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Development of the Interactive Educational Game "Kelma" Addition and Subtraction in Mathematics Learning Phase Using Scratch

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Abstract: This study aims to develop a virtual lab game for addition and subtraction of Mathematics subjects in phase A of Elementary School (SD) using the Scratch platform to overcome students' problems related to addition and subtraction. The research method used is qualitative development research with the ADDIE model (analysis, design, development, implementation, and evaluation). Validation is carried out by experts in learning media and materials. The findings reveal that the addition and subtraction lab virtual game consist of content that aligns with learning objectives, has comprehensive game content, and is interactive and engaging. This research makes a significant contribution to the development of innovative learning media in Mathematics, improves and strengthens students' understanding of addition and subtraction materials, and opens up opportunities for further research in *the* integration of game technology in addition and subtraction.

Keywords: Development, ADDIE, Scratch, Subtraction, Mathematic

1. Introduction

Educating is a conscious effort made towards the maturation of thoughts, attitudes, behaviors and others. Through education a human being will be able to live a better life, because in this process each individual will learn to develop potential, personality, intelligence and skills that will be useful for life in the future (Sulistyani et al., 2021). Logical thinking skills and higher cognitive skills can be developed through mathematics learning. One of the basic materials in mathematics is addition and subtraction (Carpenter & Moser, 2020). Given the importance of the addition and subtraction material of phase A of elementary school and its potential Game education in increasing the effectiveness of learning, development game educational addition and subtraction using game It can be an innovative solution to make it easier for students to understand, practice, and apply the concept of addition and subtraction in mathematics lessons. An inadequate understanding of the concepts of addition and subtraction can make students have difficulty carrying out simple tasks that require numerical skills, thus making them less confident in dealing with everyday situations involving numbers.

In today's digital era, the use of technology in education is increasingly important to increase the effectiveness of learning (Ali et al., 2024). The use of technology is often carried out by teachers as a learning medium that attracts students' interest in learning. Interactive educational games have been proven to be effective in increasing students' motivation and understanding of complex learning materials (Su et al., 2021). Educational games are games that are used to stimulate students' thinking in improving their understanding of the material (Haba & Talakua, 2023). Educational games are one of the multimedia that provides opportunities for students to be more enthusiastic in the learning process. Use of elements Game such as scores and challenges are able to create a fun learning experience and increase knowledge. Scratch is a visual programming platform developed by Massachusetts Institute of Technology (MIT), offering the opportunity to create Game engaging and interactive education without the need for advanced programming skills (Zakariashvili, 2023; Libryanti et al., 2023; Suriyaarachchi, Denny & Nanayakkara, 2022). This opens up opportunities to develop Game education that is specific and in accordance with the learning needs of addition and subtraction.

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Previous research shows that the use of learning media Game Education can help improve students' ability to distinguish the characteristics and types of plants (Haba & Talakua, 2023). However, there are still limitations in the development of learning media that focus on material. The development of mobile technology and increasing access to digital devices among students opens up new opportunities in delivering learning materials (Matthew, Kazaure & Okafor, 2021; Bernacki, Greene & Crompton, 2019). The main goal of this study is to design and develop an innovative interactive educational game for learning to learn to add and subtract using the Scratch platform. Through this development, the researcher aims to create learning aids that can increase students' understanding and interest in addition and subtraction. In addition, this study also aims to evaluate the effectiveness of educational games developed in improving students' understanding of the concept of addition and subtraction compared to learning with traditional learning media. Furthermore, this study aims to identify best practices in integrating educational game technology into mathematics learning, especially in addition and subtraction materials in phase A of elementary schools.

2. Methodology

This research uses a Research and Development (R&D) approach to create and test Scratch-based learning media, which is a research method used to develop products that begin with needs research, then development is carried out to produce products that have been tested. The development model used is the ADDIE model which consists of five stages, namely analysis, design, development, implementation, and evaluation (Bukhori et al., 2022). The selection of ADDIE's research model is based on the form of a simple, complete and systematically arranged model flow as shows in Fig. 1.



Fig. 1: ADDIE Development Model (Sidekick, 2009)

The initial stage is an analysis to determine the goals of the mobile application being developed and the problems that need to be solved. At this stage, the creativity and originality of teachers are needed to create learning media that is useful for the educational process (Spatioti et al., 2022). The condition needed is an interesting learning media by utilizing the development of information technology to equip students with 21st century skills that can be easily accessed. Problem analysis began when carrying out teaching and learning activities in class II Sugiharjo 02 addition and subtraction material, there was no game media that could attract students' interest in learning.

The second stage of design is designing product concept design activities are carried out by making *a storyboard* which is an outline of media content in general which includes template and material design. During the planning, determine supporting media elements such as images, animations, materials and the selection of the main character of the Kelma Bat which is an icon of the game Kelma the Bat Mathematics. The character of Kelma is described as a bat that likes to move places and solve problems of sales and subtraction. Each stage of the design uses different software. Table 1.

Table 1: Software used for Each Purpose

Software	Purpose
Canva	Develop a storyboard
	Desi display
	Designing visual elements
	Designing Objects
Microsoft word	Writing scripts
Scracth	Create a prototype

The Kelma game contains five menus, namely instructions, material summaries, practice questions, games, and evaluation questions. Each menu allows students to better understand the Indonesian cultural heritage material that is being presented. Fig. 2. shows the prototype design of the developed digital game.

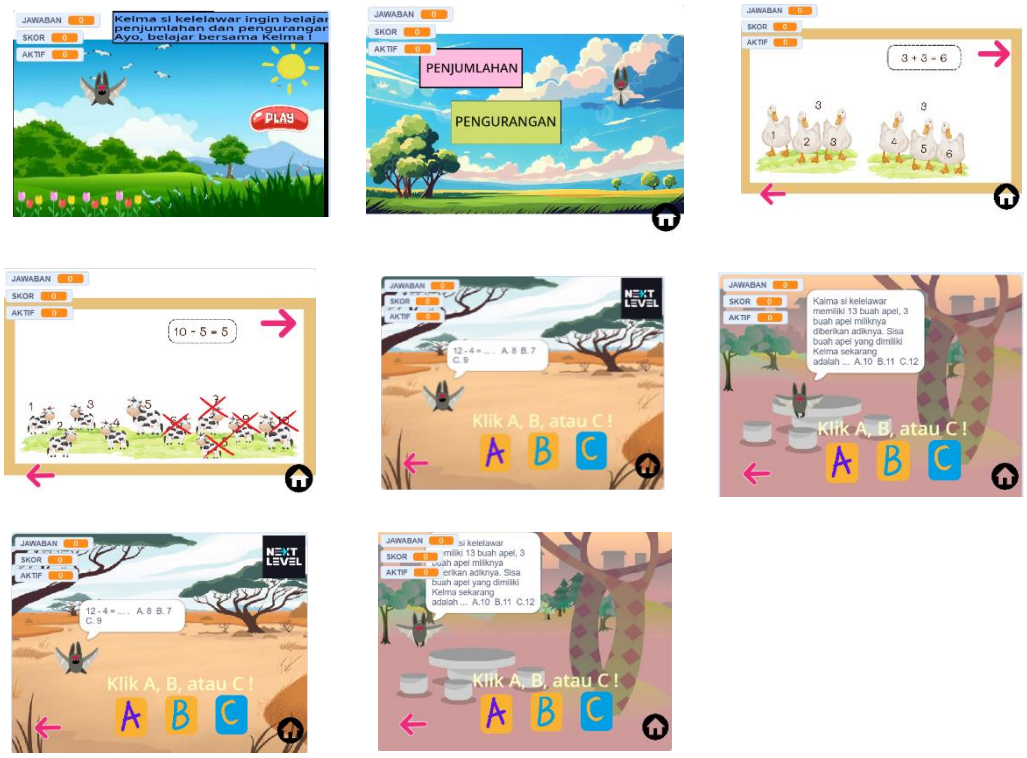


Fig. 1: Prototype

The third stage is the development stage. At this stage, the drawn-up plan is manifested in concrete form. The elements that have been collected in the design stage are assembled into a single complete product. At this stage, the prototype is improved based on expert opinions. In this study, the results of the discussions conducted during the design phase guide the creation of software and learning materials for the Kelma digital game. *Scratch* is used to program digital games and create applications, in accordance with the development strategy applied in this study. Each development is tested continuously to ensure that the game of Kelma runs smoothly and effectively.

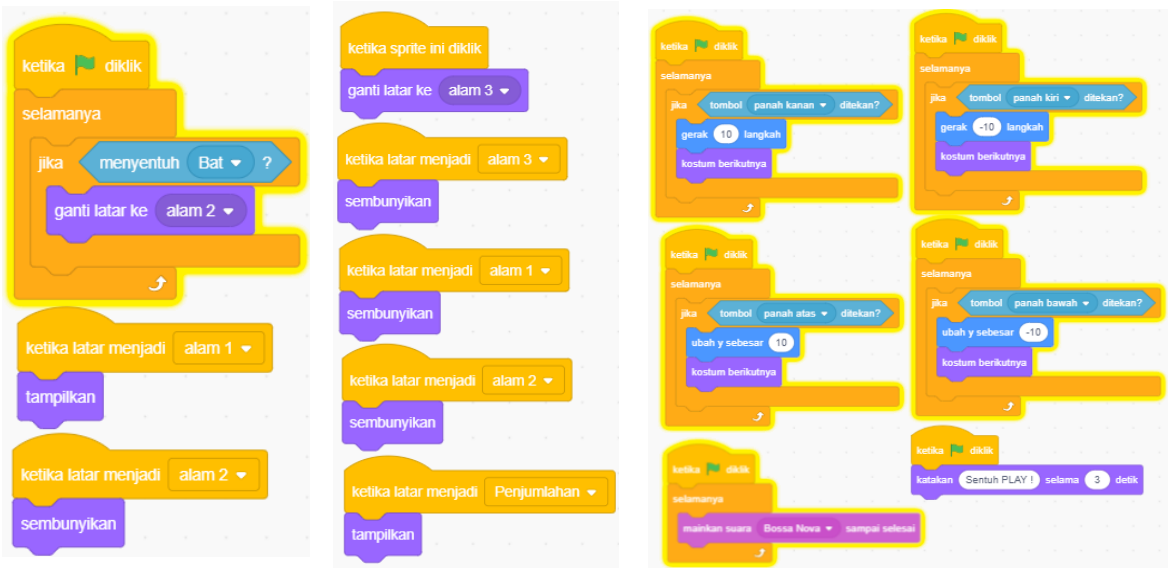


Fig. 2: (A) Coding the Start Button (B) Coding The Next Button (C) Coding The Character "Kelma"

3. Results

At this stage, a validation test of the Kelma game was carried out by 3 validators, namely 1 lecturer from Muria Kudus University who is an expert in the field of art technology, 1 lecturer from the Faculty of Technical & Vocational,

Universiti Pendidikan Sultan Idris is an expert in the field of electricity, and 1 senior teacher who is an expert in the field of learning media. The results of validation by experts can be analyzed to find the validity of the learning media of the Kelma game using the *scratch application.* In the interview activity, a series of questions were made which were divided into three parts, namely the first part, the second part and the third part. Experts were asked about 5 questions related to digital games to assess the utilization of mobile applications that have been created.

Table 2: Background and Membership Of The Members

Respond	Gender	Background
R1	Male	Lecturer at Universitas Muria Kudus
R2	Male	Lecturer di Faculty of Technical & Vocational, Universiti Pendidikan Sultan Idris
R3	Female	Senior lecturer

Part B describes the findings regarding the content of the Wibisana game. The five questions include an analysis of the content of the student's challenge, number material, and recommendations for improvement. Table 3 explains the above statement.

Table 3: Questions and Opinions Of Experts

Question	Expert opinion
Is the game interface design appropriate for the age and needs of 2nd grade elementary school children?	The interface design is appropriate, which is simple, brightly colored, and attracts children's attention. Easy-to-understand icons and avoid text that is too long
Do the animations and sound effects used support learning or actually interfere with children's concentration?	The animation and sound effects are interesting and not excessive. Sound effects can be used to provide feedback and avoid animations that are too fast or sound effects that are too loud
Is the use of Scratch as a game development platform optimal in realizing an interactive and interesting game concept?	The use of Scratch as a development platform has provided enough flexibility to realize this game concept because this scratch-based game is easy to use
How much potential does this game have to attract international players?	The game has great potential to attract international players, as the material is commonly learned by children
What is the most relevant evaluation method to measure the effectiveness of these games in achieving learning objectives and engaging players?	To measure the effectiveness of the game, evaluation methods such as questionnaires and interviews can be used, in addition to that it is necessary to conduct periodic tests to see the development of players' understanding of the material presented

Section C contains questions for suggestions and improvements to the Kelma game that has been developed. This section consists of three (3) questions for experts.

Table 4: Questions and Opinions of Experts

Question	Expert opinion
Are there any features that need to be added?	Adds multiplayer features to encourage collaboration
What about the visual and audio aesthetic aspects used to support cultural narratives?	The aesthetic aspects of the visuals and audio are quite interesting and clarify the material
What are the further development plans to improve the quality and reach of this game?	Add more challenging game levels, develop new relevant content, or do more intensive promotions

4. Discussion

Different teaching methods have been designed and applied to stimulate children's creative thinking skills during school learning and doing homework (Behnamnia et al., 2020). Scratch is an application that can be utilized for early programming learning and also for creating educational and entertainment content, creating math and science projects, simulating and visualizing experiments (Dúo-Terrón, 2023). The goal of this project is to develop media game-based learning called Kelma which is feasible and practical to use. The development of this media uses the Scratch application. The method used is the ADDIE method. The first to fifth stages of the ADDIE method include analysis, design, development, implementation and evaluation. Therefore, there are five stages involved in the creation of digital games:

analysis to design learning materials, creation of learning materials and activity planning as well as testing and evaluation of digital games as a whole.

In the first stage, namely analysis, problems are found, then identify these problems. In elementary school, precisely in grade II, there is a Mathematics subject. In the addition and subtraction material, most students are not motivated to perform calculation operations. In the second stage, the application used by researchers to develop media is *scratch.* The game developed is called Kelma Si Bat Mathematics. This game is a tool to help students understand addition and subtraction material. In the media, students were presented with material about addition and subtraction. In the third stage, the researcher develops the media *scratch* existing ones, with more interesting innovations to foster student learning motivation (Permatasari et al., 2018). The products made are arranged according to the design that has been made in the previous stage. The product design is designed using programming applications i.e. scratch. A review from three experts argued that the Kelma game was in accordance with the needs of students. Starting from the features in scratch media, colors, images, student attraction, game mechanics, and learning materials. However, it is recommended to add some features and game levels to make the Kelma game more interesting.

5. Conclusion

Scratch media is very effectively used as one of the games in learning specifically for Mathematics subjects, addition and subtraction materials. The researcher uses the ADDIE method in the development of scratch-based game media. At the stages, ADDIE is also very systematic so that products are produced that are ready to use and meet product development testing standards. The purpose of this research is to develop a game-based learning media product called Kelma that is feasible and practical to use, the development of this media uses *a scratch* application. However, this research is limited to the development stage and does not include post-development product implementation or evaluation. The potential of *scratch platforms* and gaming products is promising, and it is recommended that these products be tested for usability and effectiveness in learning on an adequate number of samples.

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Conflict of Interest

The authors declare no conflicts of interest.

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