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Development of Reciprocal Teaching-Based Interactive Multimedia to Enhance Students' Learning Outcomes of Database Fundamentals

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ABSTRACT

Database subjects are one of the basic compulsory subjects for the Computer Engineering and Informatics program. For Software Engineering students, topics such as Data Definition Language (DDL) and Data Manipulation Language (DML) are crucial for understanding advanced lessons. However, learning outcomes have been low due to factors such as suboptimal media, methods, models, and teaching processes. This research aims to design reciprocal teaching-based interactive multimedia to enhance student learning outcomes in DDL and DML materials. The research method used is adapted from the Comprehensive Life Cycle model, with a sample of students from class X-RPL-1 at Bina Wisata Lembang Vocational High School.The results of this study are as follows: 1) An average percentage of 80% was obtained from media experts and 80% from subject matter experts, both categorized as “Very Good”. 2) The use of multimedia improved student learning outcomes, demonstrated by an average score increase from 34 to 73. Furthermore, based on the pretest and posttest results, an average normalized gain (n-gain) of 0.59 was obtained with a criteria of 'Moderate' effectiveness. 3) Students responses to the created multimedia resulted in an average percentage score of 86.41%, categorized as “Very Good”.

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1. INTRODUCTION

Database is a subject within the Software Engineering package in the Computer Engineering and Informatics program. Based on the curriculum structure, the database subject is taught in the first and second semesters of class XI, as well as in the first semester of class XII, with each class having 4 teaching hours. Therefore, the database subject should employ an engaging teaching method to prevent students from feeling bored during these 4 hours of class.

Teaching methods are a crucial component of the learning process. In education, there are various teaching models that provide students with opportunities for independent, creative, and active learning. One of these models is the reciprocal teaching model. Reciprocal teaching is a learning model where students engage in teaching the material to their peers (Puspita *et al*., 2017; Machbubah, 2019). In this instructional approach, students take on the role of the teacher, delivering the content to their peers. Meanwhile, the teacher assumes a facilitator role, guiding and mentoring the students. Therefore, it can be concluded that reciprocal teaching is a learning model that places a strong emphasis on student engagement in learning. It involves four strategies for independent comprehension: summarizing, generating questions and solving them, clarifying, and predicting what questions might arise next from the given problem.

According to Miswardi (2014), instructional media plays a significant role in enhancing student engagement in the learning process. Media serves as a carrier of information from the source (teacher) to the recipient (students), and the appropriate use of instructional media can stimulate students' interest in learning. Without media, the learning process would not be as effective. Considering various learning issues and realities as described above, researchers have attempted to implement the reciprocal teaching model (flipped learning). Media can also make learning more engaging and enjoyable. One of the developing instructional media is interactive multimedia.

Interactive multimedia is the utilization of computer technology to create and combine text, graphics, audio, moving images (videos and animations), along with the incorporation of links and tools that allow users to navigate, interact, create, and communicate. Interactive multimedia can be used as a supportive tool that facilitates the process of teaching and learning, ensuring that the learning objectives are effectively achieved.

Based on the results of student response questionnaires, students express a need for interactive web-based multimedia to facilitate their understanding of the subject matter. Thus, the author is motivated to develop and create interactive web-based multimedia with the aim of making it easier for students to comprehend a particular subject. The chosen multimedia model for development is the tutorial multimedia model. Fostering students' independence in learning at school requires support from learning resources that can facilitate self-directed learning. According to Sufiyana (2016), computer-based tutorial learning media can serve as an alternative for students to learn within and beyond the school environment, and computers are one way to enhance educational quality and improve student learning outcomes.

Students should be facilitated by a medium that simplifies their learning activities. Interactive web-based multimedia can bring contemporary education together with creative and innovative technology. Thus, the author proposes a teaching approach that addresses the issues occurring within the classroom by utilizing the Reciprocal Teaching approach through interactive web-based multimedia. Through the Reciprocal Teaching approach, students can summarize, ask questions, clarify, and predict what they have learned. With the Reciprocal

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Teaching approach based on interactive multimedia, students are expected to remember the subject matter taught through the developed interactive multimedia. Subsequently, it is hoped that students can improve their learning outcomes. Therefore, the author has decided to conduct research titled "Design and Development of Reciprocal Teaching-Based Interactive Multimedia to Enhance Students' Learning Outcomes in the Subject of Database Fundamentals".

2. METHODS

The development of multimedia by Munir consists of five stages: analysis, design, development, implementation, and evaluation. The multimedia development model described by Munir can be seen in **Figure 1** below.

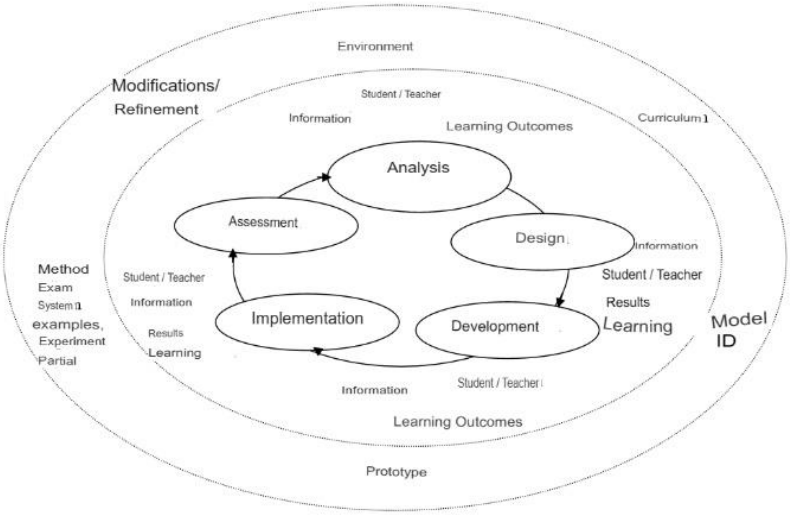

Figure 1. The comprehensive life cycle model.

2.1. The Stages of The Research Process

In the research phase, referring to the CLC method, the stages of research for developing multimedia are explained. These stages can be observed in **Figure 2**. The description of **Figure 2** is as follows:

(i) Analysis. In this stage, there are literature reviews and field studies. In the field study, data is collected about the learning problems related to the database subject. This involves gathering data not only from the field but also from other research regarding the difficulties in learning database subjects. Then, in the literature review, this activity compiles data, information, and theories that can assist the research, such as learning methods and approaches found in journals and other studies. Subsequently, an analysis is conducted based on the results of both the field study and literature review.

(ii) Design. In the design phase, using the data collected in the analysis phase, a design for the instructional media to be developed is created. This design comprises:
   a. Content compilation aims to be incorporated into the instructional media, while the creation of question instruments is used for pretest and posttest during the implementation phase.
   b. Depicting a flowchart that illustrates the sequence and relationships between processes along with their instructions within the interactive learning multimedia based on the reciprocal teaching model. Subsequently, the media is created, and then the gaps and shortcomings in the media are identified to be improved and made more

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optimal. In this testing phase, the developed media, along with its questions and content, will be validated by experts, like the stages in the SHM media development process.

(iii) Development. Firstly, students will be asked to complete a pretest. Subsequently, students will engage with the developed instructional media for learning purposes. Finally, students will be asked to complete a posttest. The improvement in students' abilities can be measured through their performance in the posttest. Prior to this, the creation of both the pretest and posttest questions will undergo validation involving educational experts.

(iv) Implementation. In the implementation phase, data processing is conducted based on the results obtained from the previous stages, which include pretest-posttest scores and feedback on the media. During this phase, the strengths and weaknesses of the media can also be identified.

(v) Assessment. In this phase, data from the implementation of interactive multimedia learning is processed, and a review of the feasibility of the interactive multimedia is conducted. Finally, conclusions are drawn from all the stages.

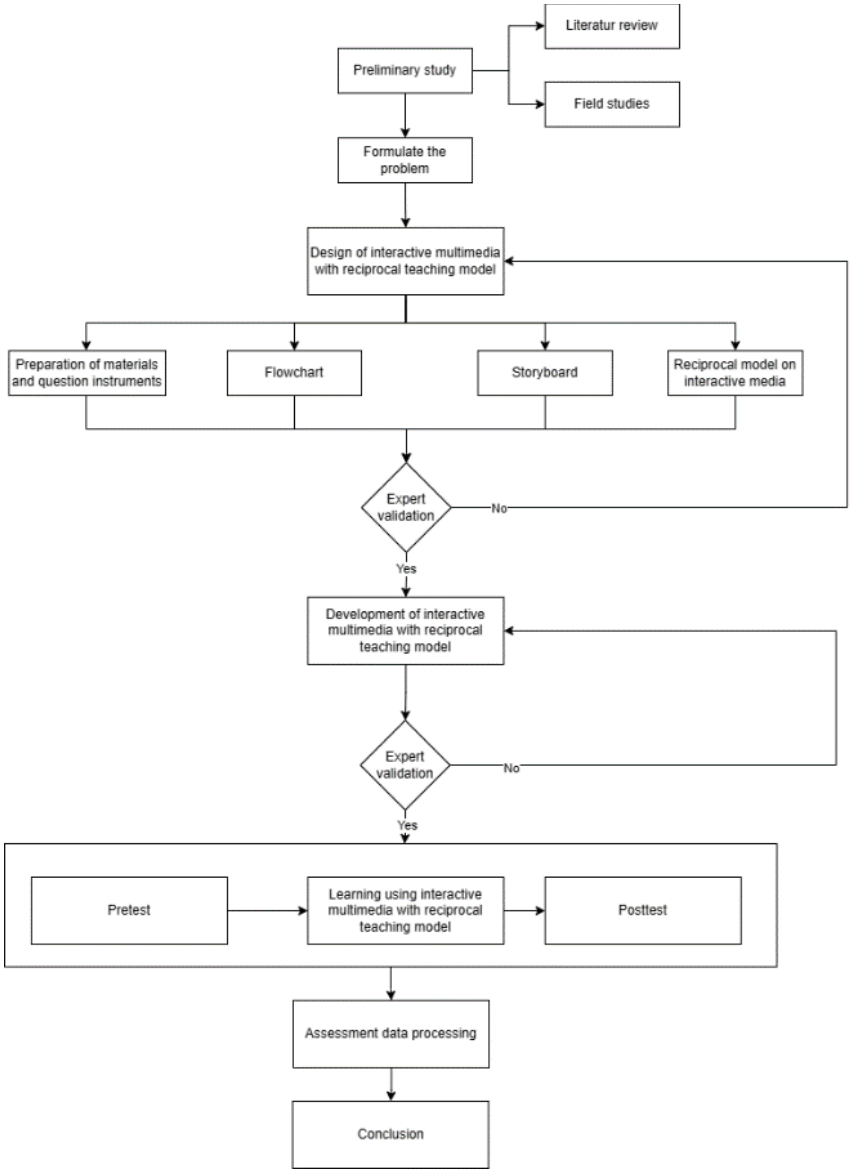

Figure 2. Stage of the research.

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2.2. Sample and Population

The population in this study consists of students at SMK Bina Wisata Lembang. The sampling technique used in this research is non-probability purposive sampling, which is a sampling technique based on specific considerations, with the consideration that the selected sample is relevant to the research problem. Therefore, the sample in this study consists of 40 students from the Software Engineering (RPL) department, in the X grade, who are currently studying the Database subject.

2.3. Research Instrument

The assessment instruments used in this research include measurements of expert validation, media expert validation, student scores, and comprehension. For expert and content validation, a questionnaire based on the Learning Object Review Instrument (LORI) is used. The student response perception instrument is structured using a Likert scale. Below is the questionnaire created in **Table 1**.

Table 1. Student response questionnaire to the media.

No	Indicator	Item No
Software Engineering Aspects		
1	Usable	1-3
2	Reliable	4-6
3	Compatible	7
Aspects of Learning Design		
4	Material	8-10
5	Interactivity	11-12
6	Motivation	13-14
Aspects of Visual Communication		
7	Communicative	15-16
8	Visual	17-18
9	Layout	19-20

2.4. Instrument Analysis

The data analysis techniques used in this research consist of: (1) Analysis of field study instrument data, (2) Analysis of question instrument, including validity test, reliability test, item difficulty index, and item discrimination (3) Analysis of expert assessment data using the Learning Object Review Instrument (LORI) (4) Analysis of student response instrument data using a Likert scale.

3. RESULTS AND DISCUSSION

3.1. Problem Formulation

The researcher conducted initial observations, including field study and literature review. The field study was conducted through interviews with teachers at SMK Bina Wisata Lembang who teach the Database subject and students who are currently studying the Database subject. In addition to interviewing teachers, the researcher also distributed questionnaires about the importance of multimedia in the Database subject. Below is the result of the student questionnaire depicted in **Figure 3**.

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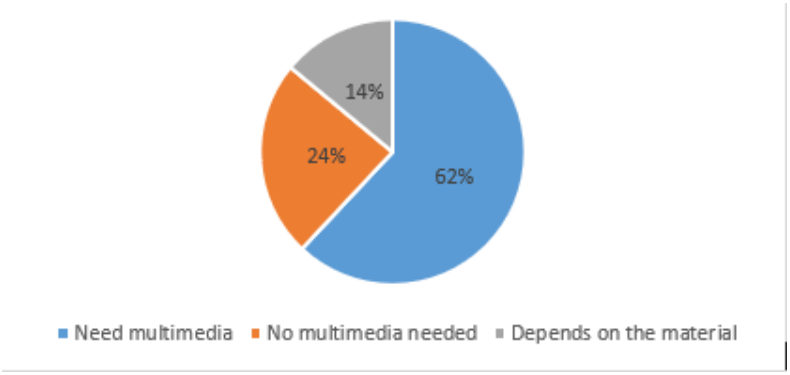

Figure 3. Diagram of student analysis regarding multimedia in databases.

From the analysis in the above **Figure 3**, there is a need for innovation in database learning. The introduction of interactive multimedia by the researcher is expected to prevent students from feeling bored and provide a novel learning experience.

3.2. Hypothesis

Based on these findings, an instructional tool was developed in the form of learning media to help learners understand the database subject. The chosen content for the material focuses on Data Definition Language (DDL) and Data Manipulation Language (DML), aligning with the Learning Objectives and Learning Outcomes defined by the Directorate of Vocational Schools for the Database subject. The content of this media encompasses DDL and DML materials, followed by mini games related to the provided content. After that, students are required to summarize, generate questions, followed by the teacher's clarification, and finally, students predict the next steps. These activities adhere to the reciprocal teaching model (Palincsar & Brown, 1984).

Subsequently, the creation of content material, question instruments, and activity diagrams were aligned with the identified needs. The instructional media was then developed using the Laravel framework with the PHP programming language. Below is a screenshot of the user interface of the developed instructional media, based on the previously designed layout.

3.2.1. First page

The initial page displays the “login” and “register” options. If a student already has an account, they can then log in using their registered email and password. If they don't have an account yet, they need to register first by providing their full name, email, and password. The first page view is presented in **Figure 4**.

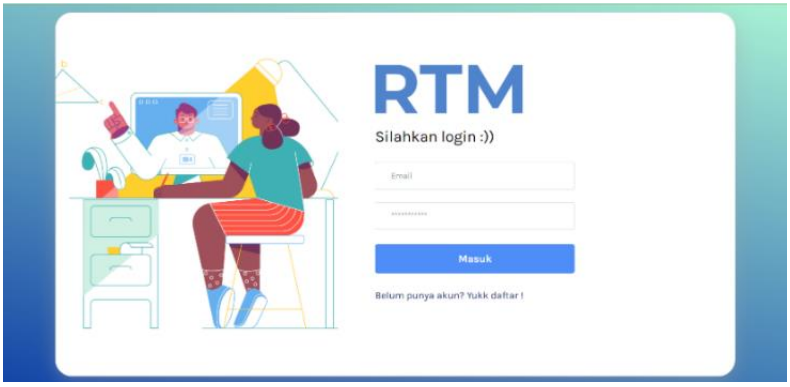

Figure 4. First page

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3.2.2. Home page

The home page will appear once the student has logged in using their previously registered account. On this home page, the teacher will provide an explanation of the interactive multimedia's functions and offer encouragement to the students. The home page view is presented in **Figure 5**.

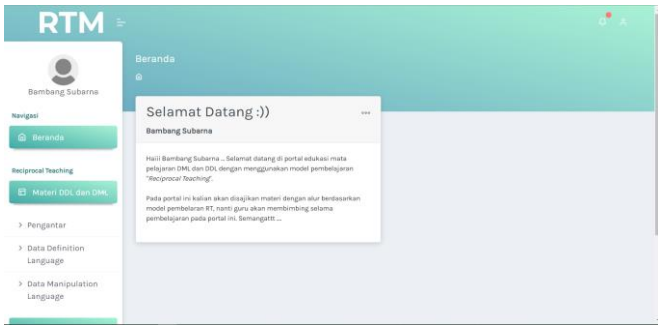

Figure 5. Home page.

3.2.3. Material page

The material page consists of three tabs: Introduction, DDL Material, and DML Material. In this introduction interface, there is an explanation of the materials that will be covered, such as data types in MySQL, DDL, and DML. The introductory page view is presented in **Figure 6**.

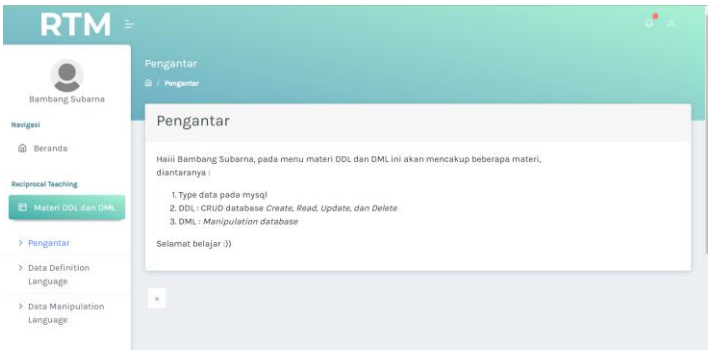

Figure 6. Introduction interface.

Then, there are tabs for Data Definition Language and Data Manipulation Language, each containing textual explanations and videos related to the respective topics. The DDL material page is presented in **Figure 7** and the DML material page is presented in **Figure 8**.

Figure 7. DDL material interface.

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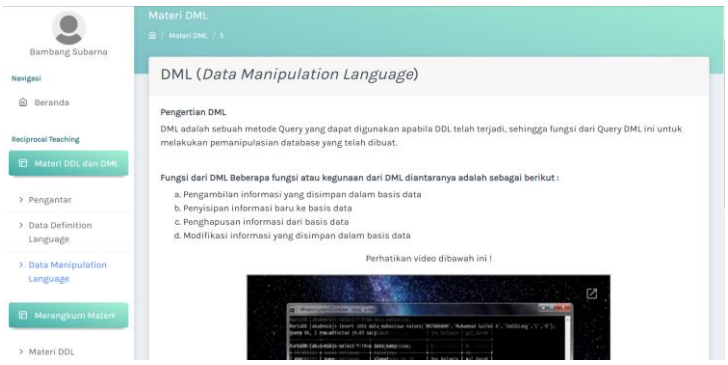

Figure 8. DML material interface.

3.2.4. Evaluation page

On the evaluation page, there is a mini game included within the tabs for DDL and DML materials. This mini game is in the form of a 'matching' activity. After reading the material, students are required to complete the mini game to recall the previously studied content. The DDL material evaluation page is presented in **Figure 9** and the DML material evaluation is presented in **Figure 10**.

Figure 9. DDL material minigames interface.

Figure 10. DML material minigames interface.

3.2.5. Notification page

The notification page serves as a notification system for teachers when students have uploaded assignments assigned by the teacher. Similarly, there is also a notification page for students, informing them whether their assignments are correct or need further improvement. The notification page for students is presented in **Figure 11** and the notification page for teachers is presented in **Figure 12**.

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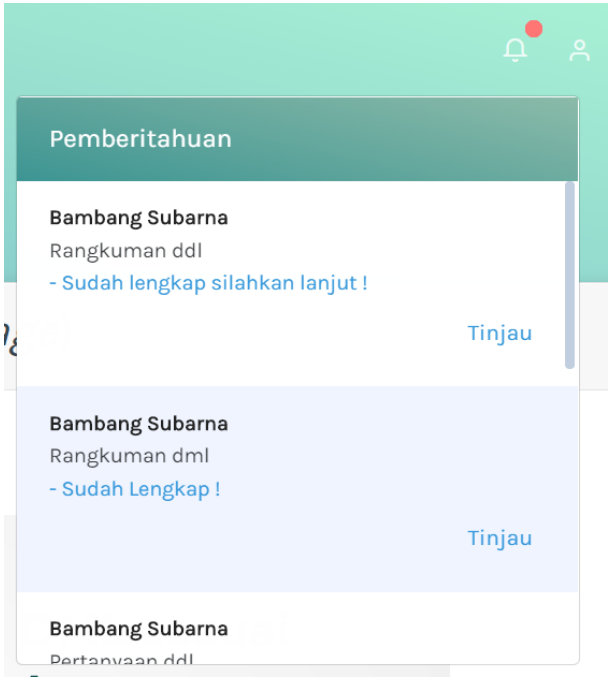

Figure 11. Notification interface at student-side.

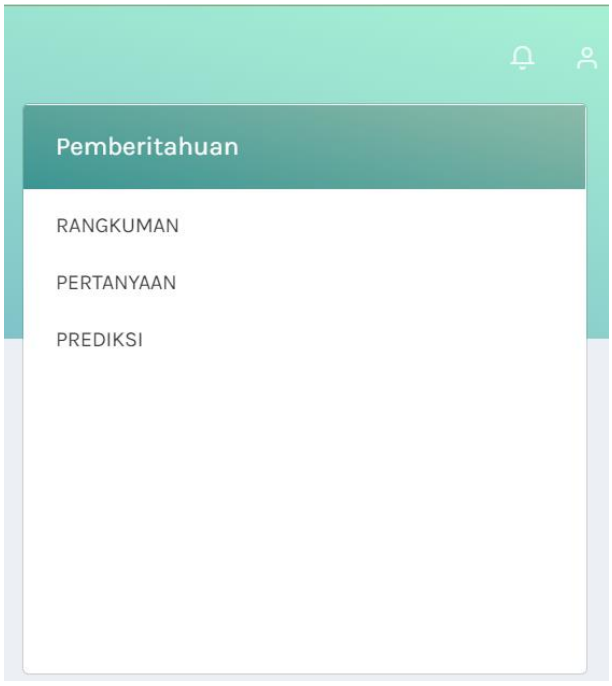

Figure 12. Notification interface at teacher-side.

3.3. Stage of Question Instrument Testing

The phase of the question instrument testing process consists of 40 questions for both posttest and pretest. The student-based instrument testing covers validity, reliability, difficulty level, and discriminative power. Based on the results of the question instrument testing, 26 questions were selected for use, while 14 questions were not used. There were two decisions made in selecting the questions. First, questions were used because they met the validity test criteria. Each question deemed valid had a validation classification at a minimum of 'sufficient' level and a discriminative power status at a minimum of 'sufficient' level. Second, questions were not used because they did not meet the validity criteria, falling

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below the 'sufficient' category, and have poor discriminative power status. Below is the result of the question instrument testing, as shown in **Figure 13**.

Question item validation classification		
Criteria	**Total**	**Percentage**
Very low	3	8%
low	11	28%
enough	19	48%
tall	7	18%
Very high	0	0%
Total	40	100%

Classification of difficulty levels of question items		
Criteria	**Total**	**Percentage**
Difficult	0	8%
Medium	11	28%
Easy	29	73%
Total	40	100%

Classification of the distinguishing power of question items		
Criteria	**Total**	**Percentage**
Negative	0	8%
Signs	0	28%
Enough	17	43%
Good	21	53%
Excellent	2	5%
Total	40	100%

Figure 13. Evaluation analysis result.

3.4. Stage of Question Instrument Testing

The validation of the instructional media was carried out by experts. The media validation was conducted by a media expert, who is a lecturer teaching visual programming. The media validation received a percentage score of 80% with the category 'very good'. This percentage score was obtained from the average value of research criteria, including presentation design, interaction ease, accessibility, reusability, and compliance standards.

The second validation was content validation of the media, which was done by a subject matter expert in the field of databases. Content validation of the media received a percentage score of 80% with the category 'very good'. This percentage score was obtained from the average value of research criteria, including content quality, learning, feedback, and adaptation, as well as motivation. Below are the results of the instructional media instrument testing by the content expert and the media expert.

3.5. Data Analysis

After collecting data from the pretest and posttest, the n-gain was calculated. Here are the results of the pretest, posttest, and student responses to the instructional media.

The average student score obtained based on the pretest and posttest was 34 for the pretest and 73 for the posttest. In other words, there was an improvement from before using

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interactive multimedia based on the reciprocal teaching approach. The average scores of both student results can be illustrated in **Figure 14**.

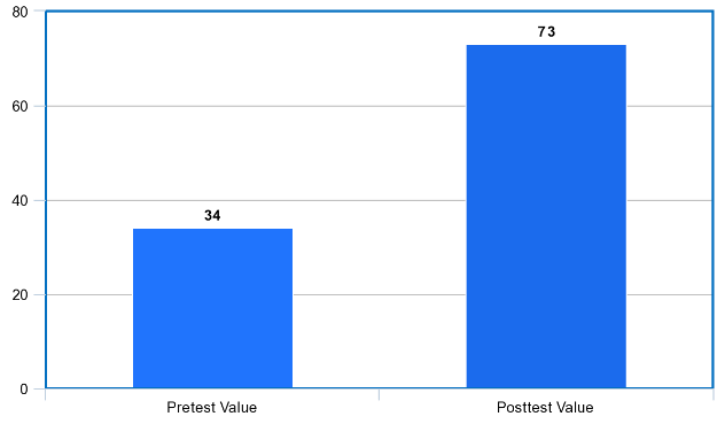

Figure 14. Bar chart of average pretest and posttest scores.

Based on the bar chart in **Figure 14**, it can be observed that there is a significant increase in the results of pretest and posttest scores. From the comparison based on the bar chart above, a difference of 39 is obtained, which means that the use of interactive multimedia based on reciprocal teaching for the subject of database fundamentals has led to an improvement in student learning outcomes.

To determine the improvement in student learning outcomes regarding the use of interactive multimedia based on the reciprocal teaching model, an n-gain analysis was conducted. The results of the n-gain analysis can be seen as **Table 2**.

Table 2. N-gain.

x̄ Pretest	x̄ Posttest	x̄ Gain	Effectiveness
34	73	0,59	Moderate

Based on the results from **Table 2**, an average n-gain of 0.59 was obtained. When interpreted according to the criteria for learning effectiveness, this falls under the "moderate" category, indicating a moderate impact but not a significant one. Student responses can be observed in **Table 3.**

Table 3. Student questionnaire responses.

Student questionnaire responses			
Assessment aspect	**Ideal score**	**Acquisition score**	**Percentage (%)**
Software Aspect	1400	1222	87.29%
Learning Aspect	1400	1208	86.29%
Visual Communication Aspect	1200	1028	85.67%
Average			86,41%

4. CONCLUSION

A reciprocal teaching-based learning media was developed using the SHM method, which includes stages of analysis, design, development, implementation, and assessment. There was an improvement in student learning outcomes, particularly in enhancing students cognitive abilities. This was evident from an increase in the average score from 34 in the pretest to 73 in the posttest, resulting in a gain score of 0.59 categorized as “moderate”. As a

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recommendation, the learning media should be more responsive and incorporate the content present in the database.

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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