Educational Games for Learning Mathematics Medium at Elementary School Level

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Abstract— Observation data shows various problems experienced by elementary school students when learning about Greatest Common Factor (GCF) and Least Common Multiple (LCM). This research aims to: (1) understand the effectiveness of learning math through education game, (2) introduce technology to students without interrupting their regular study time, and (3) increase students' interest in learning math through education game. Sample used were 62 students in grade 5 and 6. The method of this research uses 4 variables, i.e. Performance Expectancy (PE), Effort Expectancy (EE), Hedonic Motivation (HM), and Behavioral Intention (BI). After the respondents have tried playing the game, they fill out Google form and the result obtained with 51 respondents.

Keywords— educational games, effectiveness, interest in learning

I. INTRODUCTION

School is important for children's development to prepare themselves for the future. During the elementary school period (6-13 years), children are expected to gain basic knowledge which is considered very important for preparation and adjustment to life in adulthood [1]. The attention of young children will easily be distracted by other

things, especially those that can attract their attention, so teachers and parents pay attention to this when conveying important learning [2]. Therefore, teachers and parents must be able to understand and accompany children in adapting as they grow both at school and at home. As technology evolves, educational methods through digital games are slowly emerging as a different form of learning model as a new model of e-learning, which is usually called digital game-based learning or educational games as an alternative form of e-learning [3].

Mathematics is a conceptual science that really demands reasoning and development of these concepts [4]. Based on a survey conducted on a sample of students in grades V and VI of SD Santa Theresia Surabaya, the majority stated that the material was the most difficult to understand because it was often confused between GCF and LCM, the steps were too long to follow, and required high precision.

To remain relevant and effective, education systems need new technologies. Augmented Reality (AR) is the next logical step in the evolution of the education system [5]. AR is a technology that combines two-dimensional and three-dimensional virtual objects into a three-dimensional real environment and then projects these virtual objects in real time [6]. Until now, AR has been used in various education-based applications, for example Matematika Alive, Animal Alphabet, and Bugs3D [7].

Based on the problem above, an alternative learning media for mathematics subjects emerged which was included in educational games and used as a learning

media at home, entitled Game Labirin: FPB dan KPK (Number Maze: GCF and LCM). The material used in the game is limited to Mathematics lessons about finding the Greatest Common Factor (GCF) and the Least Common Multiple (LCM). The game was created using Unity and Vuforia and is in the form of a puzzle. In the Game Labirin: FPB dan KPK, Augmented Reality features are inserted to make the game more interactive and dynamic, because AR allows users to move and observe the models displayed from various sides [8]. In this way, it is hoped that it can arouse students' curiosity to learn mathematics in a fun way.

II. METHOD

The research was conducted at Santa Theresia Catholic Elementary School located on Jalan Residen Sudirman No. 5, Surabaya with the respondents are class V and VI students totaling 23 people and 39 people.

2.1. Population and Sample

A population is all components that are considered to have one or more similar characters in a group. In this case, the component in question are humans [9]. The population used was all students in grades V and VI for the 2023/2024 academic year, totaling 23 people and 39 people.

Sample is part of the population that has the same characteristics as the population and can represent the population observed in general [10]. If the number of research subjects is less than 100, then the research sample is taken from the entire population. Meanwhile, samples with more than 100 subjects can be taken from 10% to 15% or 15% to 25% of the entire population [11]. Because the total population is 62 people, based on the statement above, the sample size is 62 people.

2.2. Game Development

Game design begins by creating a flow diagram (Figure 2.1), then creating the entire game and its contents using Unity 3D, Vuforia and Clip Studio Paint software. Game testing and improvements were carried out repeatedly until the game was deemed suitable for testing on research subjects.

Unity is a game-engine for creating video games on various platforms that is not only used by professionals, but also by novice game developers [12].

Vuforia is a Software Development Kit (SDK) for creating mobile applications that can be used in the Unity game engine [13]. The simple way of use makes many developers use Vuforia to create AR, besides that Vuforia can also be used for free. Users only need to upload the markers used to display virtual objects to the Vuforia Engine website and install the Vuforia SDK into Unity.

Clip Studio Paint, or previously known as Comic Studio, is software developed by the Japanese company Celsys. Used to create digital images in the form of comics, illustrations and 2D animation [14]. All illustrations including assets in the Labyrinth Game: FPB and KPK were created using Clip Studio Paint software.

2.3. Game Testing

Testing on respondents was carried out online by distributing game links that have been uploaded in a Google Drive folder along with a questionnaire in the form of a Google Form link to get results in a shorter period of time. After the number of respondents reached the minimum criteria, the questionnaire result is processed using SPSS software.

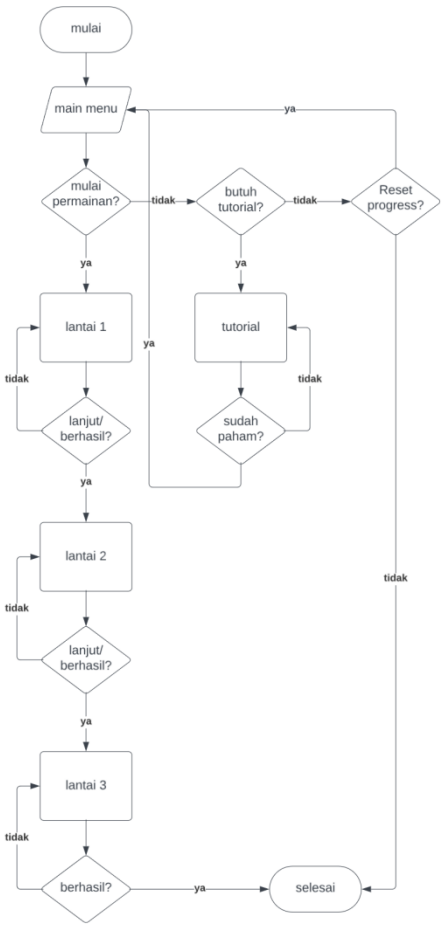

Figure 2.1. Game flowchart

III. RESULTS AND DISCUSSION

A. Interface Implementation

Game Labirin Bilangan: FPB dan KPK (Number Maze: GCF and LCM) consists of several features such as:

a. Main Menu

Main menu contains the game title, a button to enter the level list, and a button to exit the application.

Figure 3.1. Main menu appearance

b. Level List

Level list contains buttons to go to the tutorial page, back to the main menu page, Lantai 1, Lantai 2, and Lantai 3. There is also a button to reset the entire game score.

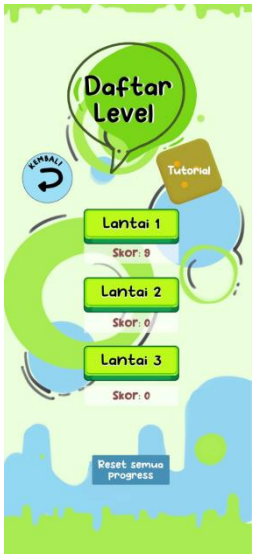

Figure 3.2. Level list appearance

c. Tutorial

Tutorial contains an introduction to the features used on and how to play the game. Players can reopen the tutorial page anytime.

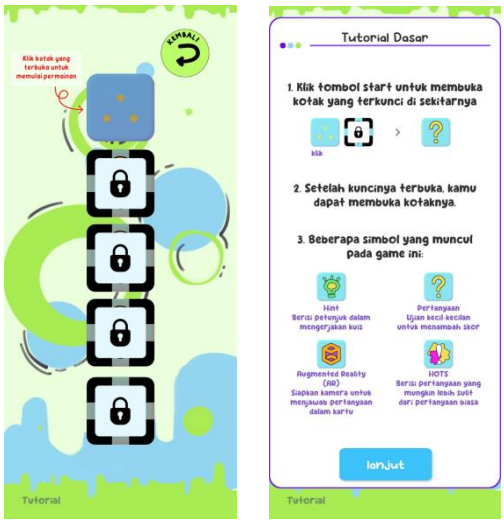

Figure 3.3. Tutorial appearance

d. Hint

Hint contains instructions for answering questions about GCF and LCM. Hints can be reopened and do not affect the score in the game.

Figure 3.4. Hint appearance

e. Question

Questions about GCF and LCM that players must complete to get a score. For every correct answer get 5 points, while for every wrong or blank answer the score is reduced by 1 point. There are HOTS questions, namely questions with higher variations in difficulty to test players' ability to understand GCF and LCM.

Figure 3.5. Question appearance

f. Augmented Reality

Augmented Reality (AR) is a special stage where players must prepare special card set. Player should block one of the virtual buttons using their hand, according to the true or false statement.

Figure 3.6. Augmented Reality

B. Data Results

The statements in the questionnaire are made based on the UTAUT model and adapted to research needs. Meanwhile, the answer model is created using a Likert scale to measure respondents' perceptions or attitudes by submitting several statements and respondents were asked to provide answers on the measuring scale provided

with the following levels: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree [15]. The questionnaire distributed contained 12 statements which were divided into 4 parts.

1. Performance Expectancy (PE)

   Performance Expectancy is the level of an individual believes that using a system can help them gain some advantage in an activity or job. The statement model for the PE variable is:

   a. Game Labirin Bilangan: FPB dan KPK increases my knowledge about GCF and LCM lessons. (PE1)

Figure 3.7. Answer results chart for PE1

Based on the chart above, 68.6% respondents answered Strongly Agree, 15.7% answered Agree, 13.7% answered Undecided, and 2% answered Disagree.

   b. Game Labirin Bilangan: FPB dan KPK can make me understand FPB and KPK lessons more quickly. (PE2)

Figure 3.8. Answer results chart for PE2

Based on the chart above, 47.1% respondents answered Strongly Agree, 25.5% answered Agree, 21.6% answered Undecided, and 5.9% answered Disagree.

   c. Game Labirin Bilangan: FPB dan KPK is useful for filling my free time (PE3)

Figure 3.9. Answer results chart for PE3

Based on the chart above, 54.9% respondents answered Strongly Agree, 19.6% answered Agree, 15.7% answered Undecided, 7.8% answered Disagree, and 2% answered Strongly Disagree.

2. Effort Expectancy (EE)

   Effort Expectancy is the level of convenience and usability that someone expects when using a system. The statement model in the EE variable is:

   a. Game Labirin Bilangan: FPB dan KPK is easy to play (EE1)

Figure 3.10. Answer results chart for EE1

Based on the chart above, 35.3% respondents answered Strongly Agree, 27.5% answered Agree, 29.4% answered Undecided, and 7.8% answered Disagree.

   b. The game instructions are easy to understand. (EE2)

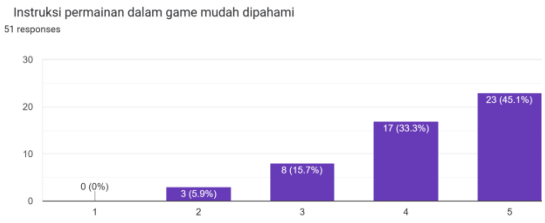

Figure 3.11. Answer results chart for EE2

Based on the chart above, 45.1% respondents answered Strongly Agree, 33.3% answered Agree, 15.7% answered Undecided, and 5.9% answered Disagree.

c. The subject matter presented in Game Labirin Bilangan: FPB dan KPK are matched with the subject taught at school. (EE3)

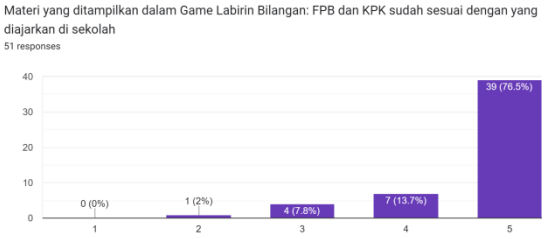

Figure 3.12. Answer results chart for EE3

Based on the chart above, 76.5% respondents answered Strongly Agree, 13.7% answered Agree, 7.8% answered Undecided, and 2% answered Disagree.

3. Hedonic Motivation (HM)

Hedonic Motivation is the level of satisfaction or pleasant experience a person expects from using a system. The statement model in the HM variable is:

a. I enjoy playing Game Labirin Bilangan: FPB dan KPK. (HM1)

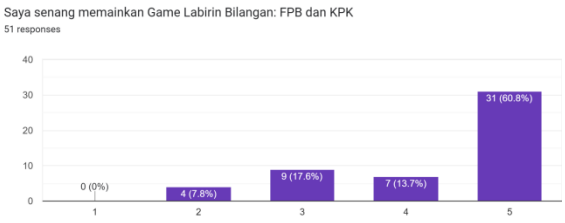

Figure 3.13. Answer results chart for HM1

Based on the chart above, 60.8% respondents answered Strongly Agree, 13.7% answered Agree, 17.6% answered Undecided, and 7.8% answered Disagree.

b. I enjoyed the game flow, especially the Augmented Reality (AR) feature in the Game Labirin Bilangan: FPB dan KPK. (HM2)

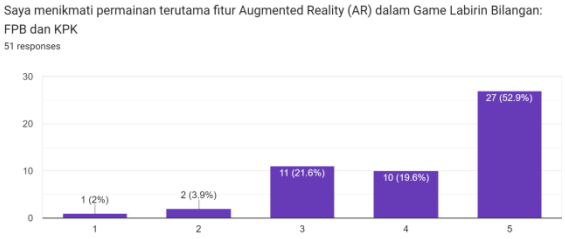

Figure 3.14. Answer results chart for HM2

Based on the chart above, 52.9% respondents answered Strongly Agree,19.6% answered Agree, 21.6% answered Undecided, 3.9% answered Disagree, and 2% answered Strongly Disagree.

c. I like the card design and the look of Game Labirin Bilangan: FPB dan KPK. (HM3)

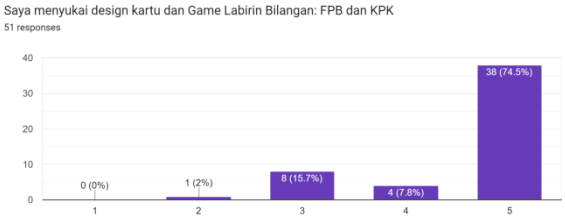

Figure 3.15. Answer results chart for HM3

Based on the chart above, 74.5% respondents answered Strongly Agree, 7.8% answered Agree, 15.7% answered Undecided, and 2% answered Disagree.

4. Behavioral Intention (BI)

Behavioral Intention is the level of a person's intention or loyalty to a system and beliefs to spread the advantages of that system to the people around them. The statement model in BI variables is:

a. I plan to play Game Labirin Bilangan: FPB dan KPK for a long time (BI1)

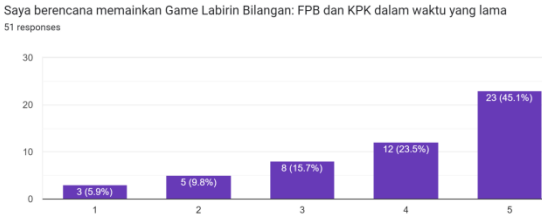

Figure 3.16. Answer results chart for BI1

Based on the chart above, 45.1% respondents answered Strongly Agree, 23.5% answered Agree, 15.7% answered Undecided, 9.8% answered Disagree, and 5.9% answered Strongly Disagree.

b. I intended to complete all stages in Game Labirin Bilangan: FPB dan KPK in the future (BI2)

Figure 3.17. Answer results chart for BI2

Based on the chart above, 62.7% respondents answered Strongly Agree, 11.8% answered Agree, 11.8% answered Undecided, 11.8% answered Disagree, and 2% answered Strongly Disagree.

c. I have urge to using Game Labirin Bilangan: FPB dan KPK as one of my learning medium in the future (BI3)

Figure 3.18. Answer results chart for BI3

Based on the chart above, 62.7% respondents answered Strongly Agree, 11.8% answered Agree, 13.7% answered Undecided, 9.8% answered Disagree, and 2% answered Strongly Disagree.

C. Statistic Test Result

After the questionnaire results were obtained, several statistical tests were carried out to determine the validity of the results. The following is the test in question:

1. Validity Test

To determine the data validity, validity test is carried out for that purpose. Using Dimension Reduction method, the following results were obtained as below.

Table 3.1. Validity test result

	Component	
	1	2
PE1	.771	.34
~~PE2~~	~~.355~~	~~.66~~
PE3	.806	.29
EE1	.305	.82
EE2	.519	.51
EE3	.124	.68
HM	.822	.40
HM	.839	.29
HM	.772	.31
BI1	.813	.32
BI2	.901	.13
BI3	.846	.36

From the test results, PE2 was invalid because it was in a different component to PE1 and PE3. Therefore, for the next stage PE2 variable will not be used to avoid errors.

2. Reliability Test

Reliability test is useful to measure how consistent the respondents' answers are. Because the PE2 variable is not valid, in this reliability test the PE2 variable can be excluded and the results displayed in table below.

Table 3.2. Reliability test results

Variable	Cronbach's alpha	Description
PE	0.779	Acceptable
EE	0.705	Acceptable
HM	0.903	Excellent
BI	0.919	Excellent

It can be concluded that all valid respondents' answers are reliable or consistent.

3. Correlation Test

As the final step, correlation test is used to determine the relationship between variables along with the direction of the relationship and its degree.

Table 4.2. Correlation test result

		PE_R	EE_R	HM_R	BI_R
PE_R	Pearson Correlation	1	.620**	.842**	.864**
EE_R	Pearson Correlation	.620**	1	.686**	.612**
HM_R	Pearson Correlation	.842**	.686**	1	.885**
BI_R	Pearson Correlation	.864**	.612**	.885**	1

From the table above it can be concluded that the BI variable is correlated with the HM, PE and EE variables.

IV. CONCLUSION

The results of validity test show that all variables except PE2 are declared valid. The reliability test shows that the results of the questionnaire questions for the PE and EE variables are acceptable, while HM and BI are excellent. Meanwhile, the correlation test shows that four variables are interconnected. It can be concluded that the method of learning mathematics through educational games can be applied to elementary school students. The results for the three HM variables showed that the average respondent answered Strongly Agree and the test results stated that the HM variable was valid with an average of 0.811. It can be concluded that the use of educational games as a mathematics learning medium for elementary school children has been proven to increase interest in learning FPB and KPK material. Then, based on the results of the questionnaire for the PE3 variable, the Game Labirin Bilangan: FPB dan KPK (Number Maze: GCF and LCM) can be used as an alternative learning medium without

disrupting regular study schedule because it can be played in free time.

REFERENCES

[1] M. F. Nugraha, et al., *Pengantar Pendidikan dan Pembelajaran di Sekolah Dasar*. Tasikmalaya: Edu Publisher, 2020.

[2] F. Lestari, et al., *Memahami Karakteristik Anak*. Madiun: Bayfa Cendekia Indonesia, 2020.

[3] K. Squire, *Game-Based Learning: Present and Future State of the Field*. New York: MASIE Center e-Learning CONSORTIUM, 2005.

[4] S. Yati and A. Vidya, *Strategi Jitu Pembelajaran Matematika Asyik dan Seru*. Bantul: Ananta Vidya.

[5] V. K. Kanvaria, A. Yadav, and Monika, *Augmented Reality & Virtual Reality*. Bengaluru: Archers & Elevators Publishing House.

[6] R. Rizky, *Panduan Membuat Aplikasi Augmented Reality: Membuat Aplikasi Augmented Reality Sederhana untuk Pemula*. Athana Studio.

[7] Maryana, D. A. Maulida, S. S. Jannah, Y. R. Saktilia, L. A. Sajidah, and F. Kamelia, *Media Pembelajaran Digital di Sekolah Dasar: Pembelajaran Bahasa Indonesia di Era Merdeka Belajar*. Semarang: Cahya Ghani Recovery, 2024.

[8] Ani Ismayani, *Membuat Sendiri Aplikasi Augmented Reality*. Elex Media Komputindo, 2020.

[9] P. Cronin, M. Coughlan and V. Smith, *Understanding Nursing and Healthcare Research,* 2015. Accessed: Dec 10, 2023. doi: 10.4135/9781473910836. [Online]. Available: https://doi.org/10.4135/9781473910836

[10] S. Riyanto and A. A. Hatmawan, *Metode Riset Penelitian Kuantitatif Penelitian di Bidang Manajemen, Teknik, Pendidikan Dan Eksperimen.* Yogyakarta: Deepublish, 2020.

[11] S. Arikunto, *Pengembangan Instrumen Penelitian dan Penilaian Program*. Yogyakarta: Pustaka Pelajar, 2017.

[12] J. Hocking, *Unity in Action, Third Edition: Multiplatform Game Development in C#.* New York: Manning Publications, 2022.

[13] A. Khang, V. Shah & S. Rani, *Handbook of Research on AI-Based Technologies and Applications in the Era of the Metaverse*, 2023. doi: 10.4018/9781668488515.

[14] "Clip Studio Paint," Wikipedia. https://en.wikipedia.org/wiki/Clip_Studio_Paint (accessed April 30, 2024)

[15] H.M. Sukardi, *Metodologi Penelitian Pendidikan Kompetensi dan Praktiknya (Edisi Revisi)*, Jakarta: Bumi Aksara, 2021.

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