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Implementation of Computational Thinking in Data Structure Subject Using Problem-based Learning Models

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ABSTRACT

Computational thinking skills are one of the skills required in the 21st century. Computational thinking can teach students to think logically, critically, and use appropriate and efficient strategies in solving problems. However, computational thinking skills require an appropriate learning approach. Learning process must be designed to hone problem-solving skills and to acquire essential knowledge and concepts of the subject matter. This study aims to develop a computational approach media with thinking and problem-based learning and to improve students cognitive. This study uses a Comprehensive Life Cycle (SHM) methodology to develop the media. One-group pretest-postest was used for the research design. Media with computational thinking and problem-based learning approach have been developed and has obtained a score of 90% or "Very Good" by experts on media testing and get a percentage score of 92% or "Very Good" by experts on material testing. The use of media with Computational Thinking and problem-based learning approach can improve student cognitive with an increase in the average N-gain of students by 0.42 which is in the "Medium" category. On the other hand, student responses to the learning media resulted in a score of 84%.

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1. INTRODUCTION

The ability to think computationally includes skills such as reading, writing and arithmetic, thus every individual in the 21st century must possess Computational Thinking skill (Wing, 2017). Wing believes that computational thinking can train students to think logically, critically, and use appropriate and efficient strategies in solving problems. CSTA believes that computational thinking can be applied in various scientific disciplines to solve problems, design systems, create new knowledge, and increase understanding of the power of computing in the modern era (Weintrop *et al.*, 2016). Computational thinking skills are important because it is expected that with computational thinking skills in various scientific fields, we can have a new thinking paradigm in understanding and interpreting the world in general.

Computational thinking is often associated with calculating and programming. But computational thinking skills cannot be equated with programming because the scope of computational thinking is very broad. However, computational thinking and programming is related, which indicates that the cultivation of computational thinking requires programming support and programming requires computational thinking guidance. One of the areas in advanced programming is data structures. Data structures are considered a difficult subject because the material is abstract and difficult to understand, one of the materials being Graphs. Based on the preliminary study obtained through a questionnaire distributed among 63 students who had contracted data structure subject, 60% of respondents said that Graphs were difficult material compared to other material in data structures. Apart from that, there are factors that influence students' difficulties in understanding learning material, namely 27% of the material is difficult to understand, 23% of the material is too abstract, 25% of the material delivered is less interesting, 13% lack of tools and no learning preparation. From the results of the questionnaire, it was also found that respondents needed interesting learning media which can visualize the material, such as learning videos.

Aside from the learning media, there is a need for learning model. The learning model used in this media is Problem-based Learning (PBL). According to Moffit, the Problem-based Learning (PBL) model is a learning approach that uses real-world problems as a context for students to hone problem-solving skills and to gain essential knowledge and concepts from the subject matter (Khairani, 2020).

Based on these problems, this research aims to create a multimedia learning design by implementing computational thinking and Problem-based Learning mode to improve students' cognitive abilities in Graph material for data structure subject. The learning media will implement computational thinking and Problem-based Learning model. The media is expected to improve students' cognitive abilities. It is also expected that the results of the research will be useful for further research, as well as for educators when teaching Graph material and for students using multimedia learning as a means to more easily understand Graph material.

2. METHODS

This study used the Comprehensive Life Cycle (SHM) multimedia development method. This is because the aim of this research is to produce a product in the form of interactive multimedia by applying computational thinking and the Problem-based Learning (PBL) model in the Data Structure subject. There are five stages in the Comprehensive Life Cycle (SHM) multimedia development process, namely, Analysis stage, Design stage, Development stage, Implementation stage and Assessment stage (Nugroho *et al.*, 2023).

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2.1. Research procedure

In the research procedure section, it refers to the Full Life Cycle (SHM) method developed by Munir. **Figure 1** below is a research procedure in the form of a flowchart.

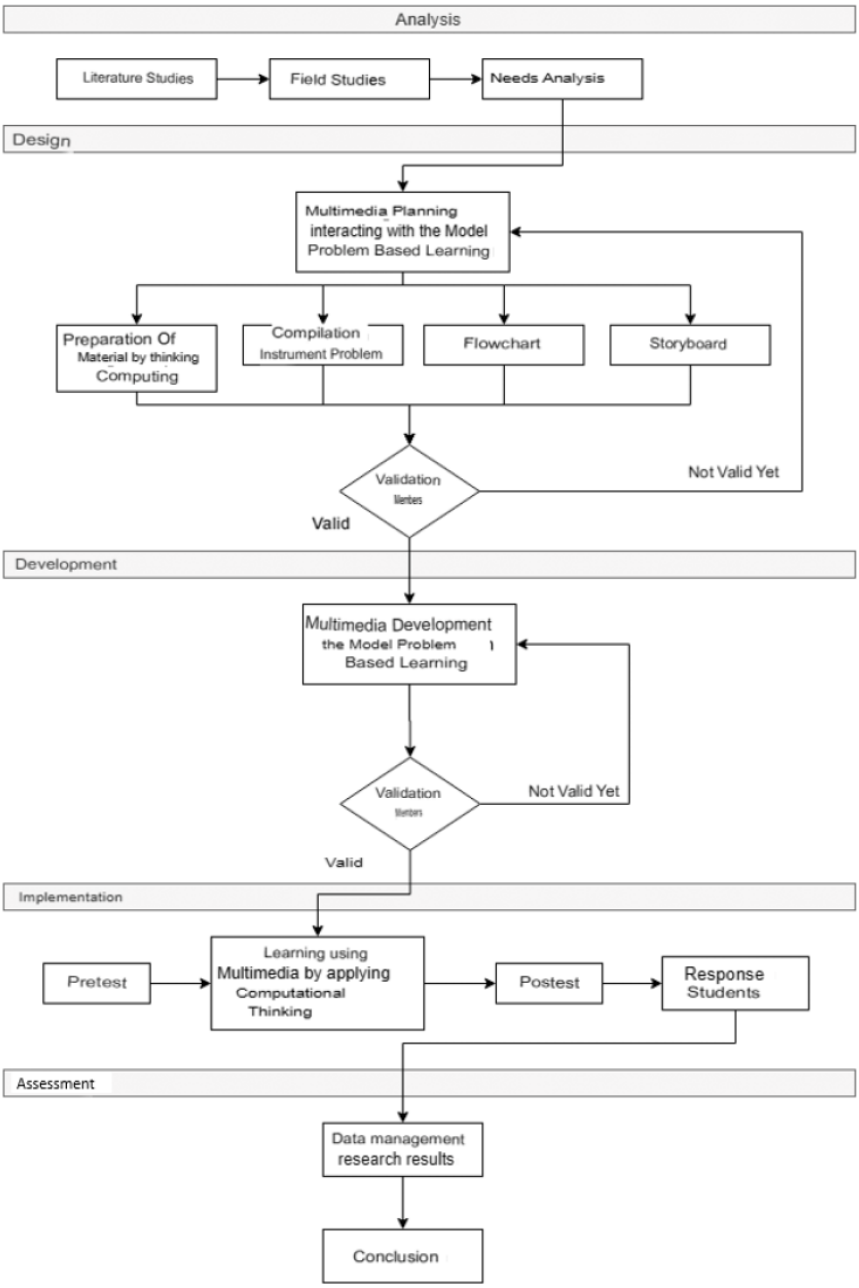

Figure 1. Research procedure.

The following is an explanation of the stages of conducting a more complete research that will be carried out as follows:

2.1.1. Analysis phase

At this stage there is literature study, field study and needs analysis. In literature studies, data/information and theories are collected which can help research such as learning methods, computational thinking found in research journals. Afterward, the researchers conducted field studies to collect information about student's learning problems. Then a need analysis was carried out based on the data obtained of literature studies and field studies.

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2.1.2. Design Stage

At this stage, material is prepared by implementing Computational Thinking, question instruments and the researchers also designed flowcharts, storyboards and interface designs for the intended multimedia. Before proceeding to the next stage, expert validation is carried out with the aim of getting suggestions so that the material, question instruments, storyboards and flowcharts are in accordance with the interactive multimedia that will be developed.

2.1.3. Development Stage

This stage involves developing the media based on the design of flowcharts and storyboards, and gradually implementing computational thinking and the Problem-based Learning model. After ensuring that the multimedia is error free, the multimedia will go through the expert validation stage. The experts will provide some input and suggestion regarding the media, then revisions will be made accordingly.

2.1.4. Implementation Stage

At this stage, learning multimedia which had undergone expert validation is tested to the student. Before using the multimedia, the students are given pretest questions. After that, students learn Graph materials using multimedia learning which has implemented Computational Thinking. Finally a posttest is carried out to improve students' cognitive abilities after using multimedia.

2.1.5. Assessment Stage

At the assessment stage, multimedia that has gone through the four processes above is then processed data from the implementation results. At this stage, the strengths and weaknesses of learning multimedia can be identified.

2.2. Research Design

The research design used was re Experimental Design research with the One Group Pretest-Posttest type. First, the pretest stage is carried out before being given treatment in class, and the posttest is to measure the comparison of posttest data with pretest data. The research design is described in **table 1** below:

Table 1. One-group pretest posttest.

Pretest	Treatment	Posttest
O_1	X	O_2

Information:
O1 : Pretest value (before treatment)
X : Treatment
O2 : Posttest score (after treatment)

2.3. Population and sample

The population in this study were students majoring in Computer Science Education at the Indonesian Education University. The sampling technique used in this research was non-probability sampling, purposive sampling, which is a sampling technique with certain

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considerations that the sample selected is appropriate to the problem raised. The sample in this research were students majoring in Computer Science Education 2019.

2.4. Research instruments

The instrument used in this research is a field study instrument, namely in the form of giving questionnaires to students; The question instrument is a collection of multiple choice questions; The media and material validation instrument is using the Learning Object Review Instrument (LORI) v1.5. The student response instrument in the form of a questionnaire assessment given to students who have used multimedia. The questionnaire assessment can be seen in **Table 2.**

Table 2. Student response questionnaire to the media.

Nu.	Dimensions	Statement	Evaluation				
1	Media	Media is easy to access and use	1	2	3	4	5
2		Media is fast and responsive	1	2	3	4	5
3		Media has a well-structured menu	1	2	3	4	5
4		Useful media for learning basic programming	1	2	3	4	5
5		Media makes it easier to learn basic programming	1	2	3	4	5
6		The material in the media is interesting	1	2	3	4	5
7		Material on complete media	1	2	3	4	5
8		The material on the media is useful and reliable	1	2	3	4	5
9		The material in the media is easy to remember and understand	1	2	3	4	5
10		The language used in the media is in accordance with Indonesian rules so it is easy for me to understand it	1	2	3	4	5
11		The learning instructions in Media are clear, making it easier for me to use them	1	2	3	4	5
12		I started to be interested in basic programming lessons when learning started using media	1	2	3	4	5
13		The use of media during basic programming lessons encourages and motivates me to learn and discover new ideas	1	2	3	4	5
14	Understanding	This media helps me in completing programming algorithm assignments	1	2	3	4	5
15		Practicing questions in the media made me understand more about basic programming	1	2	3	4	5
16		I feel that learning basic programming using media is more efficient	1	2	3	4	5
17		I feel that learning basic programming using media is more effective	1	2	3	4	5
18		I feel that learning basic programming needs to use media	1	2	3	4	5

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2.5. Research instruments

The data analysis technique used in this study consisted of: (1) Field study instrument data analysis which was carried out by formulating the results of the data obtained through questionnaires; (2) Data analysis of expert validation instruments raced based on the Learning Object Review Instrument (LORI) with a rating scale measurement scale, (3) Data analysis of the instrument questions, consisting of validity tests reliability tests, difficulty level tests, and discriminating power, (4) Analysis of student response instrument data to multimedia using a Likert scale , (5) Analysis of learning outcomes data in the form of a gain test (Hake, 2014).

3. RESULTS AND DISCUSSION

3.1. Analysis Stage

In the early stages of designing learning multimedia by implementing computational thinking and the Problem-based Learning model, an initial study was carried out in the form of a literature study. The field study was carried out in the form of giving questionnaires to students. Based on the questionnaire, the following results were obtained:

1) In the data structure subject, the material that is considered the most difficult among Queues, Link Lists, Trees and Graphs is Graphs.
2) Factors that cause students to have difficulty understanding the material include material that is (a) difficult to understand, abstract material, (b) delivery of material that is less interesting and (3) no appropriate learning tools.
3) Tools that are expected to increase student understanding include learning in video and audio formats.

Based on these finding, innovation is needed in learning activities with the help of learning multimedia by implementing Computational Thinking and Problem-based Learning models which are expected to help increase students' understanding of the material and make learning activities more interesting.

3.2. Design Phase

Creating the multimedia interface refers to the storyboard and flowchart that has been designed. The designed user interface is as follows:

1) Login Page

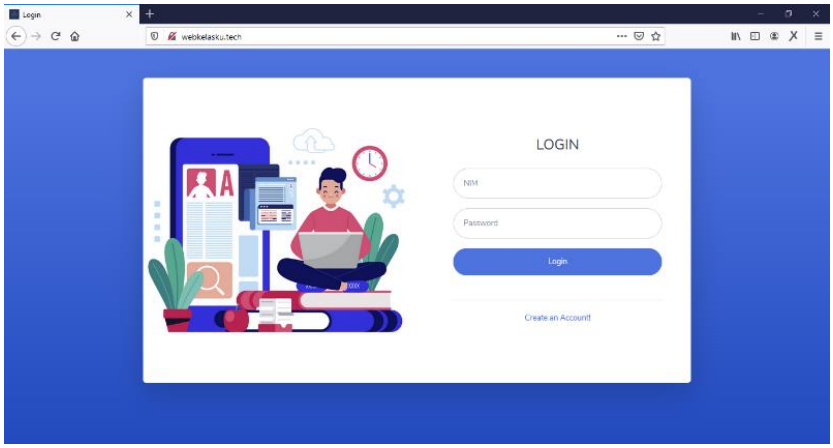

Figure 2. Login page.

The interface in **Figure 2** will appear when e-learning is accessed. In this interface, students must fill in the student ID (NIM) section that has been registered in e-learning and Password. Furthermore, the Login Menu will direct the user to the e-learning dashboard page.

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2) Sign up Page

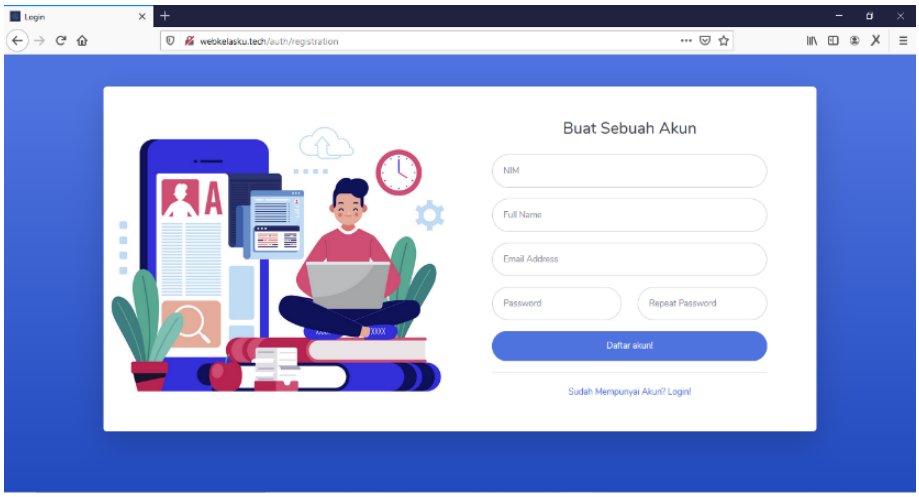

Figure 3. Sign up page.

The display in **Figure 3** will appear when students select the menu to create a student account on the login page. This page is intended for students who have not registered for e-learning or registered a new account.

3) Dashboard page

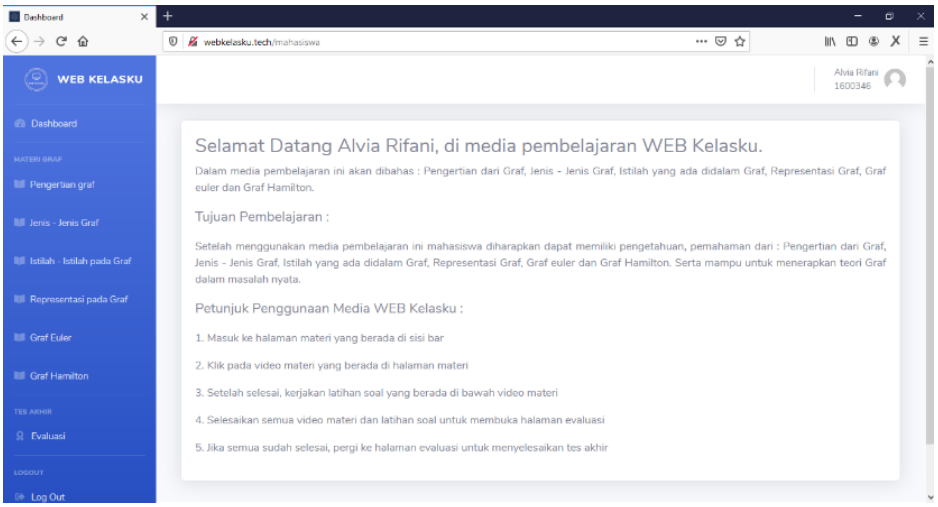

Figure 4. Dashboard page.

The display in **Figure 4** will appear when students have logged in to e-learning. This page informs students of what material will be studied, the objectives of the learning, and instructions for using e-learning.

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4) Page Material and practice questions

On this page the Graph material is presented and can be selected in the left navigation pane. There is also a brief description of the material to stimulate students' curiosity about the material. A learning video with the implementation of computational thinking as in **Figure 5**.

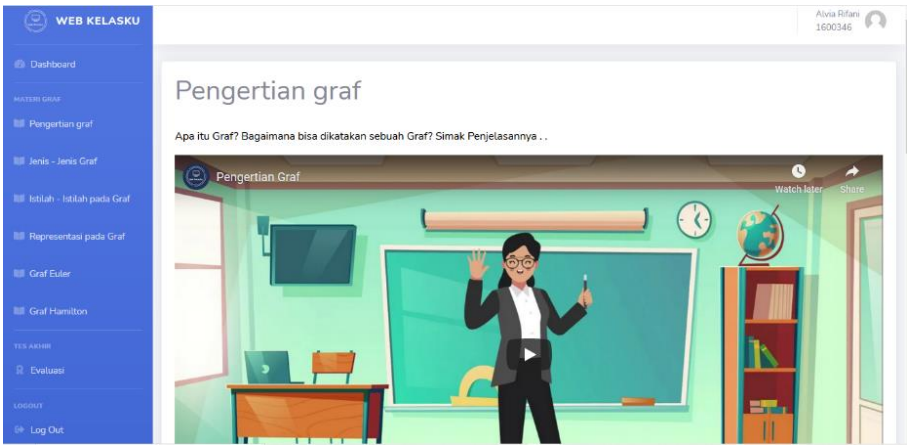

Figure 5. Material page

The practice questions which are right below the video in shown in **Figure 6**

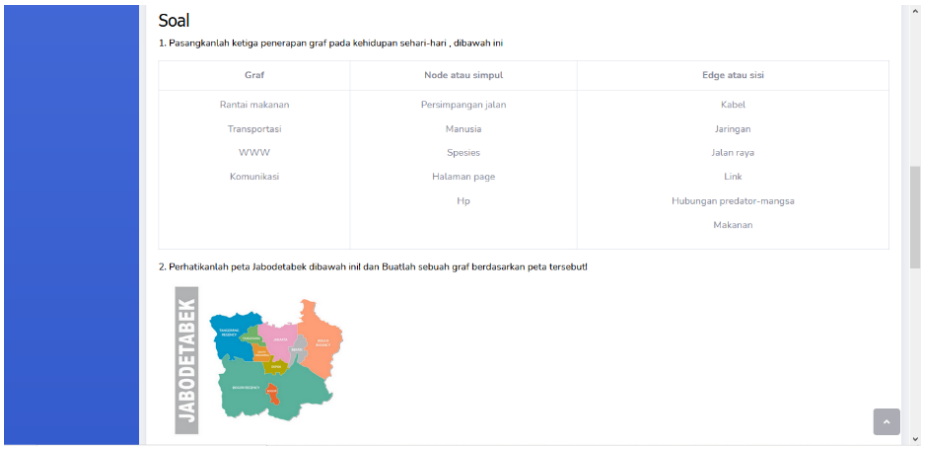

Figure 6. Material page

The page leading to the answer for practice questions can be seen in **figure 7**, which explain the answer to the problem using Computational Thinking skills.

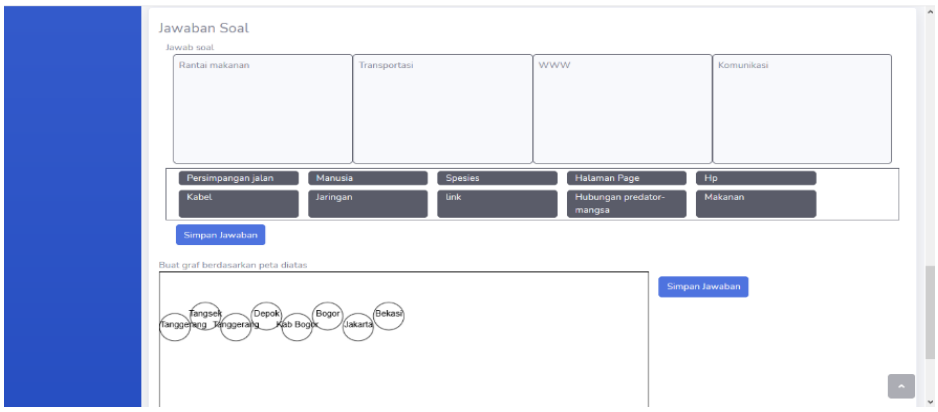

Figure 7. Material page

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5) Evaluation Page

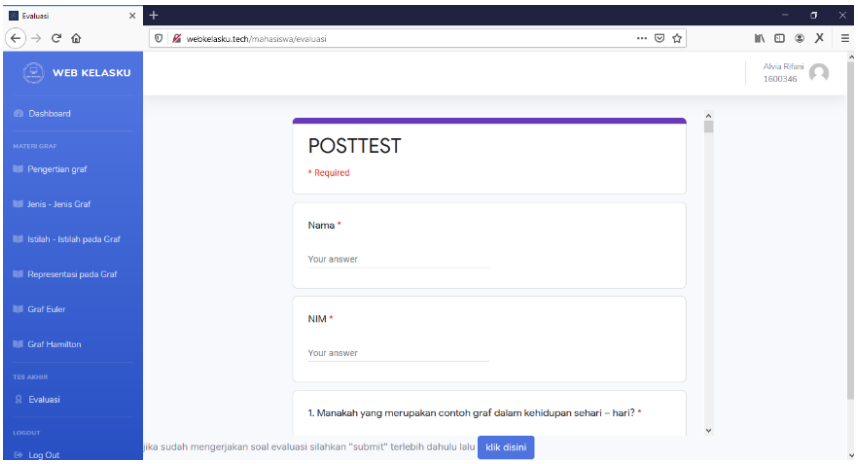

Figure 8. Evaluation page.

Figure 8 show a page containing posttest questions that must be filled by students. If students have done the posttest questions, the questions on the evaluation page will change to a media response questionnaire as in **Figure 9**.

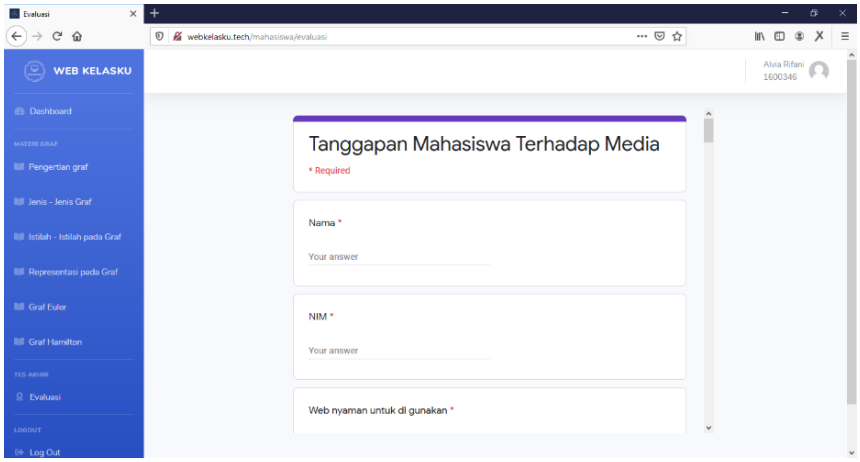

Figure 9. Student response page.

3.3. Expert Validation Test Results

Validation of learning multimedia was carried out on experts in the field of study. The learning multimedia received a score with a percentage of 90% in the "Very Good" category. Secondly, validation of media content was carried out by an experts or lecturer who taught the subject "Data Structure", material validation on material experts received a percentage of 92% in the "Very Good" category.

3.4. Assessment Stage

Collecting pretest, posttest and student responses is carried out using Google Form, the gain calculation comes from the pretest scores on the posttest. The following in **table 3** is the result pretest, posttest results.

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Table 3. Pretest posttest gain results.

Respondent	Pretest	Postest	N-Gain	Average gain	Class
R1	65	85	0.57	0.58	Top
R2	60	90	0.75		
R3	60	80	0.50		
R4	55	85	0.67		
R5	55	75	0.44		
R6	55	90	0.78		
R7	50	70	0.40		
R8	45	70	0.45		
R9	45	65	0.36		
R10	45	85	0.73		
R11	45	55	0.18		
R12	40	85	0.75		
R13	40	55	0.25		
R14	40	60	0.33		
R15	40	70	0.50		
R16	40	75	0.58		
R17	40	60	0.33		
R18	35	80	0.69		
R19	35	55	0.31	0.4	Middle
R20	35	70	0.54		
R21	35	70	0.54		
R22	35	65	0.46		
R23	35	75	0.62		
R24	35	45	0.15		
R25	35	50	0.23		
R26	35	65	0.46		
R27	35	40	0.08		
R28	35	60	0.38		
R29	30	45	0.21		
R30	30	40	0.14		
R31	25	35	0.13		
R32	25	55	0.40		
R33	25	45	0.27		
R34	25	55	0.40	0.33	Bottom
R35	25	50	0.33		
R36	20	45	0.31		
R37	15	40	0.29		
R38	15	55	0.47		
Average gain				0.42	

Based on **table 3**, the results of the pretest-posttest the highest gain value is obtained by the upper class, which is equal to 0.58 which is categorized as a "Medium" gain increase. The gain values in the middle and lower classes also obtained the category of "Medium" gain increase with the score of 0.4 and 0.33.

3.5. Assessment Stage by Students

The responses given by students to interactive multimedia were very good, seen from student responses that multimedia was comfortable to use, increased understanding and knowledge, provided a new atmosphere in teaching and learning activities, this can be proven from the results of student response instruments regarding learning using interactive

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multimedia with the implementation of computational thinking and the Problem-based Learning model with an average value of 84% categorized as "Very Good".

4. CONCLUSION

Multimedia learning that implements Computational Thinking and the Problem-based Learning model is designed and developed using the Comprehensive Life Cycle Model (SHM) which includes the stages of Analysis, Design, Development, Implementation and Assessment, there is an increase in improving students' cognitive abilities. This is proven by the average gain value of 0.42 which is interpreted as a "Medium" level of effectiveness. Students' responses to learning using interactive multimedia in the data structure subject on graph material obtained positive results and were rated as “Very Good” by the students.

For further development, the multimedia should emphasize the Computational Thinking aspect and students should first informed about Computational Thinking skills so they can utilize Computational Thinking skills in solving a problem. Another recommendation is to make the learning multimedia display more attractive to increase students' enthusiasm and to implement dual-device mode so that multimedia can be used anytime and anywhere. Finally, there should be a manual for using the multimedia to avoid student’s confusion.

5. AUTHORS’ NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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