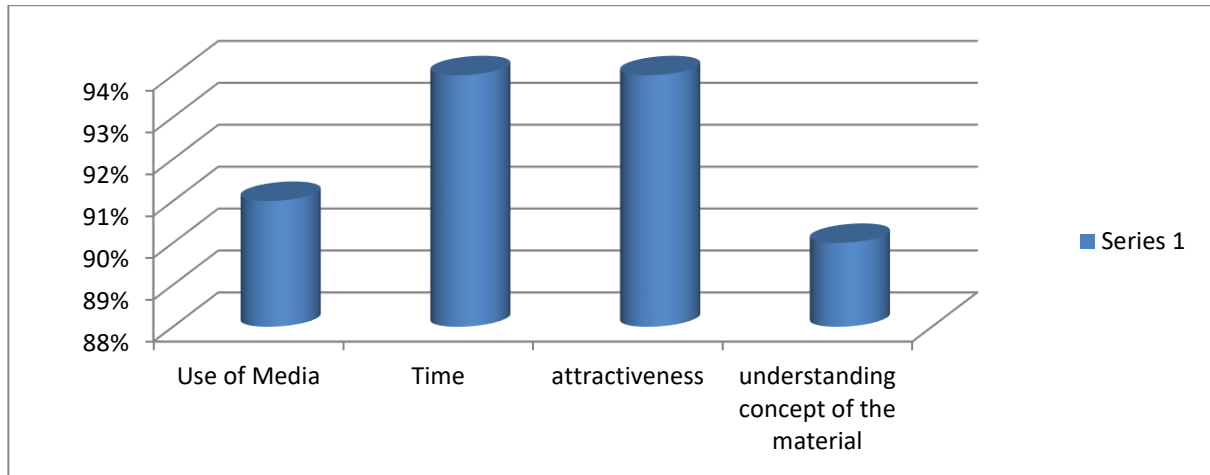
Validity, Practicality and Effectiveness

FIGURE 1
VALIDITY OF THE EDUCATIONAL GAME



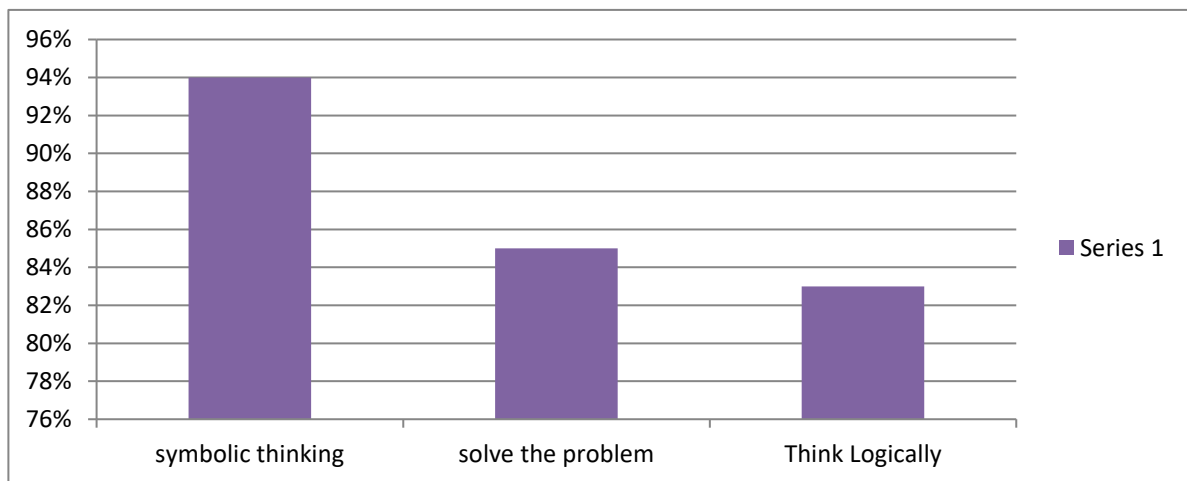
Based on the figure above, the validity of the game product was 0,88 and it was categorized as “very feasible.”The validity includes material validity which was 0,81 and media validity which was 0.95. These results indicate that the validity of the educational game products is valid.

**FIGURE 2
PRACTICALITY OF THE EDUCATIONAL GAME**



Based on the figure 2, the data of the practicality were 92 % and it was categorized as “very practical”. The practicality assessment includes 91 % of the media use , 94% of time, 94% of attractiveness, and 90 % of understanding of the concept of the material.

**FIGURE 3
THE EFFECTIVENESS OF EDUCATIONAL GAME**



Based on the figure 3, it can be seen that the effectiveness of educational game products was 87 % which was categorized as “very good.” The effectiveness of educational game assessment includes the aspects of symbolic thinking, problem solving and logical thinking.

CONCLUSION

Logical-mathematical intelligence is a determinant for the early childhood. One of the efforts to improve children’s logical/ mathematical intelligence is a game application in the form of educational games. This study aimed to produce educational games to improve logical/mathematical intelligence for early childhood education. The development procedure in this study followed the sequence of activities

including analysis, design, development, implementation, and evaluation (ADDIE) model. The steps were taken after the product was made among other things: validity test, practicality test, and effectiveness test. The results indicated that the the validity of the game product was 0,88 and it was categorized as “very feasible and he data of the practicality were 92 % and it was categorized as “very practical” while the effectiveness of educational game was 87 % which was categorized as “very good.” The game was designed attractively according to children’s understanding with the attractive colors. During play, children analyzed the pictures and were guided by audio that was easy for children to understand. Educational game also stimulated children’s math skills, especially arithmetic by giving children understanding of concepts through concrete descriptions of something. Therefore, educational games are very useful in developing children’s potential, especially logical/mathematical intelligence.

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