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Web-Based Personalized Learning Media for Enhancing Cognitive Abilities of Vocational High School Students in Basic Programming Subject

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ABSTRACT

Every student has different personal needs and characteristics and those must be considered as the factors that must be considered in the learning process. Therefore, appropriate learning methods must be student-centered, otherwise known as personalized learning. This study aims to implement web-based learning media with a personalized learning approach to improve cognitive abilities of vocational school students, measure the effect of media application and student responses to learning media. This study uses a quantitative method with a comparative causal design, and the Whole Life Cycle method is used for media development. The research design used was a one-group pretest-posttest. Web-based learning media with a personalized learning approach that was developed and got a percentage score of 86% or "Very Good" by experts on media testing. The use of web-based media with the personalized learning approach can improve the cognitive abilities of vocational students who are tested with post-test questions with an increase in the average N-gain of students in group A of 0.47 (which is in the "medium" category) and in group B an increase in the average N-gain of students by 0.53 (which is included in the "medium" category). There is a relationship between student responses to instructional media and an increase in n-gain at the lower-, middle-, and upper-class levels. For the overall response of students to learning media get a percentage score of 94.43%.

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1. INTRODUCTION

One of the supporting factors for successful development is through the presence of quality human resources. The government strives to produce and enhance quality human resources through education (Kharistiani & Aribowo, 2013). As a subsystem of the national education, Vocational High Schools have a strategic role in creating skilled and quality human resources. In the curriculum of Vocational High Schools, specifically in the field of Information and Communication Technology, there is a subject called Basic Programming. In this subject, students learn fundamental programming concepts that are essential for advanced programming skills.

The subject of Basic Programming is necessary to provide a foundation or basic understanding of the principles of computer operation in computer programming languages. However, a significant portion of the content in the Basic Programming subject involves abstract concepts that require logical thinking to solve problems. As a result, this subject is considered challenging for a majority of students and is not easy to comprehend.

Difficulties in learning the Basic Programming subject are partly due to inappropriate teaching methods. Regarding the teaching and learning process, the current teaching methods tend to be non-adaptive, where the same learning resources are provided to all students, often referred to as a "one size fits all" approach. However, learners have individual personal needs and characteristics, such as learning objectives, prior knowledge, learning styles, thinking skills, and cognitive styles (Papanikolaou *et al*., 2006).

In relation to the differences in individual personal needs and learner characteristics, learning styles are an internal factor that influences learners' academic achievement. With varying learning styles among students, it's undoubtedly challenging for teachers to tailor their teaching methods to accommodate the diverse needs of students (Suteja, 2016). This brings us to the concept of personalized learning. Personalized learning is an approach to education that is believed to cater to each student's strengths, needs, and interests in the learning process. However, implementing personalized learning can be difficult if the learning process follows traditional methods (face-to-face) in the classroom (Sahabudin & Ali, 2013). Placing learning on knowledge transfer in the classroom and adopting a teacher-centered approach becomes impractical (Triyono, 2015).

Based on the issues discussed, the purpose of this study is to design a learning media using a personalized learning approach to enhance the cognitive abilities of vocational high school students in the Basic Programming subject. This research aims to implement a learning media that will provide an analysis of whether a personalized learning approach can enhance students' cognitive abilities, thus leading to an improvement in their learning outcomes in basic programming. The research outcomes are expected to be beneficial for further studies, for educators when teaching basic programming materials, and for students, enabling the learning media to serve as a tool for better understanding of the basic programming concepts.

2. METHODS

The research method employed in this study is a quantitative research method with a causal-comparative design. This research design was chosen because the study aims to measure the impact of using open-ended problem-solving approach learning media on enhancing critical thinking among vocational high school students in the Basic Programming subject.

In the development of instructional technology, this study utilizes the media development method known as the Comprehensive Life Cycle (CLC) cycle. The CLC model consists of five

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stages: analysis, design, development, implementation, and evaluation. The research design employed is the one-group pretest-posttest design. This study was conducted with two classes as the experimental group that received treatment using the developed learning media. Firstly, the subjects were given a pretest, and the scores from this pretest indicated the students' abilities before receiving the treatment. Then, the learning media treatment was administered, followed by a posttest assessment using test items. The scores from the posttest reflect the students' abilities after receiving the treatment.

2.1. Research Procedure

In the research procedure section, it refers to the scientific method, outlining the stages of the research in developing the learning media. The following **Figure 1** presents the research procedure in the form of a flowchart.

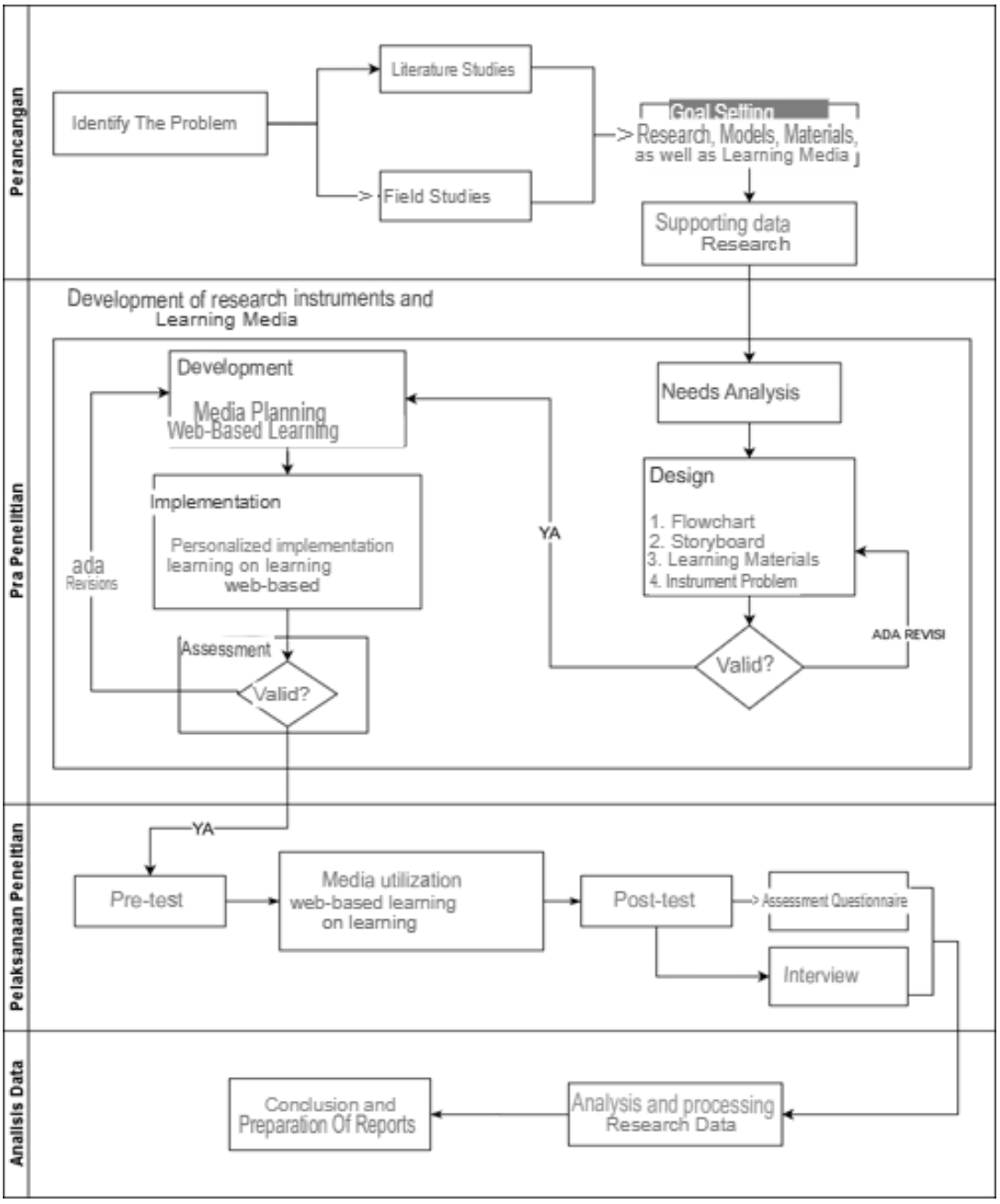

Figure 1. Research Procedure

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The description of figure 1 is as follows:

(i) Design. At this stage, literature review and field studies are conducted. In the field study, data is collected regarding the challenges faced in the learning process of basic programming and the difficulties experienced. This is done to ensure that the instructional media being developed aligns with the needs. The literature review involves collecting data, information, and theories from various sources that can aid the research. Literature review is carried out by gathering data from sources such as previous research journals and books that support the research data. This is done to find concepts to strengthen the instructional media that will be developed. Kolb Learning Style is used in the initial study to determine the student learning style.

(ii) Pre-Research. In this stage, the development of instructional media and research instruments takes place. The development of instructional media adopts the Comprehensive Life Cycle (CLC) software development method by:

a. Analysis. In the analysis phase, multimedia analysis and personalized learning approach analysis are conducted. Material analysis involves the examination of the content to be provided to the students. In the analysis of media, the instructional media is assessed to align with the personalized learning approach. Additionally, an analysis of personalized learning is carried out, considering the characteristics and stages of personalized learning that will be aligned with the content and instructional media.

b. Design. In the design phase, several designs are created for the flowchart and storyboard to outline the workflow of the instructional media being developed. This involves depicting the storyline and various components that will be present in the instructional media. The question instruments for the pretest and posttest will undergo feasibility testing. Additionally, instruments are developed to determine students' learning style tendencies. For this research, the Kolb Learning Style Inventory is used. Furthermore, content design is prepared, aligned with the Core Competencies and Basic Competencies (KI&KD) from the Directorate of Vocational High School Development for the subject of basic programming.

c. Development. In the development phase, the instructional media is created using the personalized learning approach, based on the flowchart and storyboard that have been developed. The created content will be incorporated into the web-based instructional media that is being developed.

d. Implementation. In this stage, the personalized learning steps are implemented in the web-based instructional media that has been developed.

e. Assessment. In this stage, validation is carried out by experts to assess the feasibility of the developed instructional media. If the media is deemed not suitable, improvements are made; whereas, if it is considered suitable, the media can be used for the research process.

(iii) Research Implementation. During the research implementation phase, first, students are asked to complete a pretest. This is done to assess the students' initial abilities before engaging with the instructional media. After completing the pretest, students will undergo the learning process using the developed instructional media. Subsequently, students will be asked to complete a posttest, which aims to gauge the extent of cognitive improvement after undergoing the learning process with the developed instructional media. Following this, students will fill out a questionnaire to provide an assessment of the media that was utilized.

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(iv) Data Analysis. In the data analysis phase, the collected data is processed based on the results obtained from the previous stages, including pretest and posttest scores, student feedback on the media, as well as interview outcomes. In this phase, the strengths and weaknesses of the developed media can be identified.
(v) Conclusion. In this stage, conclusions are drawn from the data analysis conducted in the previous phases. Research findings are summarized in the form of conclusions drawn from the conducted study, along with suggestions for improvements in both further development and future research.

2.2. Research Design

The research design used in this study is a Pre-Experimental Design with a one-group pretest-posttest design format. In this design, a pretest is conducted before the intervention is administered. This enables a more accurate understanding of the treatment's effects by comparing them to the baseline condition before the intervention. The research design is depicted in the following **Figure 2**.

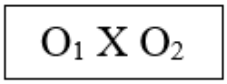

Figure 2. One-Group Pretest-Posttest Design

Explanation:
O1: Pretest score (before the intervention)
O2: Posttest score (after the intervention)
X: Treatment (intervention)

2.3. Population and Sample

The population of this study consists of 10th-grade students at SMKN 11 Bandung. Meanwhile, the sample for this study comprises two classes of students from SMK NEGERI 11 Bandung who have either completed or are currently studying the subject of basic programming with a focus on functions. The total selected sample amounts to 69 individuals.

2.4. Research Instrument

The assessment instruments used in this research include expert validation for content and media, as well as student responses to the media. The validation of the media employs the Multimedia Mania assessment, referring to the Multimedia Mania 2004 - Judges' Rubric from North Carolina State University. Meanwhile, the instrument for capturing student responses is based on the Multimedia Mania 2004 – Student Checklist from the same university.

2.5. Instrument Analysis

The data analysis techniques employed in this study consist of the following methods: (1) Analysis of Field Study Data: Involves formulating the obtained interview data results. (2) Analysis of Expert Validation Data: Based on the Multimedia Mania 2004 - Judges' Rubric from North Carolina State University. (3) Analysis of Test Instrument Data: Comprises validity testing, reliability testing, difficulty level testing, and discrimination power testing. (4) Analysis

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of Student Response Data: Utilizes the Multimedia Mania Student Checklist. (5) Analysis of Learning Outcome Data: Involves the use of the gain test.

3. RESULTS AND DISCUSSION

3.1. Research Design

During the research design phase, the researcher conducts literature reviews and field studies. In the literature review, findings reveal that students' learning outcomes tend to improve when implementing personalized learning approaches. This is because such approaches can cater to diverse student characteristics and needs, enabling students to determine how they learn best. The student-centered approach also contributes to enhanced learning outcomes as it empowers students to take an active role in the learning process.

In the field study, the researcher conducted interviews with the Basic Programming subject teachers at SMKN 11 Bandung. The interviews revealed several issues. Students were facing difficulties with the topic of functions in the basic programming subject. The teaching methods currently in use were not effectively accommodating the diverse learning characteristics and styles of the students. While these methods were effective for one group of students, they were not equally effective for others, resulting in some students not being engaged. Additionally, the instructional media being used primarily consisted of PowerPoint presentations and videos. Furthermore, the teachers expressed limitations in their ability to cater to the various learning styles of students due to constraints in terms of time and available resources.

3.2. Pre-Research

3.2.1. Analysis

In the analysis phase, multimedia analysis and analysis of the personalized learning approach along with its stages are conducted. The multimedia analysis yields insights into the required hardware and software components for creating the instructional media. Simultaneously, the analysis of the personalized learning approach involves defining the steps of personalized learning that will be implemented within the instructional media.

3.2.2. Design

In the design phase, designs are developed for content material, test instruments, flowcharts, and storyboards. The selection of content material is based on the topic of functions and procedures in basic programming, aligned with the Core Competencies and Basic Competencies (KI&KD) specified by the Directorate of Vocational High School Development for the subject of Basic Programming. The content material is designed in various formats to suit the students' characteristics based on Kolb's learning styles. For students with an Accommodator learning style, the content is designed with assignments and practical exercises dominantly using a "learning by doing" approach. Students with a Diverger learning style are provided with predominantly visual elements and flowcharts. For those with an Assimilator learning style, the material is presented in the form of animated videos. Converger learners are provided with content that is predominantly text-based. Subsequently, the creation of content material, test instruments, flowcharts, and storyboards are carried out, all of which have been tailored to the identified needs and preferences.

3.2.3. Development

In this phase, the development of web-based instructional media is carried out based on the designs created earlier. The process of creating this web-based instructional media uses

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software tools like Visual Studio Code, JavaScript, Python, and React. Below is a preview of the user interface in the developed web-based instructional media:

(i) First Page. The student's homepage is the initial display that appears when the web is accessed by the student. This page presents several menu options that users can choose from, including login or signup, starting the learning process, viewing a brief explanation of personalized learning, and accessing information about the creation of the media (see **Figure 3**).

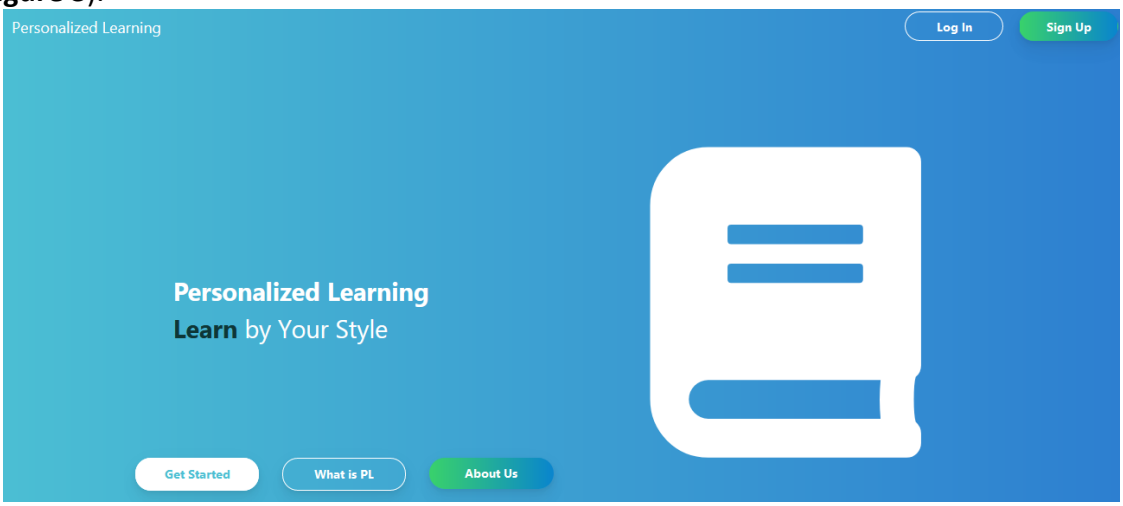

Figure 3. Home page of instructional media.

(ii) Kolb Learning Style Questionnaire Page (see **Figure 4**). Before starting the learning process, users will complete the Kolb learning style questionnaire to determine their learning style tendencies. On this page, there are several questions that users can answer. Once the questionnaire is completed, users can view the results of their learning style tendencies.

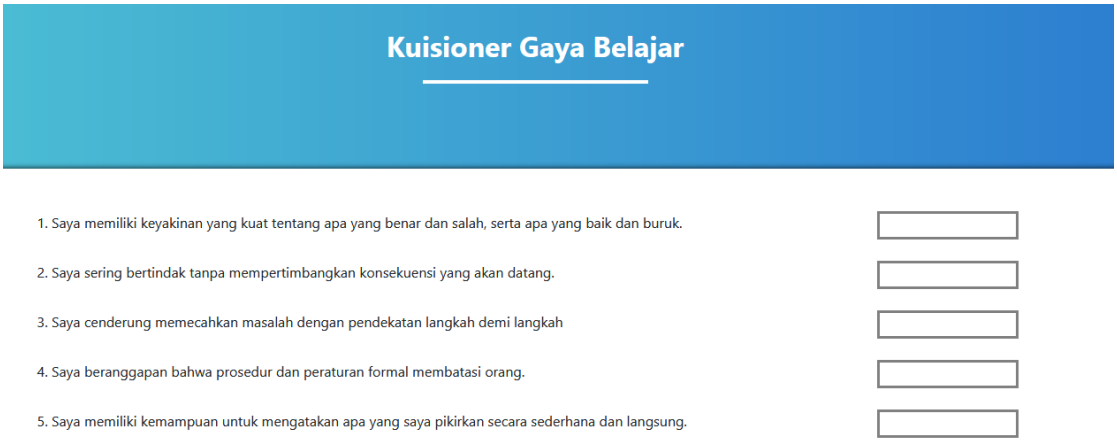

Figure 4. Kolb learning style questionnaire page.

(iii) Learning Style Results Page (see **Figure 5**). On this page, users can view a brief description of the learning style that corresponds to their Kolb learning style questionnaire results that they filled out earlier.

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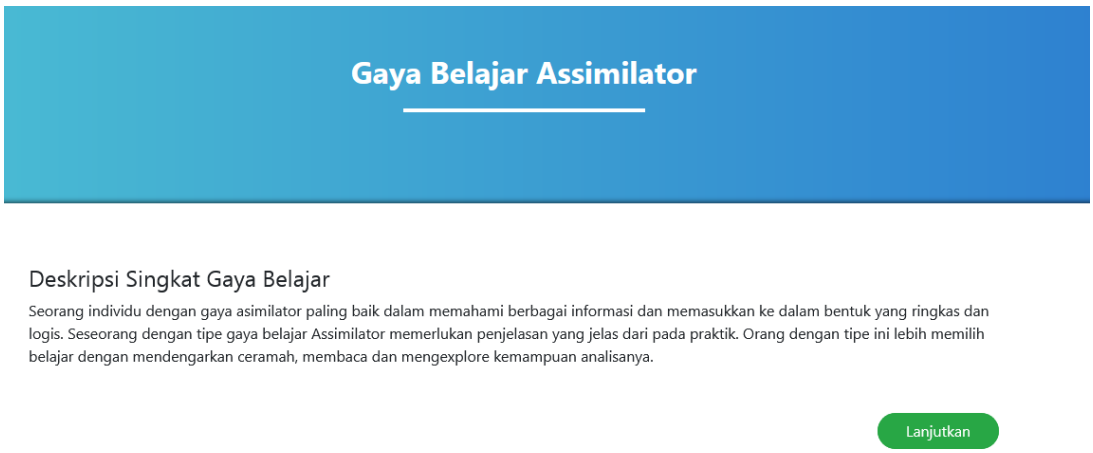

Figure 5. Learning style results page.

(iv) Material Selection Based on Learning Style Page. The student can see which learning style are more appropriate for them based on the test earlier (see **Figure 6**).

Figure 6. Material selection page.

(v) Subtopic List Page (see **Figure 7**). This page contains information about the core competencies and competency achievement indicators. Additionally, there are several menu options based on subtopics that users can access.

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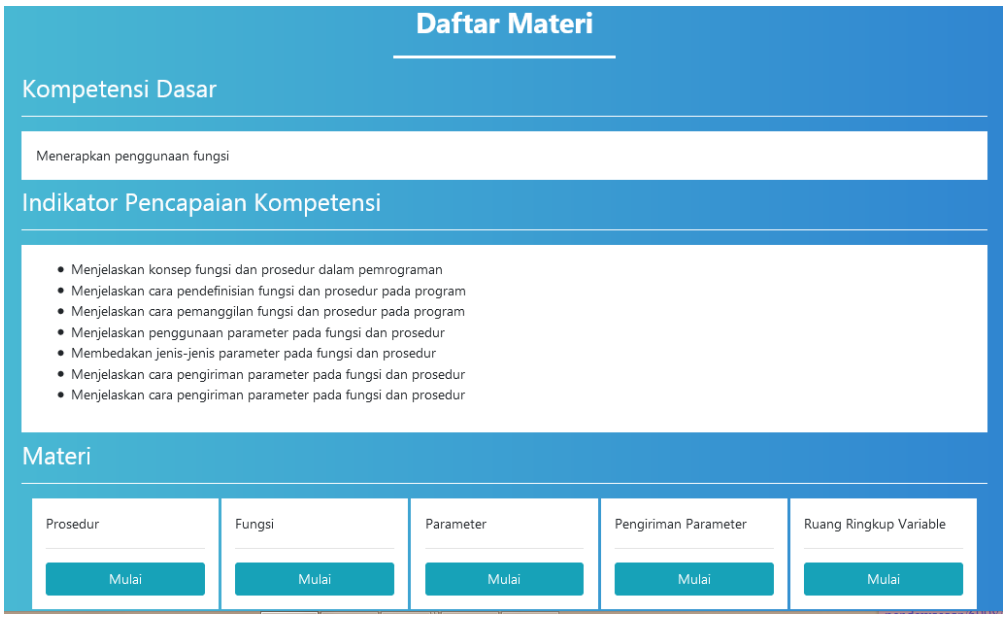

Figure 7. Subtopic list page.

(vi) Material Presentation Page (see **Figure 8**). This page contains explanations of the material, with each topic presented differently based on the characteristics of each individual's Kolb learning style.

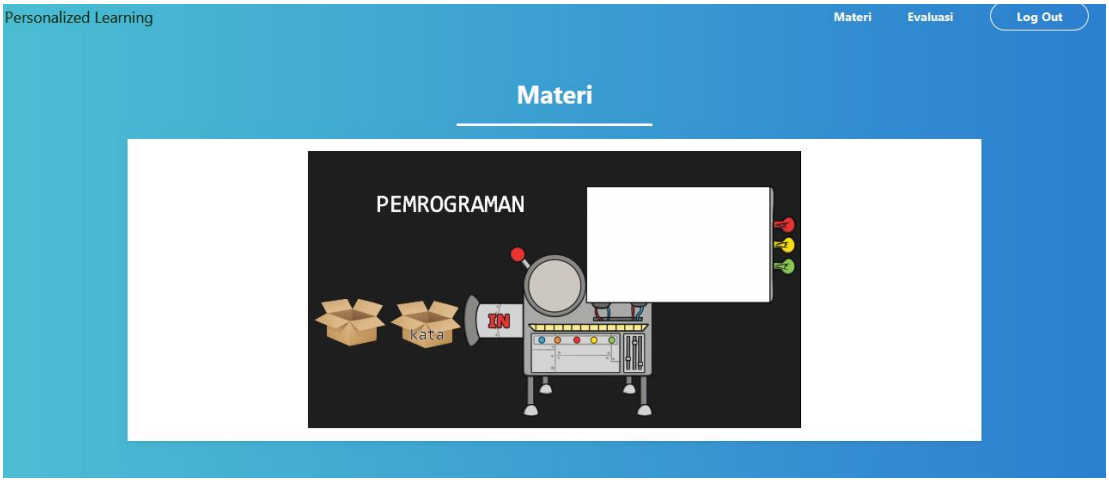

Figure 8. Material presentation page.

(vii) Evaluation List Page (see **Figure 9**). This page provides a list of evaluations based on subtopics that users can access, along with information about the duration of each assessment.

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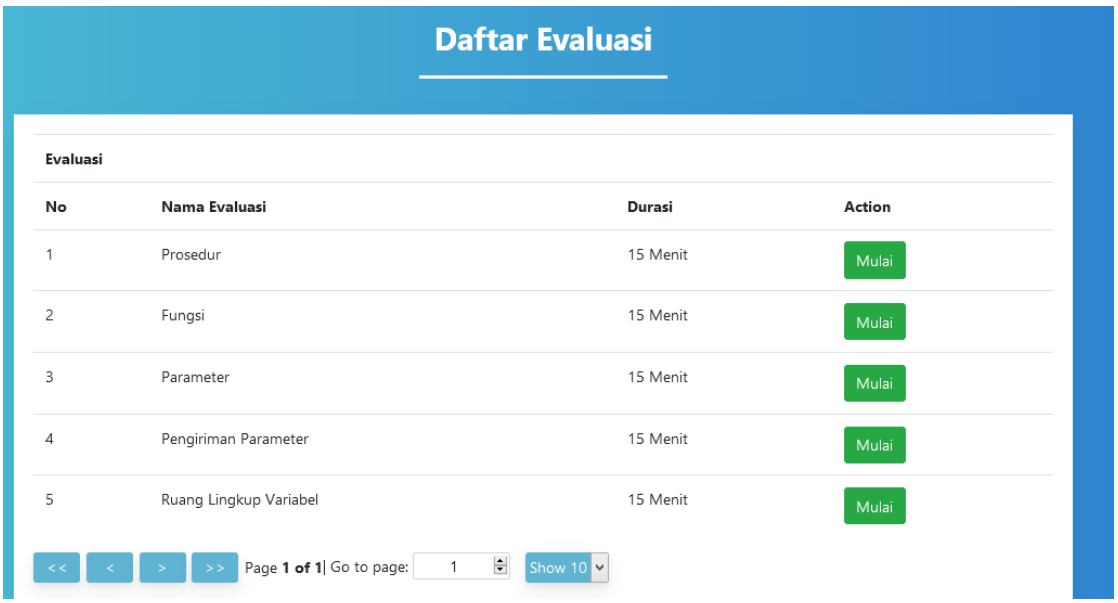

Figure 9. Evaluation list page.

3.2.4. Implementation

The web-based instructional media developed implements the personalized learning approach. The implementation of the personalized learning approach in this instructional media is explained in detail as follows: At the initial stage before students engage in learning, they are requested to complete the Kolb learning style questionnaire to determine their learning style tendencies. Following this, students receive information about their learning style tendencies. Within the instructional media, diverse content is presented to align with each student's learning style based on the Kolb learning style model. Students can then engage in learning according to their preferred learning style, maintaining a learning path that corresponds to the concept of personalized learning. Moreover, after completing their learning sessions, students are provided with quizzes or exercises to test their understanding.

3.2.5. Assessment

3.2.5.1. Testing Test Instrument

The process of testing the test instruments consists of 75 multiple-choice questions for both the posttest and pretest. This evaluation by students includes testing for validity, reliability, difficulty level, and discrimination index.

Based on the results of testing the test instruments, 44 questions were used, while 31 questions were not used. Two decisions or considerations were made in the question selection process. Firstly, questions were used if they met the validity criteria. Each question that was deemed valid had a validation classification of at least "sufficient" and a discrimination index status of at least "sufficient." Secondly, questions were not used if they didn't meet the validity criteria and fell below the "sufficient" category, with a poor discrimination index status.

3.2.5.2. Expert Validation Test

The expert validation test is conducted to assess the appropriateness of the developed instructional media. The validation of the instructional media is carried out by two experts, including a computer science education lecturer and a vocational schoolteacher. The

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validation from the media expert resulted in a percentage of 84% with the category of "Very Good".

3.3. Research Implementation

The research implementation phase takes place after the media and test instruments have been deemed suitable by experts. The process of research implementation is outlined as follows:

3.3.1. Pretest

Before initiating the learning process using web-based instructional media with the personalized learning approach, a pretest is conducted. The aim is to determine the initial proficiency of the learners in the topic of functions. The pretest consists of twenty-two questions and is collected through a Google Form. The format of the questions is multiple-choice with five options for each question.

3.3.2. Utilization of Web-Based Instructional Media with Personalized Learning Approach

First, the learners are directed to access the provided web-based learning link. The learning process takes place at their respective homes through a WhatsApp group application. Once all learners access the instructional media, the researcher provides an explanation on how to use the media and guides the learners to engage in learning activities using the media.

3.3.3. Posttest

After the learners have completed the learning process using the web-based instructional media with the personalized learning approach, the next step involves the students taking the posttest. The posttest consists of 22 multiple-choice questions, with each question having five answer choices.

3.3.4. Media Assessment Questionnaire and Interviews

After the posttest has been completed, students are asked to provide their feedback and assessment of the multimedia by filling out an interactive multimedia assessment form that has been provided. This multimedia assessment refers to the Multimedia Mania-Student Checklist 2004. Subsequently, interviews will be conducted with several students who are available for interviewing.

3.4. Data Analysis

3.4.1. Results of Student Feedback Questionnaire

Student assessment questionnaires are conducted after students have completed their learning. Participants provide their evaluations based on instruments that align with the Multimedia Mania 2004 – Student Checklist. The results of student responses to the media are depicted in the following **Table 1**.

Based on the table, it can be observed that students' assessments of the media are as follows: 91.3% for the mechanism aspect, 92.75% for Multimedia Elements, 94.2% for information structure, 92.75% for documentation, and 95.6% for content quality. Overall, the media received an average score with a percentage of 94.43%.

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Table 1. Results of student feedback questionnaire.

No	Assessment Aspect	Ideal Score	Acquisition Score	Percentage (%)
1	Mechanism	276	252	91.30
2	Multimedia Element	138	128	92.75
3	Information Structure	276	260	94.20
4	Documentation	138	128	92.75
5	Content Quality	897	861	95.60
Total				**94.43%**

3.4.2. Results of Pretest, Posttest, and Student Feedback Questionnaire Calculations

The collection of pretest, posttest, and student responses was conducted using Google Forms. Gain calculation was derived from the pretest to posttest scores. **Tabel 2** presenting the results of pretest, posttest, and student responses to the instructional media.

Based on **Table 2**, showing the results of pretest-posttest gains for Group A (the group given the freedom to access learning styles), the highest gain value was obtained by the Middle class, which is 0.49, categorized as a moderate gain increase. For the Upper class, the gain increase is also categorized as moderate at 0.40, and for the Lower class, the gain increase is 0.45, which is also categorized as moderate. The average n-gain indicates a cognitive ability increase with an average value of 0.47, categorized as "moderate".

Table 2. Results of the gain from pretest to posttest for Group A.

Group	Description	Pretest	Posttest	Gain	Media Assessment
Upper	Mean	67.27	85.45	0.40	23.60
	Standard Deviation	26.19	13.41	0.31	1.14
	Maximum Value	100.00	100.00	0.83	25.00
	Minimum Value	36.36	63.64	0.00	22.00
Moderate	Mean	62.73	81.59	0.49	24.20
	Standard Deviation	16.26	11.84	0.25	1.28
	Maximum Value	86.36	100.00	1.00	25.00
	Minimum Value	27.27	59.09	0.22	21.00
Lower	Mean	50.41	72.31	0.45	22.91
	Standard Deviation	23.40	18.12	0.21	2.59
	Maximum Value	81.82	95.45	0.75	25.00
	Minimum Value	18.18	31.82	0.17	18.00

In Table 3, Group B also experienced a moderate gain increase. The upper group average gain is valued at 0.55, the moderate group average gain is valued at 0.54 and in the lower group, the average gain is 0.49. In Group B (which was given treatment and the students are learning according to their learning styles), the gain increase is more favorable compared to Group A (students given the freedom to access learning styles).

Table 3. Results of the gain from pretest to posttest for Group B.

Group	Description	Pretest	Posttest	Gain	Media Assessment
Upper	Mean	66.23	87.01	0.55	24.43
	Standard Deviation	14.94	16.20	0.42	1.10
	Maximum Value	86.36	100.00	1.00	25.00
	Minimum Value	50.00	59.09	0.00	23.00
Moderate	Mean	50.85	76.70	0.54	23.56
	Standard Deviation	18.72	15.74	0.28	1.82
	Maximum Value	86.36	100.00	1.00	25.00

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	Minimum Value	27.27	31.82	0.00	20.00
Lower	Mean	32.73	65.91	0.49	23.50
	Standard Deviation	12.27	8.09	0.07	1.96
	Maximum Value	54.55	72.73	0.57	25.00
	Minimum Value	13.64	50.00	0.40	19.00

After obtaining the gain values, the researcher attempted to establish the correlation between the gain values and student assessments of the media. This relationship is presented in **Table 4**.

Table 4. Correlation between Student Assessment and Gain.

N	α	r_s	Critical Region
69	5%	0.457	0.336

Based on **Table 4**, it can be observed that the value of rs > critical region, indicating that there is a correlation between student assessments of the media and the gain values generated.

Also based on the interview results, it is found that students who consistently access materials according to their learning styles tend to focus more on the learning content, resulting in improved understanding.

4. CONCLUSION

The web-based instructional media developed with the personalized learning approach was created using the SHM (System Development Life Cycle) method, which includes the stages of analysis, design, development, implementation, and assessment. There was an observed improvement in students' cognitive abilities, evidenced by an average increase from 52 in the pretest to 73 in the posttest, resulting in a gain value of 0.46 categorized as 'moderate' for Group A (the group given the freedom to access learning styles). Similarly, Group B (the group learning according to their learning styles) exhibited an average pretest score of 48, posttest score of 75, and a gain value of 0.53 categorized as 'moderate'. The web-based instructional media with personalized learning approach received positive responses from students in the upper, middle, and lower classes.

Recommendations for the web-based instructional media include making it more responsive and compatible with mobile devices to enhance user accessibility. Additionally, the packaging of content in the form of videos should be made more interactive by adding animations and improving audio quality, ensuring that students can listen to and comprehend the material more clearly.

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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