Association of Researcher of Skills and Vocational Training, Malaysia

ANP-JSSH
ISSN 2773-482X eISSN 2785-8863
DOI: https://doi.org/10.53797/anp.jssh.v5i2.5.2024

Development of A Scratch Game Based on Elementary School Whole Number Material

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Received: 15 November 2024; Revised: 2 Dec 2024; Accepted: 5 Dec 2024; Available Online: 25 December 2025

Abstract: The purpose of this study is to develop a virtual game of mathematics for the material of integers for grade IV Elementary School. This game is to help students with problems in understanding the material of integers. In developing this virtual game, the research approach used is qualitative development research using the ADDIE model. The interview was conducted with two experts who have expertise in the field of engineering education, *game-based learning,* and electrical engineering. The results of the study indicate that the virtual game of whole numbers has content that is in line with the Curriculum, already has complete game content, and is in accordance with the material of whole numbers. It is expected that the use of virtual games of whole numbers can improve the quality of students' understanding of understanding whole numbers.

Keywords: Development, ADDIE, Gamification, Elementary School, Scratch

1. Introduction

Mathematics is one of the subjects studied by students. from elementary school to college (Arfiansyah et al., 2019). Through mathematics, it can help students to have the ability to think logically, analytically, systematically, critically, creatively, and be able to solve several problems in daily activities (Lestari & Sudihartinih, 2021). Therefore, mathematics is needed to develop the skills needed in the 21st century (Sholihah, Rahayu, and Handayani 2024). In reality, some students consider mathematics as a scary, boring, unpleasant and difficult subject. Students find it difficult to learn mathematics because mathematics is abstract. In addition, an understanding of prerequisite material that is not yet strong can be the cause of students' difficulty in understanding mathematics (Ningrum et al., 2023). In addition, the lack of known context and understanding of concepts that are still partial.

One of the important topics in mathematics is integers less than 10,000. In this topic, it is a prerequisite for understanding integers regarding addition, subtraction, multiplication and division operations (Ni'mah et al., 2024). However, in learning, students still experience errors and learning barriers to understanding the topic of integers less than 10,000 (Likka et al., 2023). The results of the study conducted by Ratnamutia showed that there were errors related to concepts, facts, principles, and skills in solving mathematical problems. In addition, there were several obstacles experienced by students in understanding mathematical material, namely the occurrence of leaps in the thinking process, limitations of more complex contexts, and procedural methods of forming concepts and solving problems. Therefore, there is a need for interesting learning media that can help students understand the material on integers less than 10,000.

Learning media is used as an intermediary to convey material to students using certain tools so that students can understand quickly and receive knowledge from teachers (Kusumawati, 2022). Scratch is suitable for use in today's era of technological development. Scratch is a visual programming language that was specifically developed by Lifelong Kindergarten research group at MIT Media LAB. Scratch has the use as an application for creating interactive stories, interactive and animated games. Scratch can also be spread to other people via the internet (Bagasputera et al. 2023). Scratch has a tool to help with developing applications without having to write any code,

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just by assembling puzzle-puzzles that exist. So, it is easy to make, to operate scratch You only need a computer or laptop with internet network access that can be operated online by visiting website or can be done manually offline by downloading the application scratch.

Based on the description, research on the development of mathematics learning on the topic of integers less than 10,000 in the media scratch. Several researchers have succeeded in developing learning media based on scratch on the area of the triangle (Lestari & Sudihartinih, 2021). Topics of quadrilateral plane building materials, PSLV materials, and greatest common factor (GCF). In addition, research results found that the use of media scratch in learning mathematics can increase students' interest in the learning process and become an interesting learning media (Cheung & Ng, 2021). Therefore, this study aims to describe the results of the development of learning media.

2. Literature Review

Presenting material through animation, games, or interactive stories that are created, students are actively involved in the learning process (Sarifah et al., 2023). They not only become passive consumers of information, but also become active content producers, which allows them to deepen their understanding of the subject matter. Next, the media scratch can also improve students' understanding of the concepts taught in the learning material (Bernard & Setiawan, 2020). The use of scratch as a learning tool allows students to combine the concepts they learn with concrete programming practices Prasetya, Hirashima & Hayashi (2020). This helps students to understand the concepts in a deep and contextual way, thereby strengthening their understanding of the subject matter.

Whole numbers are natural numbers that start from zero and continue to increase sequentially such as 0, 1, 2, 3, 4, and so on. The whole numbers of 10,000 consist of thousands, hundreds, tens and units. While units are whole numbers consisting of one digit, namely from 0 to 9. Tens are numbers consisting of two digits, namely from 10 to 99 (Likka et al., 2023). If more than two digits, this number is in the second order from the right. Hundreds are numbers consisting of three digits, namely from 100 to 999. If more than that, then this number is in the third order from the right. Thousands are numbers consisting of four digits, namely from 1,000 to 9,999. If it is more than that, then this number is usually fourth from the right. In whole numbers up to 10,000 there are four arithmetic operations, namely addition, subtraction, multiplication, and division.

3. Methodology

This study uses the ADDIE model as a guide for the methodical development of digital games developed in this study. The acronym ADDIE, which stands for analysis, design, development, implementation, and evaluation. Shows the division and important procedures needed for a project that aims to create a new product. This particular model was chosen because of its emphasis on the repetition of phases, with each phase having a relationship with the next phase. As a result, if a phase is not carried out if it is unsuccessful then it will be repeated until the desired results are achieved.

The ADDIE model is the basis for organizations Virtual Lab Games in the development process in this study. As a result, there are five different stages. The analysis stage is the initial stage. Creating educational resources integrated into digital games and storyboards is the task of the second stage, namely design. After the process storyboard, learning materials and activity plans are developed during the third step, called development. Learning resources and exercises are put into practice during the fourth step, called implementation. The completed program is tested and assessed in the final stage, called evaluation. The creation of this work chose to wait until the development stage to create the product rather than implementing all five phases. The ADDIE model process flow is in the following Fig. 1.

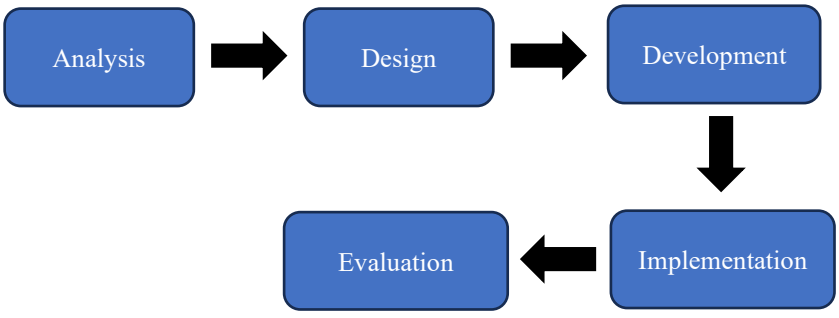


Fig. 1: ADDIE Model

The analysis stage aims to ensure that the application being developed is in accordance with the solution to the researcher's problem. According to this study, with the application *scratch* able to provide innovation in learning. The topic of whole numbers is part of mathematics. Mathematics is one of the subjects that can improve creative thinking skills. Mathematics can be used to develop creative, disciplined, systematic, logical

thinking skills, and effective cooperation in future life, and be able to compete. Students will feel challenged and have the spirit to learn mathematics in learning the operations of addition, subtraction, division and multiplication of whole numbers. In particular, students have difficulty in visualizing the arithmetic operations on whole numbers. In addition, with the implementation of this scratch application, it will make it easier for students to solve problems in the material of whole numbers.

The second stage is the design stage. At this stage, the learning material is arranged by determining the general form, structure, theoretical approach, type of media, and digital game technology. This stage is very important because it includes describing the strategy to achieve the goals of the digital game and designing a strategy to develop the product. The stages in the design phase include project documentation, development storyboard, interface design, prototype development, and use of visual design. Each stage includes different software, and complete details of the software used. In Table 1, this digital whole number game contains five multiple-choice questions that have different levels of questions. Starting from easy, medium and difficult types of questions. The five questions cover whole number material starting from addition, subtraction, multiplication and division operations. Fig. 2 shows the prototype design of the digital game that was developed.

Table 1. Software Used for Each Purpose

Software	Objective
Affinity Designer	- Develop *a storyboard* - Designing the interface - Visual design - Object design
Microsoft says	Script writing
The final steps	Prototype creation

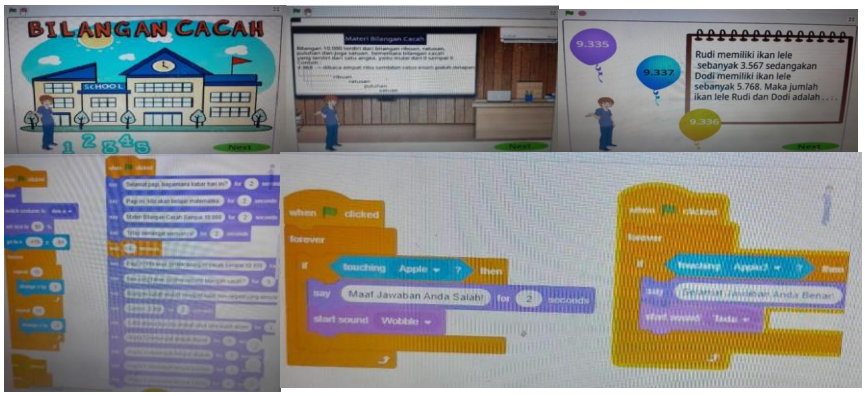


Fig. 2: Design prototype

The third stage is the development stage. At this stage, researchers make a product through the media. *Scratch* material on integers for grade 4 of Elementary School, with various stages that are passed starting from analysis, design and finally on product development. At this stage, the researcher collects integer material through various sources such as books and other electronic media. At this stage, the actual system is built by utilizing relevant media and technology components according to the purpose of the digital game being created. Each part that is designed by implementing various software at the design stage is compiled on the initial platform into a prototype. At this stage, the prototype undergoes refinement based on expert opinion. Changes in the game mechanism result in changes in the coding that needs to be used. Ultimately emphasizing the coding development process from the previous prototype to the finished product. Several games have been developed, as shown in Fig. 3.

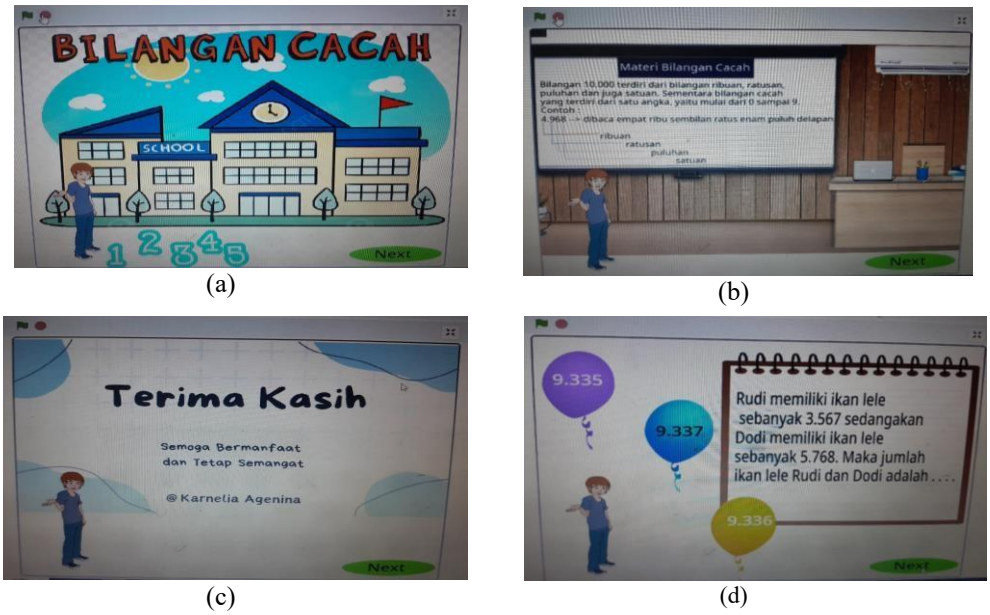


Fig. 3: (a) The first menu consists of the title of the material; (b) Whole number material; (c) Whole number questions which include whole number operations such as addition, subtraction, multiplication; (d) Closing material and words of thanks

In this discussion, the results of the discussions during the design phase combine the creation of software and instructional materials for digital games. A guide is used to code digital games and create applications, according to the development strategy. Each development is carried out through constant testing to ensure that the electric digital game runs smoothly and effectively.

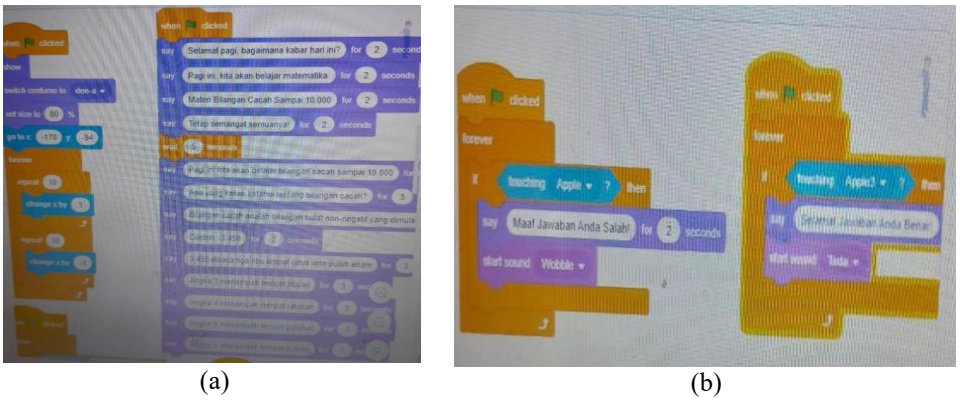


Fig. 4: (a) coding of material (b) coding of correct and incorrect answers

At this stage, application validation testing is carried out. *Scratch* material of whole numbers by 2 validators, namely 1 lecturer from Universitas Muria Kudus and 1 multimedia engineering teacher. This stage will result from validation by experts that can be analyzed to find validity regarding the application learning media *scratch.* The professionals are highly skilled in games, electronics for engineering, and the creation and assessment of multimedia learning materials. In the interview activity, a series of questions were created which were divided into three parts, namely the first part, the second part and the third part. The experts were asked about 8 questions related to digital games to assess the utilization of the mobile application that had been created.

Table 2. Expert Background and Expertise

Respondents	Gender	Background
R1	Male	Lecturer at Universitas Muria Kudus
R2	Male	Vocational High School Teacher

Part B describes the findings regarding the content of the electronic digital game. Five questions include content analysis of student challenges, whole number material, and recommendations for improvement. The following table explains the above statements:

Table 3. Questions and Expert Opinions

Question	Expert opinion
What is the media? Scratch Is it in accordance with the integer number material?	It is appropriate, this can be seen from the first slide to the last slide. On the second slide, it has been explained about whole numbers. In addition, there are also practice questions about the whole number arithmetic operations
Is the backdrop selection appropriate?	For selection *backdrop* is in accordance with the theme of the selected material
What do you think about the digital learning media that I created, has it attracted students' interest in learning, especially in mathematics?	I think it's interesting, with this media, students will indirectly learn while playing. In addition, this medium has several features that seem fun
How effective is the media? *scratch* in improving students' understanding of the concept of whole numbers?	Media *scratches* help students understand the concept of whole numbers through direct experience
What is the media? *Can Scratch* improve students' critical and logical thinking skills?	Media *scratch* effective in improving students' critical and logical thinking skills
What is the role of the media? *Scratch* in growing students' learning motivation?	Media *scratch* able to grow students' learning motivation. This is because the existence of game-based digital learning media can foster curiosity and new challenges for students
What is the media? *Scratch* suit able for students with different abilities?	Yes, this is because in the application *scratch* can be presented with 5 different types of whole number questions. Starting from easy, medium, and difficult types of questions. With the existence of these different types of questions, it shows that the media *scratch* can be adapted to different student abilities
How to integrate media *scratch* with the school curriculum?	There are several steps to integrating media *scratch* with the school curriculum, including the following: 1) Determining learning objectives means ensuring that the learning objectives are in accordance with the curriculum; 2) Selecting materials that are appropriate to learning activities; and 3) Making a learning plan means planning learning activities and time

4. Results and Discussion

One of the many digital media that have emerged as a result of the advancement of modern educational technology is web-based teaching aids (Pérez- Jorge and Martínez-Murciano, 2022). The purpose of this project is to provide new innovations for the world of education and to be able to create convenience in learning mathematics (Irawan et al., 2023). So that students do not get bored when learning takes place and to erode the notion that mathematics is a difficult subject (Dúo-Terrón, 2023). In this project, researchers used the ADDIE method as an initial platform. The first to fifth stages of the ADDIE method include analysis, design, development, implementation and evaluation (Ranuharja et al., 2021). Therefore, there are five stages involved in making an electronic digital game: analysis to design learning materials, making learning materials and planning activities and testing and evaluating the digital game as a whole (Mardianto et al., 2022).

In the first stage, namely analysis, problems are found and then the problem is identified. In elementary school, specifically grade 4, there is a mathematics subject. In this subject, most students consider mathematics to be a difficult subject. Especially in grade 4, the material is whole numbers. There are several students whose scores do not meet the student's learning completeness 1. In the second stage, the media used by researchers is media scratch with the material of whole numbers for grade 4 elementary school. The digital game of whole numbers of functions as a tool to help students understand the material of whole numbers. In this media, students are presented with whole number material starting from the definition of whole numbers to operations on whole numbers which include addition, subtraction, and multiplication operations. So that students will be more challenged in learning activities.

In the third stage, researchers developed media scratch existing ones, with more interesting innovations to increase students' learning motivation. Researchers created 7 slides in the media scratch. On the first slide, the title

of the material to be studied is presented. The second and third slides contain material on the definition of whole numbers, place values in whole numbers. The fourth to sixth slides contain exercises on operating whole numbers starting from addition, subtraction and multiplication. The last slide contains a summary of the material and words of thanks. Reviews from several experts argue that electronic digital games are in accordance with the needs of students. Starting from the features in the media scratch, colors, images, learner appeal, game mechanics, and learning materials. However, it is recommended that the application be visually appealing by using free components consistently.

5. Conclusion

Media scratch is very effective to be used as one of the games in special learning of mathematics subjects, material of whole numbers. Researchers use the ADDIE method in developing media scratch. ADDIE stages are also very systematic so that the resulting product is ready for use and meets product development testing standards.

Acknowledgement

The authors would like to thank fellow authors and organizations whose intellectual properties were utilized for this study.

Conflict of Interest

The authors declare no conflicts of interest.

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