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DEVELOPMENT OF SCRATCH-ASSISTED TEACHING MATERIALS TO DEVELOP COMPUTATIONAL THINKING SKILLS IN ELEMENTARY SCHOOLS

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ABSTRACT

This research aims to develop a Scratch-assisted module of flat building material to develop computational thinking skills in elementary schools. This research uses the R&D (Research and Development) method with the EDR (Educational Design Research) research model which consists of three stages, namely analysis and exploration; design and construction; evaluation and reflection. Data collection in this study was obtained from the results of validation tests on three material experts (mathematics and informatics materials), one learning media expert, one programming expert, and one pedagogical expert. In addition, data collection was also obtained from the results of student response questionnaires after learning using the Scratch programming module. Data analysis techniques use descriptive qualitative and quantitative. The results of the product feasibility trial from the validator of mathematical materials obtained a percentage score of 77.75% including the feasible category; Informatics material expert validators obtained a score of 86.7% in the very decent category; Learning media expert validators obtained a score of 90% in the very decent category; Expert Programming Validators obtained a score of 96.9% in the very decent category; pedagogical expert validators obtained a score of 76% in the decent category; and the student response questionnaire obtained results of 91.25% with a very decent category. Based on the results of the research conducted, the teaching materials developed, namely the Scratch-assisted module, flat building material are very feasible to be used to help develop computational thinking skills in elementary schools

Keywords: Computational Thinking, Scratch, Teaching Materials

A. Introduction

The 21st century brings out some basic skills that everyone should master. In the 21st Century Skills Framework, it is explained that everyone in the 21st century needs four basic skills which are then called 4C competencies, namely (1) Creativity Thinking and Innovation, (2) Critical Thinking and Problem Solving, (3) Communication, and (4) Collaboration (Dewantara, 2021). However, Kemendikbud (2020) explained that today's 21st century learning is not only required to be 4C but also must master Compassion and Computational Logic so that current skills become 6C skills. This is in line with the opinion that in order to welcome the era of society 5.0, one of the abilities that must be possessed is Computational Thinking.

Computational thinking was first introduced by Seymour Papert in 1980. Papert (1980) argues that computational thinking is a thinking process in formulating and solving problems which then the solution can be done in such a way by humans and computers. In addition, Papert also suggests that computational thinking is more than just a problem-solving process, but we are also required to be able to solve problems algorithmically and take advantage of developing a level of technological and language proficiency as they learn to communicate and express their ideas in a coded language. Furthermore, computational thinking began to be reintroduced by Jeannete M. Wing in 2006. Wing (2006) explains that computational thinking involves solving problems, designing systems, and understanding human behavior with reference to basic concepts of computer science. Then in 2011 Wing reiterated his opinion on computational thinking. Wing explained that computational thinking is a thinking process involved in formulating problems and solutions so that they can be represented in a form that can be done effectively by information processing agents (Wing, 2011). From this opinion, it can be concluded that computational thinking is not only for computer skills, but computational thinking can also be developed without computers. Computational thinking is believed to be a solution to solve students' problems so that they can think logically, systematically, and structured. In line with that, everyone also needs computational thinking skills to solve every problem in everyday life.

The results of PISA (Program for International Student Assesment) in 2022 show that Indonesian students obtained a math ability score of 366 points. This score is quite far from the average score of OECD member countries which ranges from 465 to 475 points. With a score of 366, Indonesia occupies the 1a lebel which means that in general Indonesian students can only answer questions with simple context and clearly defined question conditions and all the necessary information is available. The inclusion of Indonesian students at level 1a also shows that mathematical skills in using algorithms, formulas or procedures at the basic level to solve problems. At this level, Indonesian students are categorized as unable to think creatively to formulate solutions to more complex problems (OECD, 2022). From the results released PISA should be able to be an evaluation material for the education system in Indonesia. Indonesia can make several efforts to improve the education system, one of which is by improving the quality of educators and providing facilities and teaching materials that support the learning process.

The low mathematical ability of students in Indonesia is influenced by the learning process. Educators are required to be able to provide a good learning process for students. One of the efforts that educators can do to improve the ability of students is to use teaching materials. Teaching materials are one of the devices or materials used during the learning process and are very helpful for students or readers to understand certain material (Rizki & Linuhung, 2017). The teaching materials used should be interesting, can provide learning experiences and can hone the abilities of students, especially the ability to solve problems.

One of the teaching materials that can be used is the Scratch-assisted learning module. Scratch is a visual programming language that provides many interesting features and makes it easy to learn programming in the learning process (Hansun, 2014). Scratch-assisted programming modules can train computational thinking and problem-solving skills, creative teaching and learning, self-expression and collaborative, and equity in computing. This is relevant to the research of Rodríguez-Martínez et al. (2020) who conducted experimental research on grade 6 students on computational and mathematical thinking using Scratch which showed the results that Scratch can be used to develop mathematical ideas and computational thinking of students.

The use of Scratch-assisted teaching materials has been studied several times with different material studies. One of them is research conducted by Iskandar & Raditya (2017), namely the development of projectbased learning teaching materials assisted by Scratch. Furthermore, Sunarti et al. (2020) conducted research on the development of Scratch-assisted circular motion digital teaching materials based on science, technology, engineering, and mathematics (STEM). However, there has not been much research that focuses on developing computational thinking skills by developing Scratch-assisted modules on flat building characteristics material. Therefore, this study aims to develop a Scratch-assisted programming module, especially to develop students' computational thinking skills on flat building characteristics material.

B. Method

This research is a research *and development (R&D*) that aims to develop a Scratch programming module to develop computational thinking skills of elementary school students which are integrated through learning mathematics material characteristics of flat wakes. The research model used is EDR (*Educational Design Research*). Here is a chart of the steps in the study:

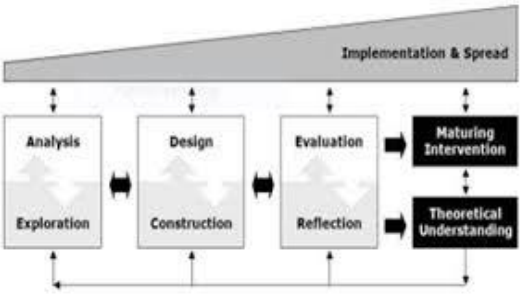


Figure 1. EDR Generic Model

The explanation of the stages of Educational Design Research (Ormel et al., 2012) (Ormel et al., 2012) is as follows:

1.Analysis and Exploration

The first stage carried out is the analysis and exploration stage. At this stage, researchers identify problems in the form of lack of mathematical ability of students. At this stage, researchers explore the causes of these problems through interviews with several grade V elementary school teachers, and researchers also conduct documentation studies.

The results of interviews and documentation studies are then used as the main reference to develop research products so that the resulting products can be in accordance with the needs and are expected to help solve problems contained in learning, especially at the elementary school level.

2.Design and Construction

After analyzing and exploring the problem, the next stage is to design and construct the research product. At this stage, researchers begin to prepare to design the Scratch programming module by compiling a teaching material design first. Furthermore, the researcher developed the design until it became a product in the form of a Scratch programming module of flat building material. After the teaching material product has been developed, the next stage is to conduct validation tests and expert validators to determine the validity of the teaching materials that have been developed.

3. Evaluation and Reflection

The last stage carried out is the evaluation and reflection stage. This stage is carried out after the research product is created and validated. After the validation results stated that the Scratch programming module was feasible to be tested, the researchers conducted limited trials and extensive trials of Scratch-assisted teaching materials for flat building materials to 20 grade V elementary school students. Furthermore, the Scratch programming module was evaluated according to the results of student response questionnaires and the results of researchers' observations during the trial.

The subjects in this study were grade V students of SDN Cicariu, Tasikmalaya City. The study was conducted using respondent questionnaires given to students after learning using Scratch-assisted teaching materials. The data analysis used in this study is qualitative and quantitative descriptive analysis. Qualitative descriptive data analysis is used to describe the results of preliminary studies in the form of interviews, observations, and documentation studies. Meanwhile, quantitative data analysis was carried out on expert validation sheets and student response questionnaires using Likert scales. This study uses a scale of 1-5 which shows strongly disagree – strongly agree with the statements given (Sugiyono, 2017).

Furthermore, the data obtained is then converted into quantitative data to determine the score weight of each validity using the following formula:

$$P = \frac{\sum x}{\sum xi} x100\%$$

Sumber: (Tegeh et al., 2014)

Information:

P = Percentage value

$\sum x$ = Number of respondents' answer scores from an assessment indicator

$\sum xi$ = Number of ideal values

The collected data is then analyzed using the Likert scale measurement formula.

C. Results and Discussion

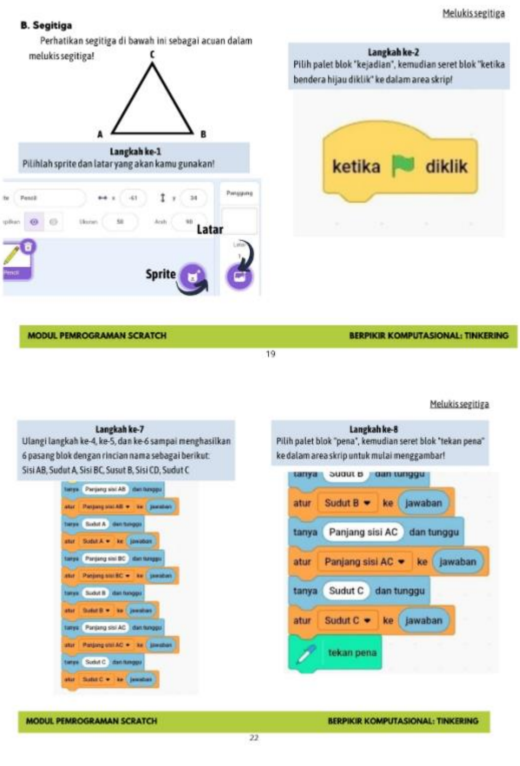
The Scratch programming module is a module developed to train students' computational thinking skills. The resulting module is packed with steps to do programming using Scratch starting from painting flat shapes, comparing flat shapes, to creating flat shapes.

1. Analysis and Exploration

Based on the results of analysis and exposure conducted through interviews with four teachers in several elementary schools, including one teacher at SDN Cicariu, one teacher at SDN Nagarawangi 1, and two teachers at SDN Sindangkasih, it is known that the teaching materials used have not varied. Teachers usually only use textbooks provided by the school or occasionally make powerpoints as additional teaching materials in learning. This is certainly very influential on learning activities because teaching materials can make learning activities more interesting, and can make it easier for students to learn independently so as to reduce dependence on teacher presence. In addition, teaching materials are also expected to help meet the demands of an independent curriculum that expects students to be able to think logically and encourage their critical power. Thus, researchers are interested in developing teaching materials in the form of Scratch programming modules for flat building materials to facilitate students' independent learning and train critical thinking skills through the development of computational thinking, especially in elementary schools.

2. Design and Construction

At this stage, design is carried out to make teaching materials in the form of Scratch-assisted programming modules. Teaching materials are designed in such a way that they have an attractive appearance and content for students. Teaching materials designed in the form of printed modules to guide students to practice compiling scripts from the codes available in Scratch and later can produce final images of flat shape creations. The discussion contained in the module begins with a brief review of the characteristics of flat wakes, then there are activities in the form of steps to paint flat shapes using Scratch, then there are activities to compare flat builds, then the last activity is in the form of steps to create flat wakes. In each activity, exercises have been provided so that students can better understand the activities that have been done before and then at the end a final evaluation is also provided to measure the final ability of students after learning to use the Scratch programming module.



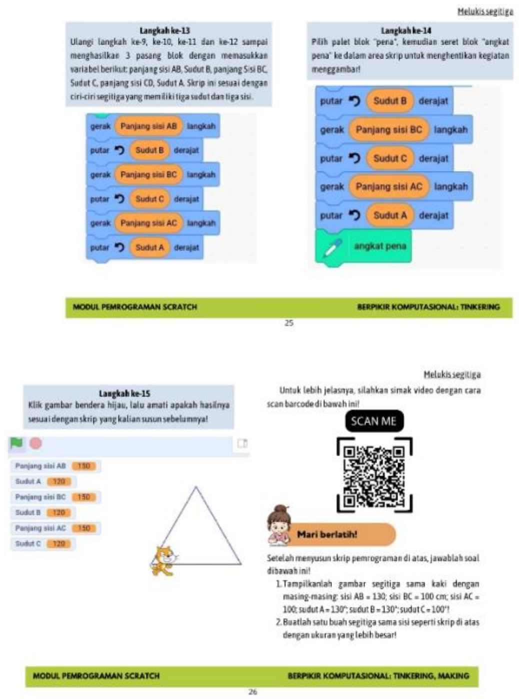


Figure 2 Flat Build Painting Activities

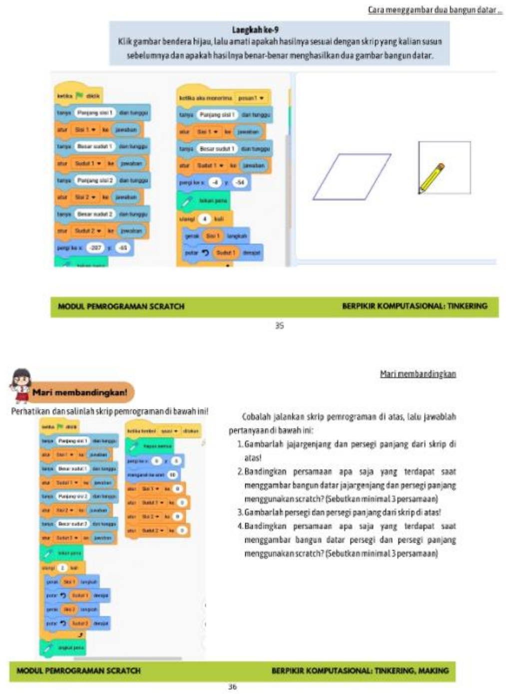


Figure 3 Comparing Flat Build Activity

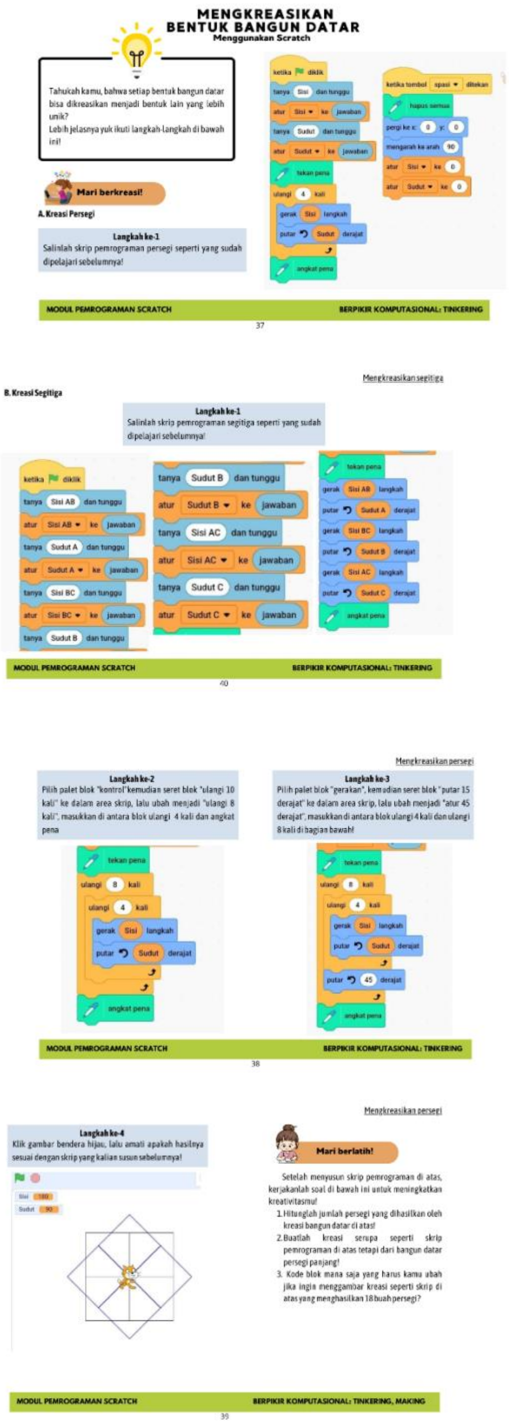


Figure 4 Flat Build Creation Activities

After design, teaching materials that have been developed are first validated by experts before implementation. Some of the experts involved in this validation are three material experts (experts in mathematics and informatics), one expert in learning media, one expert in programming, and one pedagogical expert. The results obtained from the validation test are as follows:

Table 1 Mathematical Material Expert Validation Test Results

No.	Assessment Aspect	Score Total
1.	The correctness of the content of the material	18
2.	Free from concept errors	20
3.	Current and up-to-date material	9
4.	Scope and depth of material	16
5.	Adequacy of references used	7
	Total	**70**
	Percentage	**77,77%**
	Category	**Proper**

From the validation trial of mathematics material experts, an assessment result of 77.77% was obtained which was included in the feasible category. In addition, expert validators of mathematical materials also provide several inputs, including so that researchers can insert flat building characteristics in every step of compiling programming scripts, develop evaluation questions so that they can be more relevant to learning objectives, and add bibliography in the module. These inputs are used as a reference by researchers to develop teaching materials.

The following is a table of informatics material expert validation test results:

Table 2 Informatics Material Expert Validation Test Results

No.	Assessment Aspect	Score Total
1.	The correctness of the content of the material	10
2.	Free from concept errors	15
3.	Current and up-to-date material	4
4.	Scope and depth of material	5
5.	Adequacy of references used	5
	Total	**39**
	Percentage	**86,66%**
	Category	**Very Worth It**

From the informatics material expert validation trial, an assessment result of 56.66% was obtained which was included in the very feasible category. In addition, expert validators of informatics materials also provide some input, including that researchers are expected to be able to add a final evaluation to the module.

The following is a table of learning media expert validation test results:

Table 3 Learning Media Expert Validation Test Results

No.	Assessment Aspect	Score Total
1.	Cover design	10
2.	Font colors, images, fonts	9
3.	Use of display layouts	10
4.	Ease of language	4
5.	Module ease of use operation	12
	Total	**45**
	Percentage	**90%**
	Category	**Very Worth It**

From the validation trial of learning media experts, 90% of the assessment results were obtained which were included in the very feasible category. In addition, learning media expert validators also provide several inputs, including researchers are expected to be able to add completeness of module structures such as prefaces, evaluation questions, and image captions; Then clarify the use of menus and steps in the module and correct some sentences according to standard language rules. These inputs are used as a reference by researchers to develop teaching materials.

Here is a table of programming expert validation test results:

Table 4 Programming Expert Validation Test Results

No.	Assessment Aspect	Score Total
1.	*Maintainable*	15
2.	*Reusability* (ease of use)	20
3.	*Compatibility* (ease of operation)	15
4.	*Reusable* (reusable)	13
	Total	**63**
	Percentage	**96,92%**
	Category	**Very Worth It**

From the validation trial of programming experts, an assessment result of 96.92% was obtained which was included in the very decent category. In addition, expert programming validators also provide input for the development stage of teaching materials, namely it is hoped that researchers can add media to update material content so that teaching materials can continue to be used in the long term.

Here is a table of pedagogical expert validation test results:

Table 5 Pedagogical Expert Validation Test Results

No.	Assessment Aspect	Score Total
1.	Material	25
2.	Language	8
3.	Bahan ajar	24
	Total	**57**
	Percentage	**76%**
	Category	**Proper**

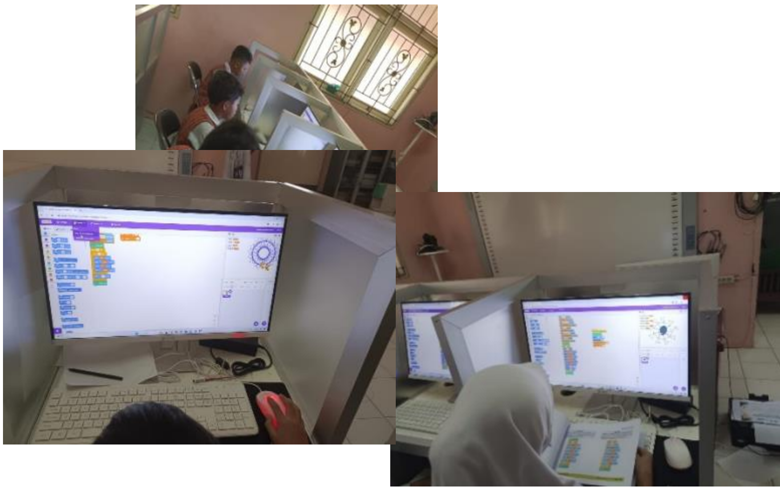
From the pedagogical expert validation trial, 76% of the assessment results were obtained which were included in the feasible category. In addition, pedagogical expert validators also provide several inputs, including the hope that researchers can clarify the references contained in the comparison activity and the material presented can be reviewed again according to the selected grade level. All input provided will be used as a reference for researchers in developing teaching materials.

From the results of validation tests by several experts, scratch-assisted teaching materials are worthy of being declared suitable for use / trial in the field with revisions.

3. Evalution and Reflection

At this stage, researchers conducted product trials in the form of Scratch programming modules for flat building materials to determine the

wearability and practicality of the modules that have been developed. The trial was carried out through two stages, namely a limited trial and a broad trial to 20 grade V students of SDN Cicariu. The activities that take place during the trial process are students divided into small groups with members of each group of 2 people, then each student is given a module and each group works together to do all the instructions in the module. Learning is carried out in a guided manner but researchers still try to encourage students to be able to learn independently. Here are some activities and learning outcomes from students:



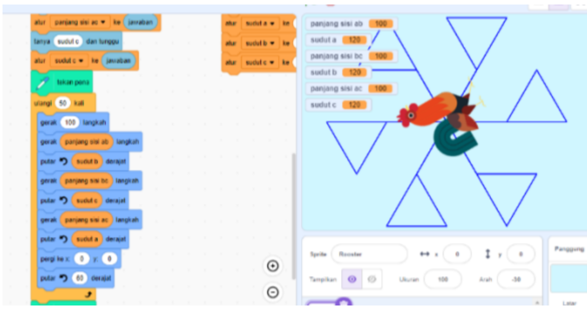


Figure 5 Scratch-Assisted Scripting Activities

Figure 6 *Debugging Activities* on Programming Results

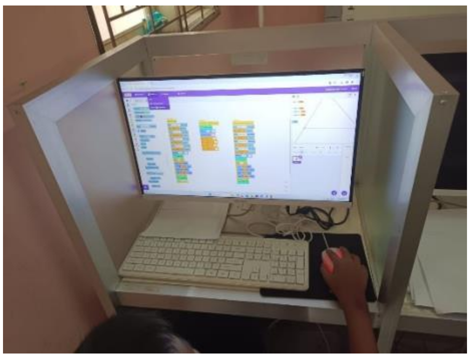
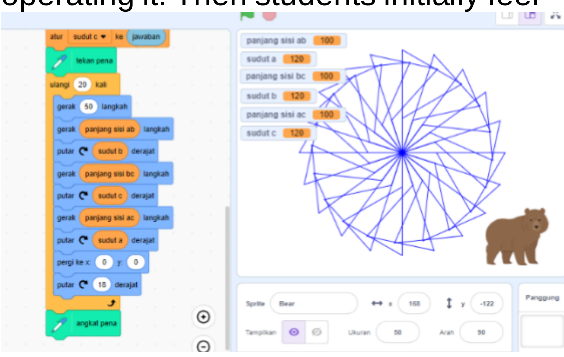


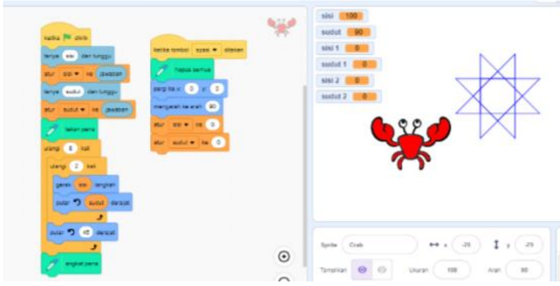
Figure 7 Flat Build Creation Designing Activities

When learning activities using scratch-assisted teaching materials, most students show a high enthusiasm when learning because based on the narrative of Scratch students is a new thing in learning. In addition, students also show their cohesiveness in working together to complete each step contained in the module. There is interaction between friends and researchers as supervisors when learning. The perceived obstacle is that most students have difficulty operating computers, they are not used to it and feel afraid of making mistakes when

operating it. Then students initially feel



confused about the operation of Scratch and cannot understand the meaning of the instructions in the teaching materials, but over time they can understand the meaning of each step contained in the module and can



get used to using the computer. As the learning process progresses, students begin to operate the computer fluently and begin to be able to create block arrangements until finally most students are able to design their own script arrangements. Here are some Scratch designs created by students themselves:

Figure 8 Student Design Results

After carrying out all the activities in the module, then students are directed to work on the final evaluation questions, after which students are given a response questionnaire as a reference to make improvements to the teaching materials that have been developed. The average results of the student response questionnaire showed a percentage score of 91.25% with a very decent category.

Scratch-assisted teaching materials can be categorized as very feasible and practical because they are able to get a positive response from students. This is in line with research conducted by Rubiyah et al. (2020) that students give positive responses to learning media and comments stating that learning media are easy and fun to use. In addition, scratch-assisted teaching materials can also provide a new learning atmosphere and can be able to provide challenges for students so that they can motivate student learning which is expected to improve student learning outcomes (Satria et al., 2022). This is because in the appearance of the Scratch application there are several characters and codes that can be *dragged and dropped* so as to produce new creations for students. In line with that, according to (Supriatin & Putra, 2023), Scratch-assisted teaching materials should be used in abstract mathematics learning such as geometry so that it can make it easier for students to understand the material, be more enthusiastic in learning, and learning can be more interactive. Therefore, the Scratch application has a very important role and deserves to be introduced and studied as an interactive learning medium and in accordance with the development of this increasingly rapid era. Scratch can be used anywhere and anytime so that students can learn independently using Scratch. In addition, Scratch can also be accessed easily even without the internet by downloading the Scratch application first on a computer device. however, in line with research put forward by Solihah et al. (2022) that the Scratch application can be used as a learning medium operated to students by teachers who previously went through training first.

E. Conclusion

The conclusion obtained from the results of this study is that the results of product feasibility trials from mathematical material validators obtained a score of 77.75% with the feasible category; Informatics material expert validators obtained a score of 86.7% in the very decent category; Learning media expert validators obtained a score of 90% in the very decent category; Expert Programming Validators obtained a score of 96.9%

in the very decent category; pedagogical expert validators obtained a score of 76% in the decent category; and the student response questionnaire obtained results of 91.25% with a very decent category. Therefore, the results of the development of Scratch-assisted modules, flat building materials are very feasible to be used as a means of teaching materials that can encourage students to learn independently and can help develop computational thinking skills in elementary schools.

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