

Development of Educational Games as a Learning Arithmetic Operations with The Sprint Design Method

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Abstract

The development of information and communication technology (ICT) has had a significant impact on various aspects of life, including education. The use of ICT-based learning media can make the learning process more engaging, effective, and efficient. One trending form of learning media is educational games. Educational games combine educational content with computer game elements to create an enjoyable and engaging learning experience. The main advantage of educational games is their ability to illustrate real-world problems and encourage players to actively seek information while improving their skills and understanding. This study aims to develop Android-based learning media in the form of educational games using the Sprint Design methodology. This method includes five phases: understanding, diverging, deciding, prototyping, and validating. The understanding phase involves curriculum analysis and user needs, while the diverging phase produces strategies and design sketches. The deciding phase selects the best ideas, the prototyping phase builds the initial model, and the validating phase includes testing by content and media experts. The results indicate that the educational game is effective in increasing students' interest and understanding of mathematics. Trials showed high validation scores from content and media experts, as well as positive feedback from students. The game is deemed feasible as a learning medium and can enhance educational quality with a user-friendly interface. Ongoing and innovative development of educational games is necessary to improve education quality in Indonesia.

I. INTRODUCTION

The development of information and communication technology (ICT), there has been a significant impact on various aspects of life, including education. Technological developments can organize the circumstances and facts of the learning process to be much more interesting, effective, and efficient and provide adaptive conditioning in the learning process wherever it is and the use of technology in the learning process is more effective than the conventional learning process[1]. One form of ICT- integrated learning media is a learning trend in the era of the Industrial Revolution 4.0. Learning media is favored by elementary school students because it can attract students' interest and attention.

Learning media can help accelerate the learning process and result by making the delivery of messages and information clearer. Student learning motivation can be increased by learning media by directing their attention. The ability for a student to learn on their own according to their environment[2].

One of the trending learning media is educational games. Educational games are a combination of educational content and computer games designed to help students learn in a more fun and interesting way[3]. One of the advantages of educational games is the ability to illustrate real-world problems. Based on the game model, players are asked to solve the problems presented. In the context of learning, digital games not only offer immersive and

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fun material experiences, but also encourage players to actively seek information and improve skills, knowledge, and understanding through the principles and functions applied in the game[4].

Educational games are currently a technology that can be used as a learning medium. The development of educational games is very interesting. When compared to conventional educational methods, educational games offer some advantages. The availability of animation, which has the potential to improve memory and help students retain information longer than conventional teaching methods, is one significant advantage[5]. Educational games consist of several components such as sound, graphics, video, and animation. Students can retain and collect information in memory for a longer period when learning using educational games than using conventional methods. This is one of the advantages of educational games because they contain components that can improve memory, such as animation[6].

Students' interest in using Android as a learning media and are accustomed to using Android smartphones shows students' need for Android-based learning media in these subjects. Teachers have not been able to make the most of technology as a learning medium, even though students are familiar with technology[7].

Mathematics learning is one of the subjects that is considered difficult, especially for elementary school students. Mathematics is the basic knowledge that students must have to achieve successful learning. One of the indicators in students that can affect their learning outcomes is interest in learning[3]. Based on observations of MINU Gresik elementary school students, they stated that they felt less interested and felt that math was a scourge in learning.

In addition to the obstacles caused by students, the lack of learning media and learning resources is also suitable for exploring students' abilities, making them tend to be passive in class. Moreover, teachers still apply lecture learning models and teacher-centered learning activities in mathematics lessons.

Interesting learning media can be created by using the right game development method. One of the right game development methods is to use the sprint design method. Based on research conducted by Alfirdaus et al[8], this research produces Android-based educational games for learning Arabic vocabulary, focusing on the material of body members, professions, and zoos. Using the Sprint Design methodology which includes five phases (understanding, branching, deciding, prototyping, and validation), validation by material and media experts showed high feasibility (93% and 91%), and learner trials showed 91% and 96% feasibility. This educational game is considered very feasible and effective as a learning media, with recommendations for further distribution.

Based on these considerations, the researchers wanted to develop Android-based learning media in the form of educational games.

II. RELATED WORKS/LITERATURE REVIEW

The use of educational games as a medium for teaching mathematics has been a primary focus in several previous studies. These studies indicate that educational games not only enhance students' learning interest but also improve their understanding of difficult mathematical concepts.

Researched the development of a mathematical maze educational game to improve the problem-solving abilities of sixth-grade elementary students, particularly in the material of adding and subtracting negative integers. This research used the Research and Development (R&D) method with the ADDIE development model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. The results of the research indicate that the developed mathematical maze educational game has a very good validity level according to material and media experts. Additionally, a limited trial with six students also yielded positive results, making the game considered suitable for use in teaching[3].

Researched the issue of using conventional teaching media such as books and lecture methods, which led to weak vocabulary acquisition among MI Darussalam students in Arabic, particularly in topics like body parts, professions, and animals. This study used the Design Sprint method, which consists of five phases: understanding, diverging, deciding, prototyping, and validating. The Gdevelop Game Engine was used to build the game. The research results showed that the content expert validation received a percentage of 93%, the media expert validation received 91%, and the student trials with small and large groups achieved feasibility scores of 91% and 96%, respectively. The media was declared very feasible and ready for distribution[8].

Researched the development of an English educational game to improve the listening skills of 12th-grade students at SMKN 3 Bangkalan. This study employed the Research and Development (R&D) method using the Multimedia Development Life Cycle (MDLC) model, which consists of six stages: concept, design, material collecting, assembly, testing, and distribution. The research findings indicate that the educational game is considered highly feasible and effective in enhancing students' listening abilities, with expert validation and user testing showing a high feasibility percentage[9].

The study evaluated the usability of mobile applications for learning and found that good usability can enhance the user experience in achieving learning objectives. This research focused on the user experience level of an Android application for booking car test drives. The method used was usability testing with an online questionnaire to measure user satisfaction, and the data analysis technique applied was descriptive analysis. The research results showed an application effectiveness of 100%, efficiency of 81%, and satisfaction of 97%. This

study revealed that the application has a very good user interface design, emphasizing the importance of usability in enhancing user experience and the success of the application[10].

The results of the literature review indicate that the use of educational games in learning, whether in mathematics or English, is effective in enhancing students' understanding and skills. Development methods such as ADDIE, Design Sprint, and MDLC have proven successful in creating valid and feasible learning media, while a good usability evaluation is crucial to ensure the application can significantly improve the user experience. Therefore, the author intends to develop a learning media in the form of an arithmetic operations game using the Design Sprint method. The application of the appropriate development method and comprehensive usability evaluation will be key to maximizing the effectiveness of educational games in supporting the learning process and optimally meeting students' needs.

III. METHODS

The research and development method is a research step used to produce certain products and test the effectiveness of these products[11]. To produce an expected product, the stages in research are needed to analyze the needs to test the effectiveness of the product, with the aim that the product can work in a wider community[8]. This research uses the design print model. The design print model is a human-centered approach to innovation that utilizes design tools that integrate human needs, possible technological developments, and requirements for goal success. Design print has five phases, namely understand, diverge, decide, prototype, and validate[12]. Figure 1 is the phase in research using the design sprint model.

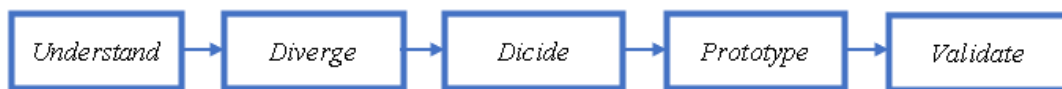


Fig. 1 Phases of The Design Sprint Model

In the understand phase, information regarding user problems and needs is gathered through an analysis of the Merdeka curriculum used at SD Minu Gresik. The identified competencies include students' abilities in addition, subtraction, multiplication, and division involving positive integers.

The diverge phase identifies potential strategies based on observation results and user needs. Evaluations are conducted, and rough sketches or diagrams, such as use case diagrams (UCD), are created to convey the system design of the game.

In the decide phase, the best ideas are selected based on the sketches created. These ideas are then developed into wireframes, which include essential elements such as content, menu, columns, and footer.

The prototype phase involves creating a visual representation of the solution to be tested by users. Software such as Unity and Corel are used to design assets for the development of the educational game, including the main menu, background, button positions, and other elements. Assets in .PNG format are exported to Android Studio after setting up Android SDK and NDK. Asset design also includes sound effects and background music. The prototype is tested through preliminary testing to verify its alignment with user needs.

The validate phase involves testing the prototype with educational media experts and content experts. Testing is conducted to ensure the application functions as intended and can be effectively utilized by users. Content validation by mathematics experts ensures that the educational media content aligns with existing learning resources.

IV. RESULTS

A. Understand Phase

In the understanding phase, information is gathered about the problems and needs of users, as well as setting goals and reviewing technologies that can be used to meet user needs. This phase involves direct observation with users to gain new insights that have never existed before.

The understanding phase is carried out by analyzing the curriculum used, namely the Merdeka curriculum. The competencies used at SD MINU Gresik are : (a) Learners can determine addition and subtraction calculation operations involving positive integers; (b) Learners can determine multiplication and division calculation operations involving positive integers.

B. Diverge Phase

In the diverge phase, potential strategies are identified based on insights, results from user observations, and user needs in this phase, an evaluation is also carried out and provides a rough description or sketch based on the insights and user needs that have been obtained in the understanding phase. In the play menu, there are instructions before starting to play, so that players can easily understand the game flow.

In determining the design of this application, the UML (Unified Modeling Language) system modeling design is used first as a medium to convey the design of the learning game system in the form of a use case diagram (Alfirdaus et al., 2023). A use case diagram (UCD) is a diagram for developing software or an information system in order to capture the functional needs of the system. The use case diagram for this game is shown in Figure 2.

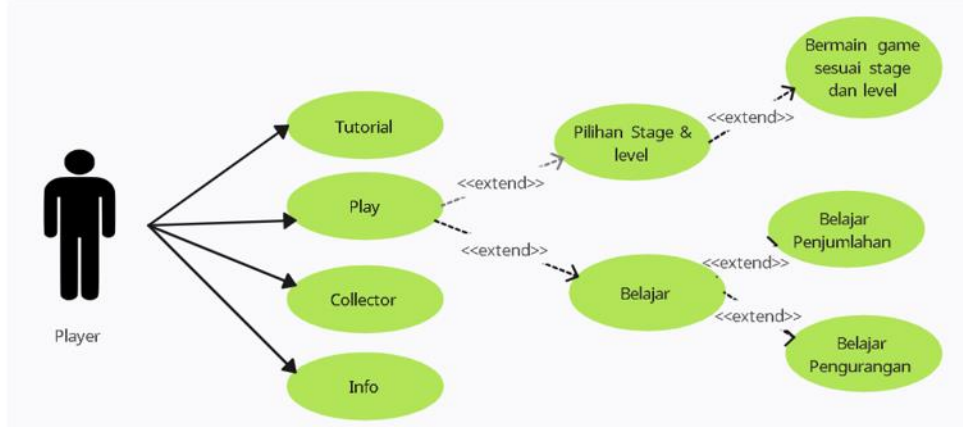


Fig. 2 Use Case Diagram

C. Decide Phase

In the decide phase, the best idea is selected based on the sketching process that has been done previously. This stage is the process of developing all the ideas that have been obtained in the previous stage into wireframe designs. Wireframe is the basic framework of an application page that includes important elements such as content, menus, columns, and footers. Figure 3,4,5,6 is the result of the wireframe design. Figure 7,8,9,10 shows the sequence diagram, which helps in understanding the flow of processes within the application and ensures that all necessary interactions are represented.



Fig. 3 Wireframe Prolouge Scene



Fig. 4 Wireframe Homeplay menu

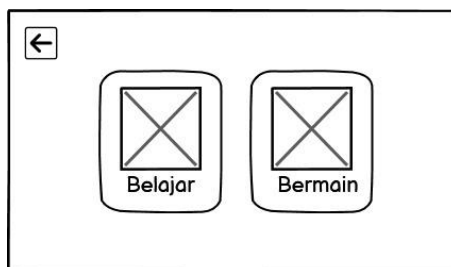


Fig. 5 Wireframe main menu

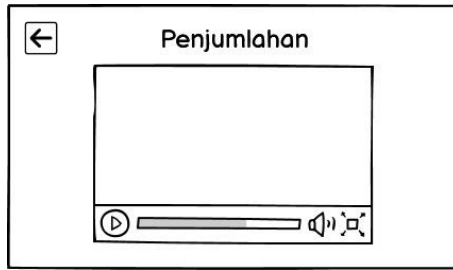


Fig. 6 wireframe of the learning scene

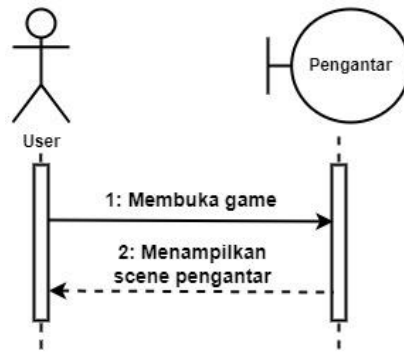


Fig. 7 Opening the Game

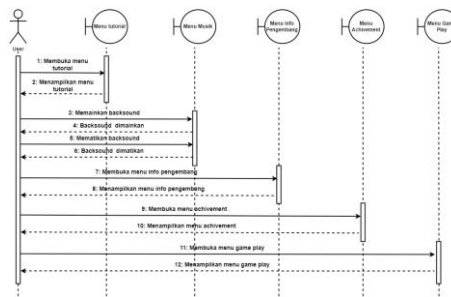


Fig. 8 Homeplay Menu Interactions

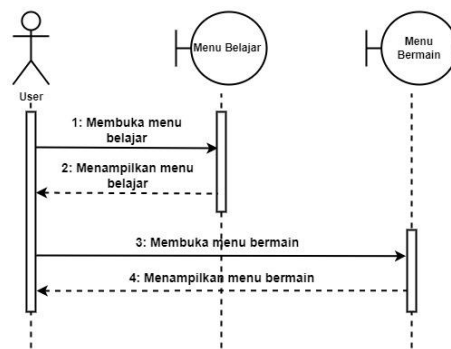


Fig. 9 Learning and Playing Menus

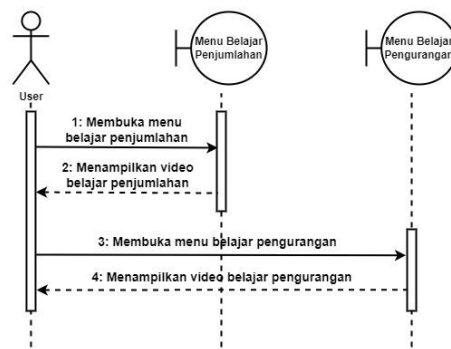


Fig. 10 Learning Content - Addition and Subtraction

D. Prototype Phase

In the prototype phase, an initial model is built based on the best concept or idea selected in the previous phase. In this phase, the ideas that have been selected will be implemented using a prototype tool that allows for user testing. This prototype is a visual representation of the solution that has been found from the existing problem and will go through a testing process to verify whether it is following user needs in the next stage. The prototype phase of the educational game was built using Unity and Corel software to design assets. In this step, researchers create a display design that includes the appearance of the main menu, background, button position, and other assets using Corel Draw software, which is then exported into .PNG format. In making asset designs using Corel Draw, which is then exported into .PNG format. Assets in an educational game are in the form of 2D designs in educational games. Other assets that need to be prepared are sound effects and background, then the game will be exported using Android Studio provided that the Android SDK and NDK have been set up. Screenshot results of each scene contained in the Math Counting Operations educational game product are presented in the Figure 11,12,13,14, and 15.



Fig. 11 Homeplay Scene



Fig. 12 Mainmenu Scene



Fig. 13 Study Menu



Fig. 14 Play Menu



Fig. 15 Reward Collection Menu

E. Validate Phase

The final phase of validation involves testing the prototype with learning media experts and material experts. This phase is able to improve existing solutions, and can even produce better solutions than the prototypes that have been made before. Once the app has been built and the material content inserted into it, it needs to be tested to make sure everything works as it should. Hence, the app needs to be tested in a real-world setting to make sure everything works properly. In addition, user testing is needed to ensure that the application can be utilized properly by users[13]. Mathematics material validation a person who has certain expertise in the subject of mathematics is referred to as a content or material expert. The purpose of the test conducted by the material expert is to determine whether or not the content of the learning media is in accordance with the content of existing learning resources.

Media expert validation is a person who has special expertise in the field of learning media called a media expert. The learning media expert trials carried out aim to determine the quality and level of attractiveness of the learning media products that have been developed. So that researchers can make product improvements if needed. The following are the requirements for selecting learning media experts.

Based on the questionnaires completed by experts, including content experts and media experts, as well as the questionnaires filled out during external testing conducted with MINU Gresik elementary school students in individual tests, small group tests, and field tests, the results are presented in Table 1: Expert Validation Results.

TABLE 1
EXPERT VALIDATION RESULTS

Expert	Presentation	Criteria	Qualification
Material	84,22%	Very good	Very Feasible
Media	88%	Very good	Very Feasible

External testing is carried out for user testing with small groups, researchers test math educational games to 8 students from grade 4 of MINU Gresik Elementary School. The following are the results of the assessment obtained through a questionnaire sheet given to the students. Testing includes 3 indicators, namely balance testing, playtesting, and usability testing. Small group users after going through the testing and analysis process. The balance testing indicator obtained a percentage score of 76.6%, the playtesting indicator obtained a percentage score of 80%, and the usability testing indicator obtained a percentage score of 83.46%.

In the large group user test, researchers tested the math education game with 20 students from grade 4 of MINU Gresik Elementary School. The following are the assessment results obtained through a questionnaire sheet given to the students. Testing includes 3 indicators, namely balance testing, playtesting, and usability testing. After

going through the testing and analysis process the balance testing indicator obtained a percentage score of 63%, the playtesting indicator obtained a percentage score of 77.33%, and the usability testing indicator obtained a percentage score of 79.92%.

V. DISCUSSION

This math educational game excels at usability indicators, which test ease of use, feedback, appearance, and usability in learning. The percentage obtained is 83.46% which is included in the "feasible" category, which shows that users while playing this educational game are easy to use and users do not experience difficulties or confusion when using it. This is supported by Hartawan's research[10], that good usability has a very big chance to be frequently visited by users because the application helps in achieving goals. High usability makes games look more user-friendly[14], this is also in line with Santoso's research[15], that with good usability users can learn and use a product to achieve their goals. Likewise with Sukmasyetya's research[16], which states that the usable interface of the scout makes users able to concentrate more on educational games. So it can be concluded that the educational games developed are good and feasible, can be used by users to learn, and achieve goals more effectively and the easy-to-use interface also increases concentration.

The usability indicator score gets the highest score, which includes ease, feedback, appearance, and usability in learning. The percentage obtained is 79.92% which is included in the "feasible" category, this shows that users while playing this educational game are easy to use and users do not experience difficulties or confusion when using it. High usability makes the game look more user-friendly[14], this is supported by Hartawan's research[10], that good usability has a very big chance to be visited frequently by users because the application helps in achieving goals. This is also in line with Santoso's research[15], that with good usability users can learn and use a product to achieve their goals. Likewise with Sukmasyetya's research[16], which states that the usable interface of the scout makes users able to concentrate more on educational games.

VI. CONCLUSIONS

This research shows that educational games are effective learning media to increase students' interest and understanding of mathematics and subject matter. The use of appropriate methodologies, such as Sprint Design, in the development of educational games can produce quality and useful games. Educational games can not only be used to deliver subject matter but can also be used to introduce local culture to students. This can increase students' interest in learning and enrich their knowledge of Indonesian culture. Sustainable and innovative educational game development needs to be done to improve the quality of education in Indonesia. It can be concluded that well-developed educational games allow users to learn and achieve goals more effectively. In addition, the user-friendly interface can also improve user concentration.

This math language educational game has undergone an assessment of its effectiveness level. The assessment results show that this game is feasible as a learning medium. Likewise, in the trial conducted, MINU Gresik 4th grade students showed feasibility after they used this game and received positive responses from students.

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