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EMPOWERING GAMIFICATION-BASED MOBILE LEARNING MEDIA TO IMPROVE MATHEMATICS LEARNING OUTCOMES FOR DYSCALCULIA STUDENTS

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Abstract. This research aims to describe the empowerment of gamification-based mobile learning media to improve mathematics learning outcomes in cubes and blocks in fifth grade elementary school students with dyscalculia. The formulation of the problem in this research is how effective the media used in developing gamification-based mobile learning media is to improve mathematics learning outcomes in cube and block geometric materials for students with dyscalculia. The research method used in the research is development research. The research and development design uses the Sukmadinata research and development model which consists of three steps, preliminary study, development and testing. The results of this research show that the learning outcomes of the experimental class are better than the control class. Even though the results of the effectiveness test have proven that the learning outcomes of the experimental class are better than the control class, the researchers conducted an effect test to determine the magnitude of the influence of mobile learning media on the mathematics learning outcomes of cubes and blocks in fifth grade elementary school students with dyscalculia. The effect size value (d) reached 1.83, which according to Cohen's effect size is in the high category. Thus, the use of gamification-based mobile learning media has a high influence in improving mathematics learning outcomes for cubes and blocks in fifth grade elementary school students with dyscalculia. Researchers conducted an effect test to determine the magnitude of the influence of mobile learning media on mathematics learning outcomes in cubes and blocks in fifth grade elementary school students with dyscalculia. The effect size value (d) reached 1.83, which according to Cohen's effect size is in the high category. Thus, the use of gamification-based mobile learning media has a high influence in improving mathematics learning outcomes for cube and block geometric material in fifth grade elementary school students with dyscalculia. Researchers conducted an effect test to determine the magnitude of the influence of mobile learning media on mathematics learning outcomes in cubes and blocks in fifth grade elementary school students with dyscalculia. The effect size value (d) reached 1.83, which according to Cohen's effect size is in the high category. Thus, the use of gamification-based mobile learning media has a high influence in improving mathematics learning outcomes for cubes and blocks in fifth grade elementary school students with dyscalculia.

Keywords**:** Mobile Learning; Gamification; Mathematics Learning Outcomes; Dyscalculia

I. INTRODUCTION

Elementary school students are a period where learning and playing are one frame in the learning process, so the expected presence of learning media is learning media that is interesting and has elements of play.(Olawale, 2022). According to Piaget, elementary school students are in a concrete operational phase where each media should be presented holistically or comprehensively(Marinda, 2020). Learning media can be presented by integrating elements of play in learning(Aljraiwi, 2019). In this way, students will not feel bored and will always be motivated to learn because by studying and playing they will not feel bored easily. So that in the end it has a positive impact on learning outcomes and learning activities(Bada & Jita, 2022).

Currently, learning media that is packaged by integrating play elements is really needed to increase learning motivation(Olkun, 2022). Gamification-based mobile learning media is one media that can be used to increase student motivation(Anunpattana et al., 2021). Mobile learning is the intersection of Mobile Computing and E-Learning providing resources accessible from anywhere, powerful search system capabilities, rich

interactions full support for effective learning and performance based assessment(Nurhidayat et al., 2020). E-learning has characteristics independent of place and time(Amer et al., 2022). Mobile Learning is related to learning mobility, in the sense that students are able to engage in learning activities without having to do so in a particular physical location(Laine et al., 2010). The use of mobile learning media apart from increasing learning motivation also builds students' higher level thinking skills(Damrongpanit, 2022). Mobile learning allows opportunities for critical reflection and can provide access to changing knowledge, effective use of information technology even though students' classroom space is limited(Aubusson et al., 2009).

Gamification-based mobile learning media can increase students' learning activities(Wang et al., 2019). Gamificationin the context of learning is the design process of adding game elements to change the existing learning process(Sailer & Homner, 2020). Gamification tends to have positive effects of various kindsresultslearn, even withresultsdiverse(Kuncoro et al., 2021). Gamification is a process that aims to change non-game contexts (eg: learning, teaching, marketing) to be much more interesting by integrating game thinking, game design and game mechanics (game elements)(Setiana & Hansun, 2017). In this way, gamification-based mobile learning is expected to increase students' learning activities both in learning, which ultimately has a positive impact on increasing students' learning motivation(Lim & Churchill, 2016).

Previous research on the empowerment of gamification-based mobile learning in mathematics learning has been widely carried out, however, the empowerment of gamification-based mobile learning media in mathematics learning for elementary school students with dyscalculia in the city of Surakarta has not been carried out much. So it is necessary to carry out research into the development of gamification-based mobile learning media empowerment to improve mathematics learning outcomes for students with dyscalculia in elementary schools, especially in the city of Surakarta. Based on the results of the preliminary study, it was found that in learning teachers only used learning media but did not make much use of gamification-based mobile learning media.

This is supported by the results of observations made on 26 elementary school teachers in the city of Surakarta who responded that of the 26 teachers interviewed who responded that they had not implemented the gamification-based mobile learning learning model. The results of observations from 26 elementary school teachers in the city of Surakarta who were interviewed randomly gave the response that 69.2% had not implemented gamification-based mobile learning. 23.1% have implemented gamification-based mobile learning and the remaining 7.7% have implemented it but it is still rare. The results of this observation provide reinforcement that the development of gamification-based mobile learning media is really needed by teachers in learning. The results of previous research conducted by The results of observations from 26 elementary school teachers in the city of Surakarta who were interviewed randomly gave the response that 69.2% had not implemented gamification-based mobile learning. 23.1% have implemented gamification-based mobile learning and the remaining 7.7% have implemented it but it is still rare. The results of this observation provide reinforcement that the development of gamification-based mobile learning media is really needed by teachers in learning.

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The results of the analysis of teacher needs through observations that have been carried out show that teachers really need the development of gamification-based mobile learning media, especially in mathematics learning for students with dyscalculia (Mohd. Yusof & Shahrill, 2021). Dyscalculia is a learning difficulty in mathematics learning. *Dyscalculia*Also known as "math difficulty" because it involves interference with mathematical calculation abilities. This difficulty can be viewed quantitatively and is divided into counting and calculating difficulties. The child in question will show difficulty in understanding mathematical processes. This is usually characterized by the emergence of difficulty learning and doing tasks that involve numbers or mathematical symbols(Setyo Budiyantoro, 2018). The causes of difficulties in learning can be caused by external factors, internal factors, and learning factors(Lappa & Mantzikos, 2021). Internal factors include physical and mental factors, external factors include school, community and family, and finally learning factors consist of the teacher's

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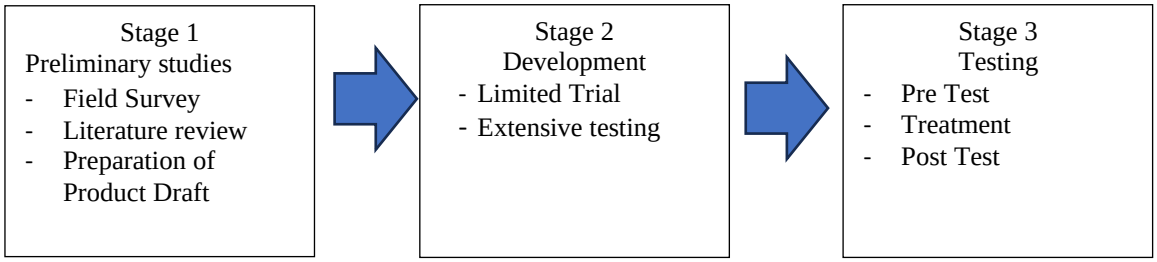
approach to the learning process, learning models and assessment (Latifah, 2021).

II. METHODS

This study uses a type of research and development (R&D). This type of research aims to develop certain product outcomes. Field studies are carried out to analyze field needs for further use in product development. Then, to get a valid product, a validity test is carried out by experts and then a limited trial is carried out in the field first. The product resulting from the trial is revised and revised to produce a finished product that is ready to be used. The output created in this development study is a gamification-based mobile learning media product. This product is a digital media that functions as a learning medium to help improve the learning outcomes of class V elementary school students with dyscalculia. The research and development design uses the Sukmadinata research and development model which consists of three steps(Sukmadinata, 2016, p. 243). The stages of the R&D steps are visualized in Figure 1 below :

Figure 1 Research and Development Steps



III. RESULTS AND DISCUSSION

1. Need for Development of Gamification-Based Mobile Learning Media for Class V Elementary School Dyscalculia Students

*First,*Based on the syllabus and curriculum, class V students are required to be able to explain volumes of geometric shapes and cube roots, however based on interviews and observations in the field, they still find it difficult to understand the teacher's explanation. This causes problems in teaching and learning and the material absorbed by students is not optimal. This needs special attention so that it does not become a protracted problem. Apart from that, the learning media presented by teachers in the teaching and learning process is only limited to concrete examples of building cubes and blocks. This media is concrete, but cannot fully explore student participation in the practice of solving cube and block geometric problems. This is because students can only watch and cannot play an active role in learning. Whereas,(Camacho-Sánchez et al., 2023).

In connection with the description above, one thing that can be done by class teachers is to increase student competence with a variety of learning media to discuss geometric volumes and cube roots. It is hoped that this will attract students' attention and increase their participation in learning. Interactive learning media can make it easier for students to understand the material(Lai, 2020). The learning media must be based on digital media that is adapted to current developments and technology. This is due to none other than the digital revolution and technological disruption which has had an impact on classroom learning(Khairunnisa & Ilmi, 2020). Therefore, educators need to have an understanding of learning media innovation(Samsinar, 2020).

However, the reality in the field is that the digital media used by teachers only consists of presenting material in the form of text via Power Point. This is not much different from the content in student books. The power point media cannot accommodate students' interests and competencies, so new digital media is needed for students' learning to run smoothly. In this case, researchers conducted a comprehensive preliminary study to provide an alternative solution for developing gamification-based Mobile Learning learning media for class V students.(Lai, 2020). This trend must be responded to wisely and can be used as inspiration to develop learning media that utilizes technology and communication packaged in the form of interactive gamification-based mobile learning media.

*Second,*Researchers followed up by developing a gamification-based mobile learning media prototype. This follow-up requires several steps such as: (1) designing the appearance of gamification-based mobile learning media, (2) arranging the cube and block building material to be included, (3) setting the number of pages, adding images, setting the layout, then changing it to a gamification application that can be used, (4) compiling questions that will be used for games in the application, and (5) arranging the appearance of the application so that it is attractive and appropriate to student needs. The appearance of the gamification-based mobile learning application has sections containing material as well as practice questions on cubes and blocks. Mobile learning applications must have an appearance that is tailored to student needs.(Samsinar, 2020). The role of color, language and image layout is very large for the development of elementary school students because it will influence the

reception of information which will later be processed into knowledge and the basis for them in solving problems on learning topics. For this reason, the prototype developed by researchers pays attention to the colors, language and images displayed so that it can attract attention and increase students' knowledge.

In detail, the prototype developed by this researcher consists of a cover page, main page (main menu), basic competency menu, learning objectives menu, learning materials menu, example questions menu, games/games menu for students, student identity menu, and menu evaluation results equipped with values and diagrams. The development of mobile learning media which is packaged with complete menus and attractive displays on the screen is also able to make mathematics learning more fun and acceptable for elementary school students after going through a period of studying at home.(Sari & Cahyono, 2020). In this way, the researchers presented a prototype that was as optimal as possible so that learning the dimensions of space could be accepted by students and make mathematics learning more professional and entertaining.

2. Results of Development of Gamification-Based Mobile Learning Media

a. Product Design

At this stage, researchers validated the development of a gamification-based mobile learning media prototype based on the assessments of experts consisting of learning media experts, inclusive education experts and elementary school mathematics experts. These experts assessed the media prototype to identify its weaknesses, which were then minimized by revising it to produce an effective product for improving the learning outcomes of class V elementary school students with dyscalculia. Based on the identification and analysis of the three experts, the prototype developed by the researchers had several deficiencies in small parts of the display. The thing that was highlighted and considered not optimal was the background or background on the storyboard. Media experts provide input so that the background color of the storyboard is changed and other color variations are given to make it more attractive. Apart from that, the overall appearance is sufficient to support learning for elementary school students. The choice of striking colors and fresh color variations can have a good impact on students because they focus more attention on the learning media display screen(Zikrillah & Humardhiana, 2021). Next, education expertsInclusion filled out a questionnaire to assess this mobile learning media and showed the results that mobile learning media can help students reduce difficulties in understanding cube and block geometric material. The content in the mobile learning media is considered to be able to facilitate students' understanding in solving problems related to cubes and blocks in Mathematics learning. This validation is also strengthened by the results of assessments from Elementary School Mathematics Experts, that gamification-based mobile learning media can help students to improve their mathematics learning outcomes regarding cubes and blocks. The development of this prototype deserves to be continued with revisions to improve the appearance and expansion of content as well as the use of technology that can support learning (Bulić, M., & Blažević, I., 2020),

The next stage after revising the appearance and content is to carry out the test instrument testing stage. The test instrument in the form of an objective description is used to measure students' mathematics learning outcomes and then calculate their validity and reliability. The test instrument consists of 10 questions which were tested on class V students at SDN Laweyan. The validity test results show thatThe 10 questions tested were declared valid because rcount > rtable (see attachment for details). Apart from that, the results of the question reliability test were also declared reliable because Cronbach's Alpha showed a score of > 0.6.

b. Limited Trial

Next, the researchers conducted a trialon a limited basis at SDN Sayangan for 26 class V students. The limited trial was carried out on 11-18 June 2023. The results of this limited trial wereThe student's score is above the KKM. After obtaining the results of mathematics learning about cubes and blocks, the next step is to test using the one sample t-test technique. One sample t test or what is called a one sample test is generally used to compare the average of the sample being studied with the average of the existing population. The significance value is < α (0.05), then H0 is rejected so H1 is accepted. Therefore, it can be concluded that the average learning outcomes of students who use gamification-based mobile learning media are more than 75 (KKM). As found by Nurjannah et al, gamification is effective in learning mathematics(Nurjannah et al., 2021). Gamification learning media also has a positive effect on student activity as shown by an increase in learning outcomes(Sudana et al., 2021). Gamification has also been proven to be a useful tactic for students to increase motivation and trigger better learning behavior.(Zsigmond et al., 2020)

The results of student learning outcomes were also confirmed by the results of a user questionnaire regarding the use of mobile learning media in cube and block building material, showing that the choice of score 2 or in the "Enough" category was the one most rated by students. Then, the results of the teacher questionnaire showed that the choice of score 4 or in the "Very Good" category was the one most rated by teachers. Suggestions and input on this limited trial were provided by users (students and teachers) as a basis for researchers to improve the product so that the product developed can be optimal in improving mathematics learning outcomes in cube and block geometric material. After this, researchers tested the product extensively.

c. Extensive Trial

Extensive trials were carried out after the researchers made revisions and improvements to this mobile learning prototype.This stage was carried out in class V in two

elementary schools, namely SDN Bratan 2 and SDN Bratan 3. After the test was carried out, most of the students' learning outcomes achieved a score above the KKM (75). The one sample t test analysis shows thatThe average learning outcomes of students who use gamification-based mobile learning media is more than 75 (KKM). Apart from that, the results of the student questionnaire regarding the use of mobile learning media in cube and block building material showed that the choice of score 4 or in the "Very Good" category was the one most rated by students. Then, the results of the teacher questionnaire showed that the choice of score 4 or in the "Very Good" category was the one most rated by teachers. The response of teachers and students to this extensive trial was that they were happy with digital media in the form of mobile learning because it was interesting, flexible and practical.

The existence of better learning outcomes in extensive trials shows that the use of gamification-based mobile learning media has an influence on students' academic abilities. As found by Aljraiwi, there was high academic achievement and creative thinking after using gamification(Aljraiwi, 2019). Apart from that, gamification is also a significant learning method in having an impact on student motivation and academic performance(Camacho-Sánchez et al., 2023). Even though broader trials in this research show that the use of gamification-based mobile learning media can improve student learning outcomes regarding building cubes and blocks, researchers carried out the next stage, namely testing the effectiveness of the product so that the product developed can effectively improve student learning outcomes. material for building cubes and blocks.

3. Effectiveness of Gamification-Based Mobile Learning Media

The testing stage for the effectiveness of gamification-based mobile learning media began by carrying out the final testing stage in the experimental class and control class, showing thatThe average student learning outcomes in experimental classes at both SDN Laweyan and SDN Setono have increased after using gamification-based mobile learning media. Before using this media, it was seen that the student average was only 71.85 at SDN Laweyan and 68.89 at SDN Setono. After using the developed product, it increased to 86.30 at SDN Laweyan and 82.22 at SDN Setono. Meanwhile, the average student learning outcomes in the control class at SDN Bratan 1 also increased, from 69.64 to 70.36. The control class normality test reached a significance of 0.056 and the experimental class 0.055. Both of these figures are greater thanα so that H0 is accepted. Thus, the conclusion that can be drawn is that the data is normally distributed. Meanwhile, the homogeneity test reached a significance of 0.732 which is also greater than α so it can be concluded that the test data in the control and experimental classes have homogeneous variants. In other words, the data comes from a population with the same variance.

Table 1 Results of Prerequisite Test Analysis

Testing	Test Type	Results	Decision	Conclusion
Normality	*Kolmogorof-Smirnof*	Control class (Sig.0.056) Experimental Class (Sig.0.055)	H0 is accepted	Data is normally distributed
Homogeneity	*Lavene Statistics*	Sig. 0.732	H0 is accepted	Homogeneous Data
Balance Test	*Independent Sample t-test*	tcount = -0.352 df = 80 ttable= 1.99006 Sig. 0.726	H0 is accepted	Results have no difference (balanced)

Then, the tcount of the independent sample t-test in the balance test shows the number -0352, which is smaller than ttable = 1.99006. The probability value reaches a significance of 0.726 which is greater than α. The results obtained in this balance test show that there is no significant difference between the pretest mean mathematics learning outcomes of students in the experimental and control class groups. In other words, both groups have equal abilities.

The next stage of testing carried out is carrying out a comprehensive effectiveness test.The independent sample t-test was carried out after the students' posttest test data was normally distributed and homogeneous. The prerequisite test is fulfilled because the data is normally distributed and homogeneous. Next, the researchers carried out further tests with an independent t-test to see whether there were significant differences in the samples given different treatments. Furthermore, the t-count is greater than the t-table, so it can be concluded that there are significant differences in the control and experimental classes. Thus, the results of testing mathematics learning outcomes in the control and experimental classes are not the same. In other words, the learning outcomes of the experimental class were better than the control class. Although the results of the effectiveness test have proven that the learning outcomes of the experimental class are better than the control class.

Table 2 Independent Sample T-test Results

Testing	Test Type	Results	Decision	Conclusion
t test	*Independent Sample t-test*	tcount = 7.858 df = 80 ttable= 1.99006 Sig. 0	H0 is rejected	There is a difference

Table 3 Effect Test Analysis Results

Data source	Test Type	Results	Conclusion
Post-test scores for control and experimental classes	*Cohen's Effect Size*	d = 1.83	The size of the effect resulting from the use of the product being developed is in the high category

The effect size value (d) reached 1.83, which according to Cohen's effect size is in the high category. Thus, the use of gamification-based mobile learning media has a high influence in improving mathematics learning outcomes for cube and block geometric material in class V elementary school students with dyscalculia.

The results of the effectiveness test which show that the learning outcomes of the experimental group are better than the control group and the effect test which is in the high category are proof that the product developed by the researcher can effectively improve the mathematics learning outcomes of cubes and blocks. Gamification can also increase student involvement and participation so that their academic potential can be further stimulated(Thurairasu, 2022). Apart from that, gamification can also be said to be a fun, interesting, motivating and successful way to learn(Dehghanzadeh & Dehghanzadeh, 2020).

IV. CONCLUSION

Digital learning media innovation has become a necessity amidst developments in technology, information and communication. The results of the development of gamification-based mobile learning media were declared suitable for use to improve fifth grade students' mathematics learning outcomes regarding cubes and blocks. This feasibility is not only reflected in the learning outcomes of students but also the users (teachers and students).admitted that he was happy with the existence of digital media in the form of mobile learning because it was interesting, flexible and practical.The gamification-based mobile learning media that was developed has been proven to be effective in improving fifth grade students' mathematics learning outcomes on cubes and blocks. This can also be seen in the effect calculation results which show d = 1.83 which is included in the high category. This means that the use of gamification-based mobile learning media has a high influence in improving mathematics learning outcomes for grade V elementary schools on cube and block geometric material.

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