Research Article

Simple Math Learning Application for Children Aged 7–11 Using Scratch

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Abstract: Mathematics cannot be separated from numbers, counting, reasoning, and so on. This application is made using Scratch, which is open source. The learning method begins to recognize abstract numbers. The author also makes learning media using computers, which are expected to be more fun. The research method used for writing this scientific research is the SDLC (Software Development Life Cycle) method. Learning Application to Solve Simple Math Problems Using Scratch has been completed, and children aged 7 to 11 years can increase their interest in learning about simple math. This application contains 10 questions about simple math problems. Based on the results of testing using a black box, it can be concluded that this application functions properly following the planning and design that have been made. Development suggestions that can be done in this scientific writing application are adding levels or levels from the easiest to the most difficult, animated characters that can move, and adding other interesting features so that users are more entertained when using this application.

Keywords: Application, Mathematics, Scratch, Learning Process, Children

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1. Introduction

Mathematics is a science of numbers that is important and necessary in everyday life. Mathematics cannot be separated from numbers, counting, reasoning, and so on. In fact, in our daily lives, we cannot be separated from math, for example: time, money, distance, many objects, the weight of objects, and others. A person's life is helped and easier if their math skills are good. Learning math begins with recognizing numbers, starting from the smallest number to the largest number. After students recognize these numbers, they continue with the introduction of basic arithmetic operations such as addition, subtraction, multiplication, and division.

Some students think that math is difficult because math is organized logically, so math has a relationship with abstract concepts. Currently, teachers in delivering material mostly do not use media; teachers only use the lecture method and explain on the blackboard. Piaget (in Crain) states that the way of thinking of children aged 7 years to 11 years or elementary school age is the concrete operational stage, where children think with real objects or activities. So, to make it easier to understand math material, teachers must use media so that abstract math becomes concrete.

Learning media, such as pictures, videos, or props, can make learning more interesting and interactive for learners. This encourages the active involvement of learners in the learning process, so that they are more enthusiastic about learning and more easily understand the subject matter. Learning media can also allow teachers to visualize abstract concepts that are difficult to understand through oral explanation. Learning media helps illustrate these concepts in a way that is more concrete and easily understood by students (Yunda Assyuro Hanun & Akhmad Asyari, 2023).

Furthermore, with the author using Scratch, this learning method is a method that the author wants to make not only entertaining but also educational for children. This learning method has several multimedia displays, such as images, writing, and sound, which are intended to make it easier for children to digest and obtain information and are expected to attract children to use this application to learn.

Moreover, this application is made using Scratch, which is open source, which means it can be distributed for free. This desktop-based application is intended for children aged 7 to 11 years or early childhood, which contains Learning to Solve Simple Addition, Subtraction, Division, and Multiplication Problems. This application uses the Scratch programming language and can only be run using the Scratch application. In this application, there are only 10 quiz questions in the form of essays. The author's aim in making this application is so that there is another alternative for learning media besides reading books, and children are expected to be more interested in this application. The author also makes learning media using computers that are expected to be more fun.

2. Method

2.1 SDLC (Software Development Life Cycle)

The research method used for writing this scientific research is to use the SDLC (Software Development Life Cycle) method. SDLC is short for the Systems Development Life Cycle, or in Indonesian called the system development life cycle. SDLC is a cycle used in the creation or development of information systems that aim to solve problems effectively. In another sense, SDLC is a stage of work that aims to produce a high-quality system that is in accordance with the wishes of the customer or the purpose of making the system. SDLC is a framework that contains the steps that must be taken to process the development of software. This system contains a complete plan for developing, maintaining, and replacing specific software. Figure 1 shows an overview of the SDLC, making it easier for readers to understand. Which consists of several stages, which are as following point:

1. *Identification Phase*
   Identifying the problem, namely, the need for early childhood entertainment media that educates.
2. *Analysis Phase*
   Solving problems in making applications by conducting literature studies, namely by studying the SCRATCH application by reading books or watching tutorial videos on YouTube.
3. *Design Phase*
   Designing the process of making applications using Moc up designs and mixed navigation structures.
4. *Creation Phase*
   The stage of making this application by coding, following the design of the application using the Scratch software.
5. *Implementation and Testing Phase*
   The test results use the black box testing method to ensure that there are no errors contained in the application that has been made by testing the application.

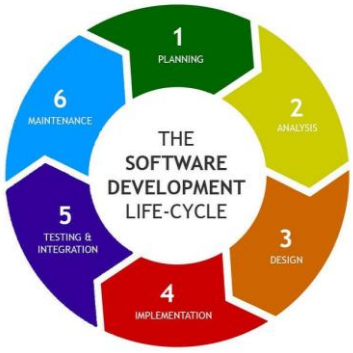

Figure 1. The Software Development Life-Cycle

2.2 Mathematics Operations

Mathematics is the knowledge or science of logic and numerical problems, mathematics helps humans interpret precisely various ideas and conclusions". Then Yurniwati stated "Mathematics not only develops computational skills (counting operations) but also soft skills, such as finding concepts, processing information, communicating ideas in the form of symbols, charts, images, or sentences orally and in writing. Yurniwati (2019:8), Addition is one of the most basic number operations in math calculation. This mathematical integer operation is also quite often done in our daily lives, starting from knowing the number of groceries at the supermarket or knowing the amount of dough when making a cake. Addition is combining or adding two or more numbers to make a new number. Ruqoyyah, S. (2021). Moreover, the definition of subtraction calculation operation according to Sri Sbarinah (2020) is one of the arithmetic concepts that must be learned by students after addition. And according to Khafid and Suyati (2020), subtraction is taking some or all of it so that the result becomes less and less. Meanwhile, according to researchers, subtraction is one of the four basic operations of arithmetic, which, in principle, is the opposite of the addition operation. In its operation, subtraction is symbolized by the symbol (-).

Moreover, Division is the basic math operation opposite to multiplication. Division is used to calculate the result of a number against its divisor. The symbol for division is "÷", ":" or the slash /. Division is already taught in elementary school to calculate simple numbers. Basic division can be taught to children from numbers 1 to 10. Finally, Multiplication is repeated addition. In learning multiplication, the basic part that must be mastered by students is multiplication of 1 to 10. After students can master multiplication of 1 to 10, multiplication of one number by two numbers, and multiplication of two numbers by one number. Multiplication is the mathematical operation of scaling one number by another. Simply put, multiplication is repeated addition. It is one of the four basic operations in basic arithmetic (the others are addition, subtraction, and division). So a multiplication pattern is an arrangement of several numbers that form a certain pattern by repeated addition. Tantular. (2018).

2.3 Unified Modeling Language (UML)

UML (Unified Modeling Language) is a standard specification language for documenting, specifying, and building systems (Fowler, 2006. UML is a set of structures and techniques for modeling the design of object-oriented programs (OOP) and their applications. UML is a methodology for developing OOP systems and a group of tools to support the development of these systems. UML was introduced by the Object Management Group, an organization that has been developing OOP models,

technologies, and standards since the 1980s. UML is now widely used by OOP practitioners. UML is the basis for IBM's object-oriented design tool.

Furthermore, the author designed the Application of Solving Simple Math Problems Using Scratch. Using three diagrams, namely use case diagrams, activity diagrams, and sequence diagrams, that are adjusted to the function of the diagram and are related to the system in the Application of Solving Simple Math Problems.

2.4 Use Case Diagram

The Application System for Solving Simple Math Problems Using Scratch, which can be accessed by users, provides entertainment, a menu, an explanation of the Application, quizzes, and getting scores. The Use Case diagram of this application can be seen in Figure 2. In this application, there are 2 main menu options, namely Explanation and Quiz. When selecting the Explanation menu, the user is moved to an explanation page about this application. If the user wants to return to the main menu, the user can click the Explanation page once then the page will automatically change to the main menu page. In this application, there is a Quiz. If all the Quiz questions have been done by the user, then the user will get a scale score of 0 to 10.

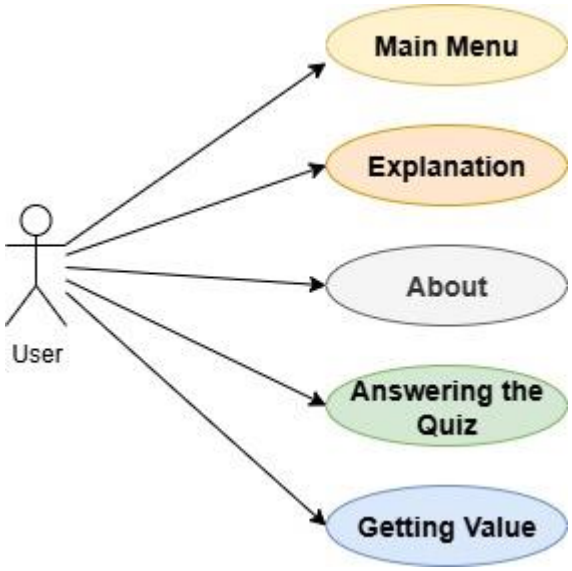

Figure 2. Use Case Diagram

2.5 Scratch

Scratch is an educational visual programming language developed by the Massachusetts Institute of Technology (MIT). Scratch can be used to create programs, create animation designs, and even create games. The Scratch program can be useful as a stepping stone for beginners who want to dive deeper into computer programming. Scratch programming has a user interface that is friendly enough for beginners. Scratch is a programming language that is not complicated, and the programming language is replaced with blocks that are easy to apply by using the concept of clickable program blocks, drag and drop, which includes a visual language. In Scratch, a program is represented by a project, the smallest code is called a block, and a collection of blocks forms a script. The script in Scratch is a collection of commands to run a sprite. In the development of Scratch simulations, there are elements of non-physical and physical simulations. Scratch supports the arrangement and addition of sound to the simulation, and the addition of many images that support the simulation. Borromeo, N. A. (2021), Ferrone, H. (2021), Finska, N. (2023), Horton, J. (2021), Horton, J. (2024), Several studies

have developed student thinking patterns and learning concept development using Scratch and building games based on C++ and other programming languages.. Smith, E. (2022), Teale, P. (2022), Vanhove, S. (2024), Carvilhe, et.al.(2024), Carvalho, et.al (2024), Chen, Y, et.al.(2023), De La Hoz Ruiz, A., & Hijón Neira, R. (2023), Duplantis, T, et.al.(2021), Huansong, Y, et.al (2021), Lu, X, et.al (2023), The hope of how to build a learning game is to be able to explore creativity and reasoning so that the educational process takes place more creatively, interestingly, and tends not to be boring, so that students can capture the concept of programming, such as Scratch software and also other blockly programming will be able to increase reasoning power, imagination, and also the ease of making games. Ordoumpozanis, K., & Apostolidis, H. (2025), Scheiermann, J., & Konen, W. (2023), Suandique, T. M. H., Beça, P., & Aresta, M. (2023), Ying, Y. (2022).

2.6 Navigation structure

The navigation structure is the structure or flow of a program. Determining the navigation structure is something that should be done before making an application. There are 4 (four) basic forms of navigation structures that are commonly used in the application development process, namely: Linear navigation structure, hierarchical navigation structure, non-linear structure, and mixed navigation structure.

2.7 Black box testing

Black box testing can also called Behavioral Testing, is a test conducted to observe the input and output results of the software without knowing the code structure of the software. This test is carried out at the end of making the software to find out whether the software can function properly. To perform testing, testers do not have to have the ability to write program code. This test can be done by anyone.

In this research, the author wants to design a Learning Application for Solving Simple Math Problems for Early Childhood Using Scratch 3.0. This application is expected to help children to be able to solve simple math problems, because there are images, text, and sounds that are expected, so that application users are not bored. In building this application, several stages are needed to facilitate the design and manufacturing stages. The design includes several stages, namely application concept design, UML, display design, and script creation.

2.8 Navigation Structure Design

This navigation structure aims to see the sequence of the application. In making this application, the author uses a mixed navigation structure. The Navigation Structure Chart is shown in Figure 3, where the Main Menus are Explanation, Quizzes, and About. And in Explanation, there is Application Explanation Page Display; in Quizzes, there is Introduction to quizzes, Question, and Quiz Results; while in About, there is Author Data Page Display.

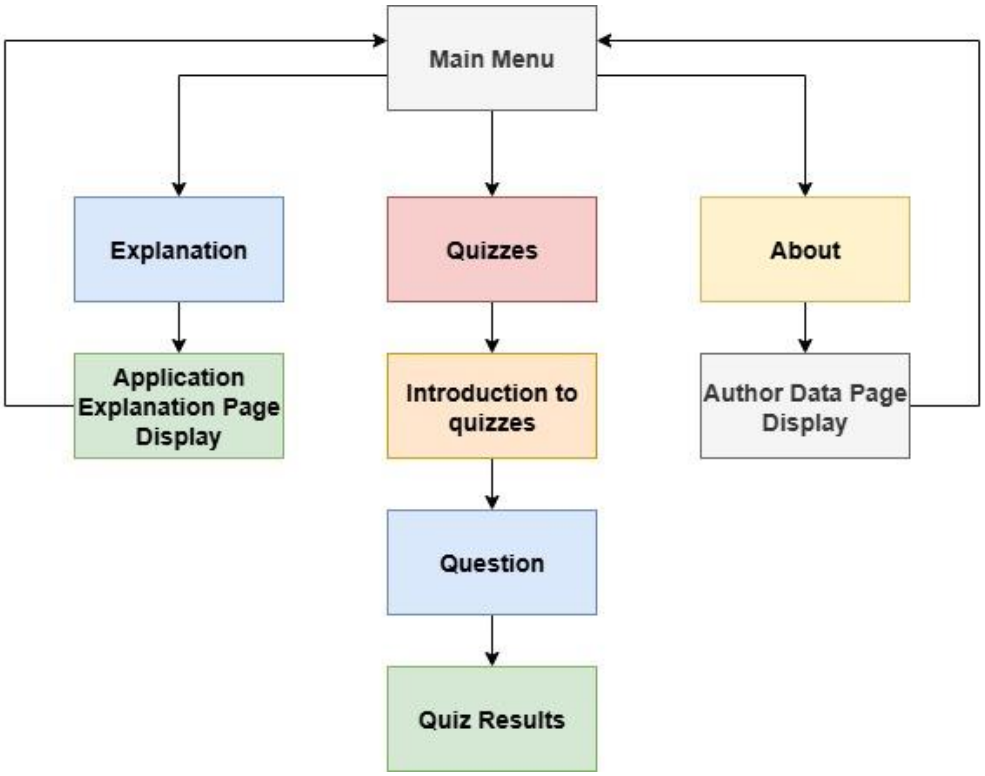

Figure 3. Navigation structure

2.9 Activity Diagram

In Figures 4 and 5, the user will start the application by clicking on the desktop icon "Learning to Solve Simple Math Problems," which then the system will display a main menu containing Explanations and Quizzes. On the Explanation menu, there is an explanation page about this application. After the user has finished reading the explanation of the application, click once on the explanation page to return to the main menu. If the user chooses the Quiz menu, the user will be directed to the Quiz intro page, which contains instructions for doing the Quiz questions. Only then can the user answer the Quiz questions. If the user has answered all the Quiz questions, the user will be shown the final result value.

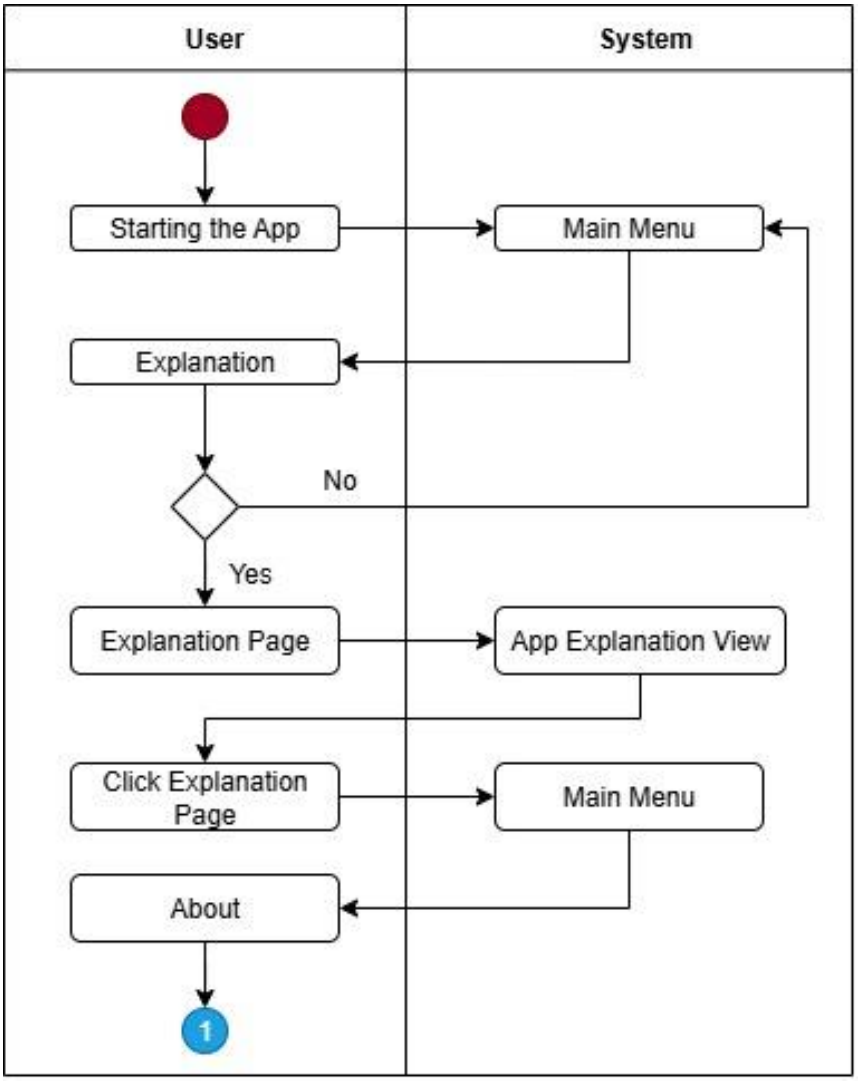

Figure 4. Diagram Activity 1

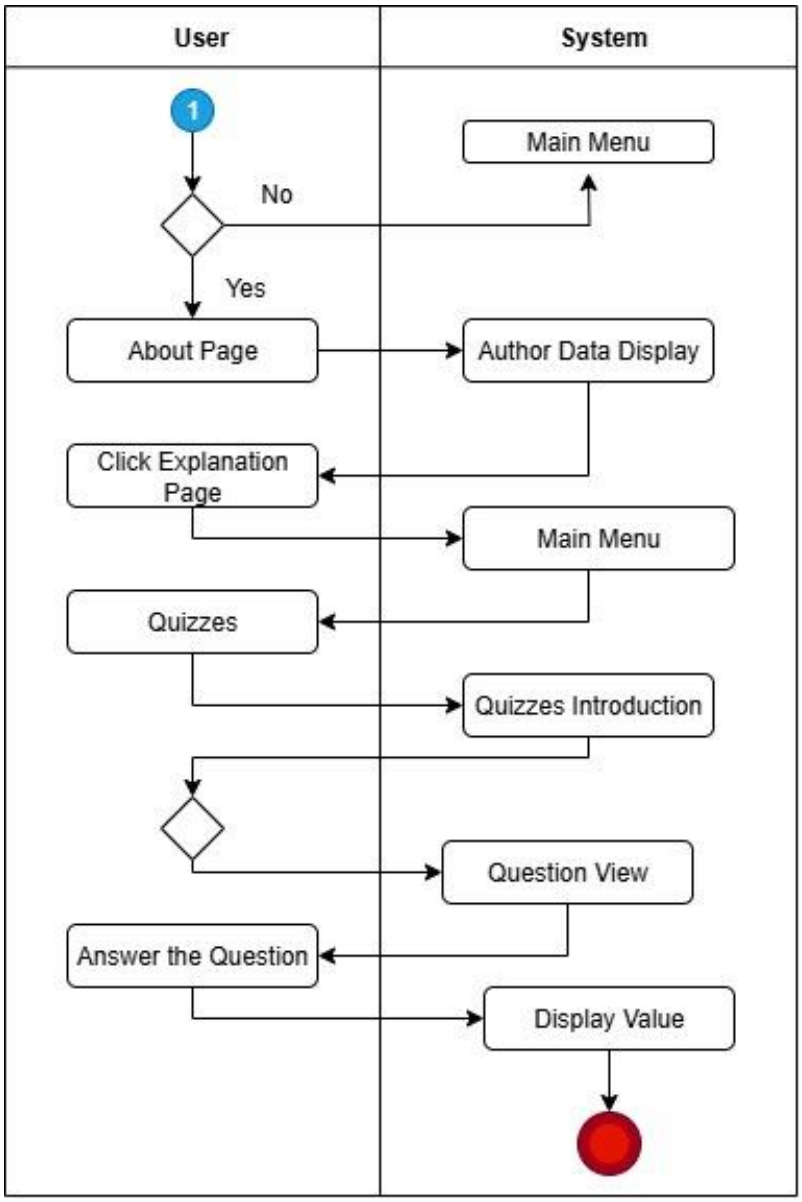

Figure 5. Diagram Activity 2

2.10 Sequence Diagram

The sequence diagram in this application can be seen in Figure 6. Figure 6 explains the flow in using this application. Where the user will select the menu available in the application. After that, if the user selects the explanation menu, the user will enter the application explanation page. After the explanation page, the user can go directly to the about page or return to the main menu. On the about page, the user will get the author's information. From the about page section, the user can return to the main menu. If the user chooses the quiz menu, the user will be taken to the quiz question section. After the user answers the quiz question, they get a quiz score. In this section, the user can return to the main menu.

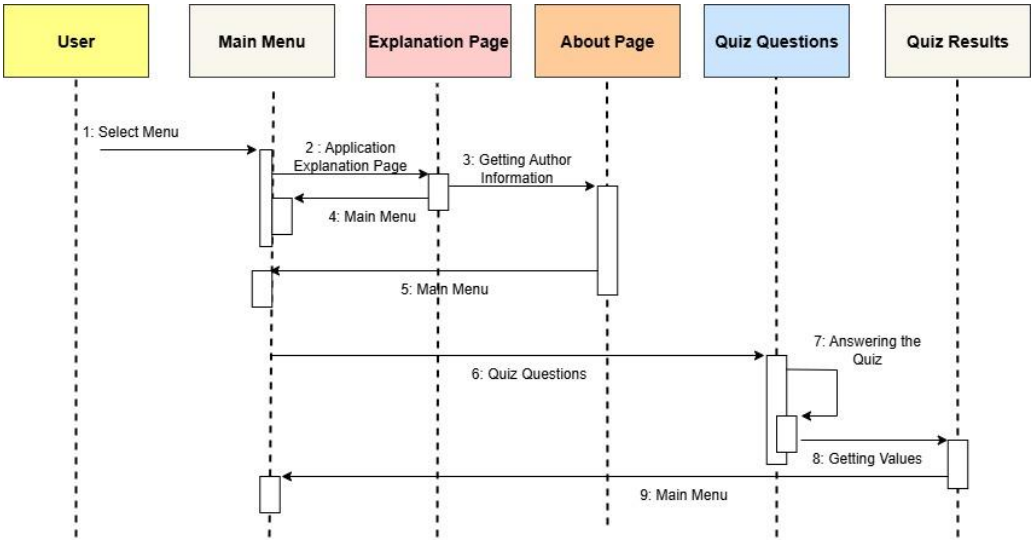

Figure 6. Sequence Diagram

2.11 Graphical User Interface design positioning

GUI (Graphical User Interface) design is a stage that must be done in making this application. This GUI design is important because by making a display design, application makers can easily design the appearance of the application to be made. At this stage, the interface design is roughly implemented, which is then made in the actual program in the script preparation process. In Figure 7, there is a backdrop, four texts and images, and on this page, it functions to display the author's student data.

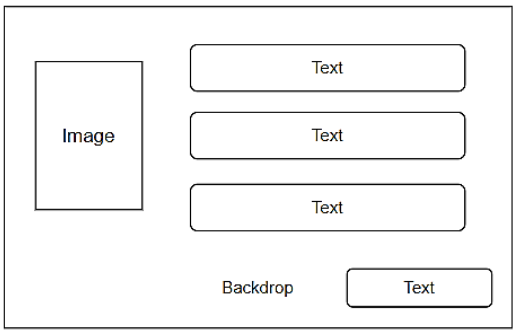

Figure 7. About menu design

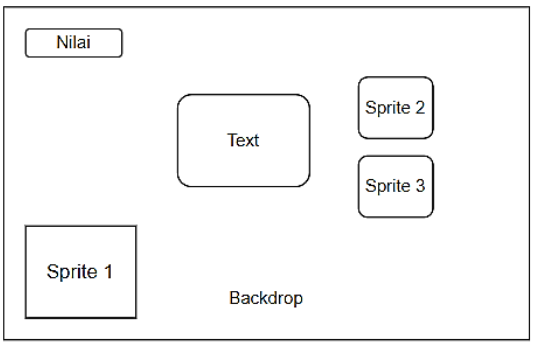

Figure 8. Quiz display design

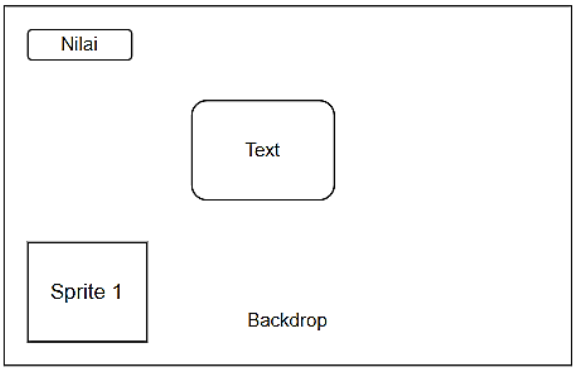

Figure 9. Quiz result display design

Furthermore, in Figure 8, there is a backdrop, text, sprite 1, sprite 2, sprite 3, and a scoreboard. Sprite 1 is a character who will give questions, sprite 2 is an animation of a check mark or a correct sign that will appear if the user answers the question correctly, sprite 3 is an animation of a cross or a wrong sign that will appear if the user answers the question incorrectly, while the value board functions to increase the value by 10 if the user answers one question correctly, and will remain or not increase by 10 if the user is wrong in answering the question. In Figure 9, there is a backdrop, sprite 1, text, and a scoreboard; the text functions to display the final score obtained by the user.

3. Result and Discussion

In this implementation section, the author will discuss how to run the Application to Solve Simple Math Problems Using Scratch. This learning application uses Scratch software to compile scripts and explain the project. The first step in creating this Simple Math Problem Solving Application Using Scratch is to install Scratch. After Scratch is installed, create a new project by clicking new file, to save the file by clicking save or save as. In this application, the author uses a block pallet to compile the script that is left on stage. In the GUI implementation introducing the Scratch interface, there is a script to support the application so that it can run properly. The following will explain the steps taken in the process of making applications using Scratch: [1] Install Scratch. Installing Scratch is needed because the author uses this application to make the application Solving Simple Math Problems Using Scratch. If it has been installed, there will be a Scratch desktop folder on the local disk C, then click the program files folder. [2] How to open a Scratch worksheet. To open a Scratch worksheet, click on the Scratch icon on the user's desktop. The following is how the Scratch icon looks on the desktop [Figure 10].

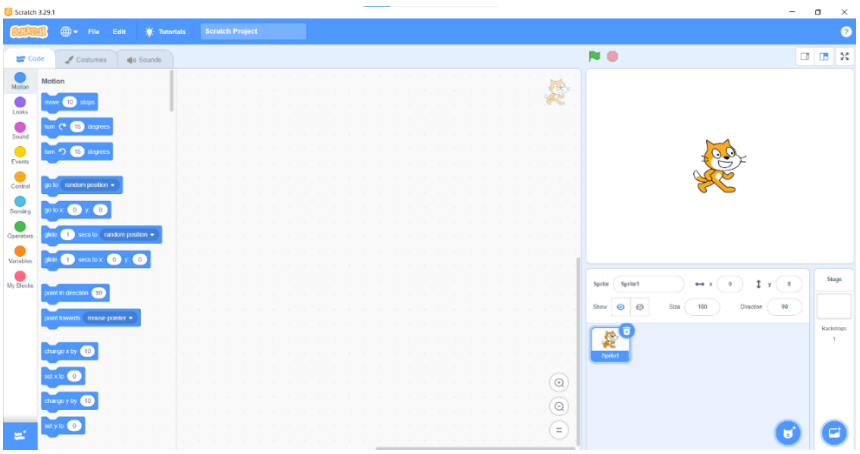

Figure 10. Quiz result display design

Furthermore, the next essential component is the Backdrop [Figure 11]. To see the backdrops that have been uploaded, click Backdrop, and Scratch will display any backdrops that have been uploaded. Scratch also provides tools to edit the backgrounds that we upload. Then, to upload a sound, click the sound tab and select upload sound from file. Scratch also provides built-in sounds, and some tools can add effects to sounds, edit, and record sounds, as the Figure 12.

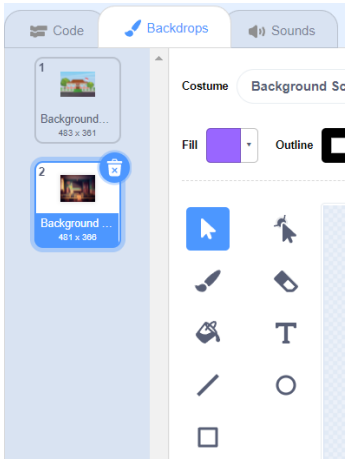

Figure 11. Display bacdrop uploaded

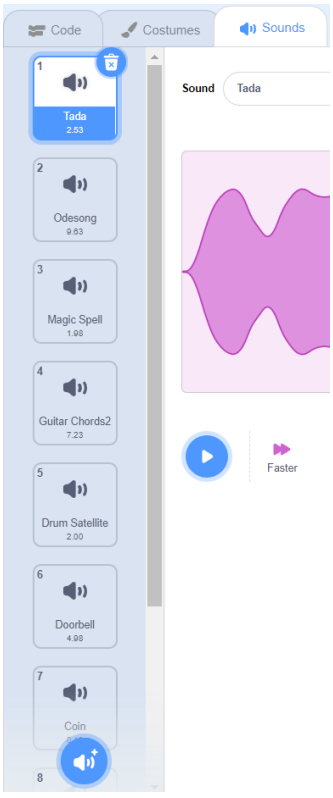

Figure 12. Sound Display

3.1 Program Implementation

Implementation of the program in creating a script to run all the sprites as a whole to become an interesting application. In this script arrangement, there are scripts available to create applications, namely Script for Backdrop, Script for Explanation Button, Script for Explanation Page, Script for Quiz Button, Script for Sprite Button 4 and Sprite Button 5, Script for Quiz Guide Sprite, Script for About Button, Script for About Page, and others. In Figure 13, there is a script for the backdrop. The command to run all scripts by press the green flag on the scratch display layer. In Figure 14, there is an explanation button script. The command to run the script if the green flag is clicked, that the explanation button will be displayed. And if you change the backdrop, then this button will be hidden.

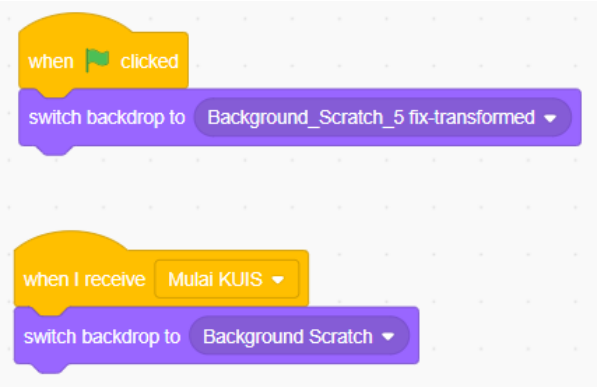

Figure 13. Backdrop Script

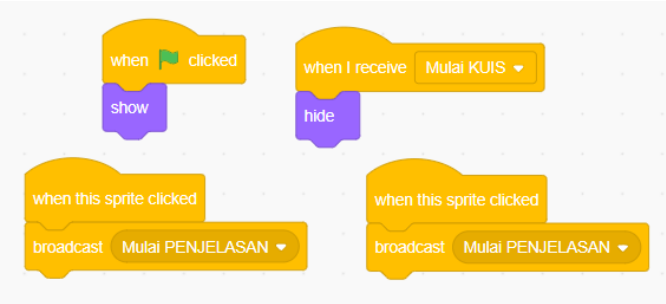

Figure 14. Explanation Button Script

Figure 15. Explanation page Script

In Figure 15, there is an explanation page script. The command to run this script receives the start EXPLANATION command. It will display the explanation page, and if this sprite is clicked, the explanation page will be hidden and will return to the main menu.

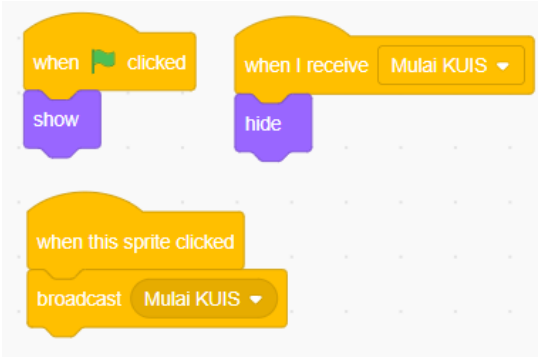

Figure 16. Quizzes Button Script

In Figure 16, there is a quiz button script. The command to run the script if the green flag is clicked, that the quiz button will be displayed, and if you change the backdrop, then this button will be hidden.

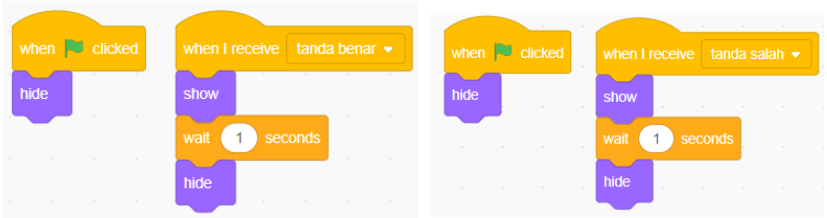

Figure 17. Sprite 4 button and Sprite 5 button scripts

In Figure 17, there are scripts for sprite button 4 and sprite button 5. The command to run the script if the green flag is clicked, then the sprite button will be hidden, and if it receives a true sign, then the sprite button 4 will appear for one second, and after that it will be hidden. Conversely, for sprite button 5, if it receives a false flag, then sprite button 5 will appear for one second, and after that, it will be hidden.

Figure 18. A quiz guide sprite script.

Moreover, in Figure 18, there is a quiz guide sprite script. The command to run this is if it receives the start Quiz command, then the quiz page will be displayed and automatically resets the value to 0, then a text from the quiz guide will appear, which will be displayed for three seconds. Then the quiz guide gives questions in the form of full

name and Are you ready, After the user fills in the full name and answers ready a set of 10 pieces will appear.

Figure 19. Quiz guide sprite script 1

In Figure 19, there is an advanced script from Figure 18. The command to run this script is that the quiz guide will give questions in the form of simple math problems. If the user answers the question with the correct answer, the score will increase by 10, and a sprite button 4 will appear along with the magic spell sound for 2 seconds. And if the user answers the question with the wrong answer, the value will not increase, and the sprite button 5 will appear along with the C2 Sax sound for 2 seconds. Moreover, in Figure 20, there is a continuation script from Figure 19. The command to run this script, the quiz guide will display the results of the user's final score after answering 10 simple math questions for 3 seconds, along with the sound of Tada. If the user manages to answer all the questions correctly, they will get a perfect score of 100. After all scripts run, it will end with the stop all command.

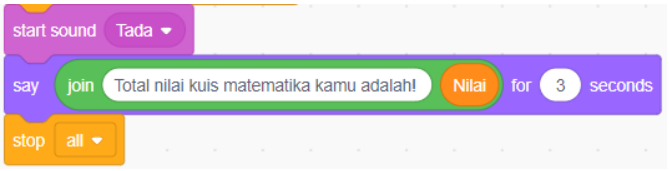

Figure 20. Quiz guide sprite script 2

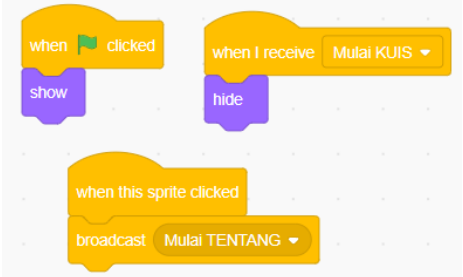

Figure 21. Script button 'about'

Figure 22. About page script

In Figure 21, there is an about button script. The command to run the script if the green flag is clicked, then the about button will be displayed, and if you change the backdrop, then this button will be hidden. In Figure 22, there is an about page script. The command to run the script if the green flag is clicked, then the sprite will be hidden, and if it receives a start command ABOUT, then the about page will be displayed. If this sprite is clicked, it will return to the main page. On the about page, the user will receive information on the author's student data.

3.2 Program Result

In the display of program results, it will display all the output from the creation of scripts that are done in the Scratch software.

Figure 23. Main Menu

Figure 23 is the main menu that allows users to choose explanation, quiz, or about. If the user clicks the explanation button, an explanation page about this application will appear. If the user clicks the quiz button, they will be shown a page answering simple math questions. And if the user clicks the About button, the user will also be shown the author's student data page.

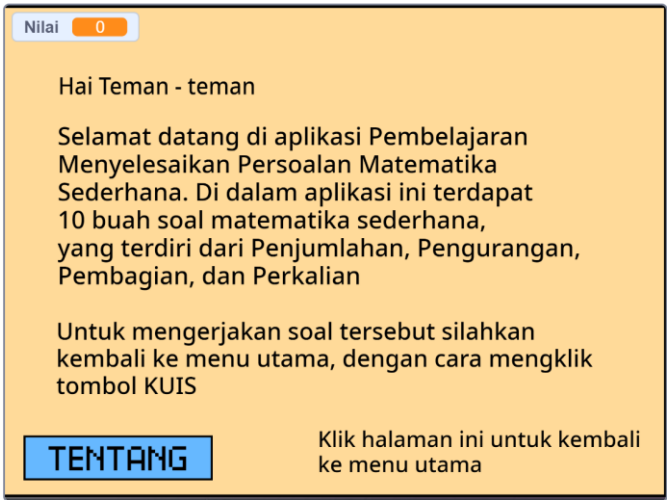

Figure 24. Explanation Page

Figure 24 is an explanation page that explains the application so that users understand it. To return to the main menu, the user can click on this page. And there is an About button that the user can click, and the About page will appear.

Figure 25. 'About' Page

Figure 25 is a display of the about page that displays information on the author's student data. To return to the main menu, the user can click on this page.

Figure 26. Quiz View

In Figure 26, there is a quiz intro display. This page is useful as information for doing quiz questions. On this page, there are also animated characters that are useful for providing interaction to users via voice or text. In Figure 27, there is an advanced view of Figure 26. In this display, the animated character asks the user to write the full name.

Figure 27. Quiz 1 View

In Figure 28, there is a continued view of Figure 27. In this display, the animated character asks whether the user is ready to start working on the quiz questions. Write "ready," then the display will move to the next display. In Figure 28, there is a continued view from Figure 27. In this display, the animated character gives a sentence stating that the user is ready to do the quiz questions.

Figure 28. Quiz 2 View

Figure 29. Quiz 3 View

In Figure 29, there is a continued view from Figure 28. In this display, the animated character gives a sentence stating that the user is ready to do the quiz questions.

Figure 30. Quiz 4 View

Furthermore, in Figure 30, there is a continued view of Figure 29. In this display, the animated character provides simple math problems totaling 10 pieces. If the user answers the question correctly, the value will increase by 10. And if the user answers the wrong question, the value will not increase. In Figure 31, there is a continued view from Figure 30. In this display, the animated character displays the final result of the value that the user can get. If the user manages to answer 10 questions correctly, the user will get a perfect score of 100.

Figure 31. Final View

3.3 Analysis Stage

After all the manufacturing stages are complete, the next step is the trial stage. This trial is carried out to find out whether the application is running well and according to design or not. Tests carried out based on the black box method. The purpose of this test is to look for incorrect or missing functions, interface errors, and data errors. Testing this application uses two cases: in the first case is answering the quiz question correctly, and in the second case is answering the quiz question with the wrong answer. In Table 1 is a test plan consisting of four test items. Moreover, about Next Test Results, in this section, we will explain the test cases and test results. In testing the main menu function, there are four ingredients to be tested, namely pressing the explanation button, pressing the quiz button, and pressing the about button. The following are the tests and test results shown in Table 2. Moreover, in the Explanation Page Function, in this test, there is an explanation of this application that has been given to be read by the user. The following are the test results contained in Table 3.

Table 1. Test Plan

Testing Items	Testing Details	Testing Type
Main Menu Function	Display the explanation page.	Black Box
	Display the quiz page.	
	Display the about page.	
Explanation Page Function	Display an explanation of the app	Black Box
About Page Function	Display author data	Black Box
Quiz Page Function	Display 10 questions	Black Box
	Answer the question correctly.	
	Answered the question incorrectly	

Table 2. Main Menu Function Testing

Test Cases and Test Results			
Testing	**What to expect**	**Observation**	**Conclusion**
Pressing the explanation button	Explanation page opens	Explanation page opens	100%
Menekan button whis	Quiz page opens	Quiz page opens	100%
Pressing the about button	The about page opens	The about page opens	100%

Table 3. Testing the Explanation Page Function

Test Cases and Test Results			
Testing	**What to expect**	**Observation**	**Conclusion**
Display an explanation of the application	App explanation opens properly	App explanation opens properly	100%

Furthermore, the Quiz Page Function, in testing the quiz page function, the test uses two cases, namely: -First, answering the quiz question with the correct answer, and - Second, answering quiz questions with the wrong answer. The results of the cases that have been tested will determine the score obtained by the user. The following are the tests and test results shown in Table 4.

Table 4. Quiz Page Function Testing with Two Cases

Test Cases and Test Results			
Testing	**What to expect**	**Observation**	**Conclusion**
Display 10 questions	All questions performed well	All questions performed well	100%
Answered the question with the correct answer	Score increased by 10 for each correct answer	Score increased by 10 for each correct answer	100%
Answered the question with the wrong answer	No points for each wrong answer	No points for each wrong answer	100%

Furthermore, Testing the Value Function. In this test, there are two materials to be tested, displaying the value results and returning to the main page shown in Table 5.

Table 5. Testing the Value Function

Test Cases and Test Results			
Testing	**What to expect**	**Observation**	**Conclusion**
Answer 10 quiz questions	Score increases if the answer is correct and remains fixed if the answer is incorrect	Score increases if the answer is correct and remains fixed if the answer is incorrect	100%
Answer 10 quiz questions	Return to the main page after the quiz question is answered	Return to the main page after the quiz question is answered	100%

Based on the test results shown in Table 1, Table 2, Table 3, Table 4, and Table 5, it can be concluded that the Learning Application for Solving Simple Math Problems runs well and the available functions have run according to its design.

4. Conclusion and Suggestion

Learning Application to Solve Simple Math Problems Using Scratch has been completed, and children aged 7 to 11 years can increase their interest in learning about simple math. This application contains 10 questions about simple math problems. Based on the results of testing using a black box, it can be concluded that this application functions properly following the planning and design that have been made.

Development suggestions that can be done in this scientific writing application are adding levels or levels from the easiest to the most difficult, animated characters that can move, and adding other interesting features so that users are more entertained when using this application. Thus, suggestions from the author, in the future, it is hoped that this application can be further developed to cover existing deficiencies so that it will be even better in the future.

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