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DEVELOPMENT OF RESPONSIVE AND INTERACTIVE MOBILE-BASED REALISTIC MATHEMATICS LEARNING APPLICATION WITH EXTREME PROGRAMMING SYSTEM METHOD

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ABSTRACT
This research has the main objective of producing a product of mathematics learning application design that supports the mathematics learning process to be more qualified. The application developed can help teachers to map the competencies and learning achievements of each student. In supporting the development of this application also combines realistic mathematics and quizzes that are designed to be interactive and responsive. In directing this research, the object-oriented extreme programming system development method was developed through the stages of planning, design, coding and testing. With this application, teachers are greatly helped in organizing students in a more qualified and interactive learning process. Based on the results of testing that has been done in the classroom, the response of teachers and students with this application gets a very positive response.

I. INTRODUCTION

In this era of rapidly developing Information Technology, it is required to adapt to the development of Information Technology, including applications and websites [1], [2], [3], [4]. Teacher-dominant math learning is very boring in the process of learning math at school [5], [6], [7]. Based on interviews conducted by researchers, researchers stated that out of a total of 50 students all said that the dominant mathematics learning process explained by the teacher was not easy to understand and students felt bored with monotonous explanations. The paradigm of students as objects in the learning process causes students to be inactive in the learning process. This problem is one of the main factors that cause the learning process of school mathematics to be uninteresting for the majority of students [8], [9], [10]. In reducing the impact of student boredom in learning, it is necessary to design alternative solutions that need to be offered that are close to student life.

In the study related to the intensity of students to cellphones, the majority of students have high intensity with an average of more than 7-12 hours per day [5], [11]. This is potentially a key factor in the success of how we design a technology that brings math learning closer to students, and students' habits in everyday life [12]. This combination gave birth to an idea of how to design a math learning application that can contribute to a more interactive math learning process. seeing the enormous potential of technology in an effort to improve the quality of education, and the potential dangers that can arise from misuse of technology, such as getting incorrect information negative content and addictive properties that have the potential to arise due to the frequency of

uncontrolled use of technology, specifically on smartphones [13]. In designing interactive learning, the research team tried to combine realistic mathematics as the basic material for learning development, and interactive quizzes used as more interactive math learning steps. The combination of quizzes and realistic mathematics learning stages is combined in a math learning stage so that there is a great hope for more active student interaction. Like the interactive quiz of multiplication rules, realistic mathematics material is presented in a form that is more easily understood by students such as using visualization of pictures of clothes and pants with a certain number of clothes and pants, with a question of how many pairs of clothes are worn.

The development of this interactive and responsive mathematics learning application uses the Extreme Programming method which is oriented towards realistic objects with the following stages planning, design, coding and testing [14], [15], [16]. The choice of Extreme Programming (XP) method in the development of this application was based on the need to increase flexibility, responsiveness to change, and high code quality. Planning Stage The development team worked closely with stakeholders to formulate clear User Stories and prioritize them. Design is iterative and incremental. Team discussions focus on simplifying the design and reducing unnecessary complexity. Each iteration involves design review and discussion to ensure the design meets the needs and allows development to continue smoothly. Coding principles of Test-Driven Development (TDD) are applied, where automated tests are built before or along with writing code. Unit testing is performed by developers on a regular basis to ensure every piece of code is working properly. The advantages of the extreme programming method are Flexibility and Responsiveness to Change, XP emphasizes short and frequent iterations (sprints), which allow teams to quickly adapt applications to changing user or stakeholder needs. In the context of educational applications, where curriculum or teaching methods may change over time, this flexibility is invaluable to ensure the application is always relevant and effective. Intensive User Involvement, XP encourages active user involvement in the entire development cycle. Through practices such as User Story-based planning and user acceptance testing at each iteration, XP ensures that applications not only meet technical needs, but also fulfill the expectations and needs of direct users, including educators and students. Responsive and interactive applications provide an excellent experience for students in the learning process thus changing the landscape where the learning process is more student-oriented [17], [18]. The hope is that the interactive and responsive realistic mathematics learning application can change the paradigm of mathematics learning to be more fun.

II. RESEARCH METHODS

Application system development methods are a series of structured development processes by carrying out various activities, methods and tools used in each stage [19]. In this research, the development method used is the Extreme Programing method. The Extreme Programming (XP) method is a software development method that emphasizes flexibility, quality, and rapid response to changing needs. XP belongs to the Agile methodologies category and has principles and practices designed to improve productivity and software quality [20], [21], [22], [23]. Extreme Programming Framework[24].

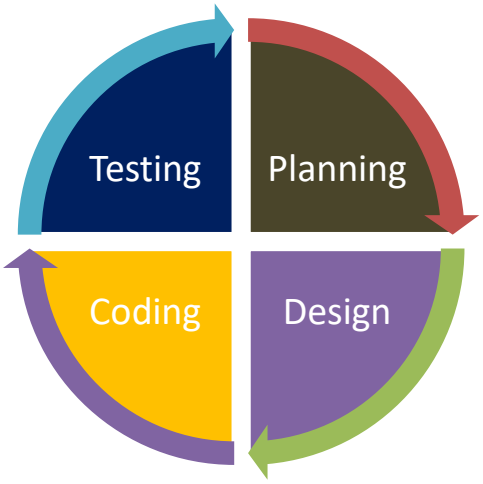

Figure 1. Extreme Programming Framework Diagram

A. Planning

At this stage, the researcher collected the needs required in the mathematics learning process. In this process,

researchers have also created a realistic math learning scenario combined with interactive quizzes. At this stage, researchers involved lecturers from the mathematics education study program in designing a responsive and interactive application. Researchers conducted it by means of direct interviews also related to the needs carried out, of course, as well as literature studies to find relevant research articles.

B. Design

In the design stage, researchers continue to work from the planning stage which has become a learning scenario. Researchers at this design stage use the Figma application to create a student user interface. There are two stages of the mode used in designing this application, namely design and prototype [14], [25]. In the design stage, researchers designed the user interface according to the results of the planning scenarios that had been consulted. The results of the user interface were then shaped to be more interactive by providing animation using prototype mode in the Figma application. Design of Realistic Learning Scenarios Identification of User Cases: the researcher identifies various realistic learning scenarios that will be handled by the application. Examples of these scenarios may include interactive exercises, simulated experiments, or interactive modules for concept exploration. User and Application Interaction Implementation, Researchers create a design organizing the interaction flow between the user and the application to ensure intuitive navigation and a seamless user experience. This involves establishing navigation paths between pages, layout of interactive elements, and responsive design for various devices. Use of Feedback and Feedback: Features such as notifications, immediate feedback on user answers or performance, and the use of animations or visual effects to clarify mathematical or scientific concepts can be integrated to enhance interaction and learning. Use of Real world Contexts: Designers focus on integrating real-world context into learning scenarios. For example, for math applications, users can be asked to solve math problems relevant to real situations such as the calculation of the number of pairs of clothes that can be worn.

C. Coding

Coding In the coding stage, it is done by interpreting figma data using the development menu that has been used. The development mode that already exists in the figma application is very helpful for researchers to code the application so that it is more real.

D. Testing

In limited testing, researchers also involved students and teachers. Researchers asked for help from teachers to teach using the application that had been made. The results of this test, carried out a comprehensive evaluation stage where aspects of student convenience, material substance aspects, and aspects of teacher convenience in teaching using this application. Testing Methods Used Usability Testing, this test is conducted to evaluate how easy the application is used by end users (for example, students, teachers). Implementation: Users are given a series of tasks or scenarios to complete within the application. Observers observe user interactions, noting navigation issues, difficulty in finding features, or confusion with the interface. Data Collection, Test data is collected using measurement instruments appropriate to the type of test being conducted. For example, in usability testing, observers record user interactions and their subjective responses. In functional testing, test result data is obtained from the execution results of test scenarios. Data Analysis, the collected data is analyzed to identify problems or non-conformance of the application with the predefined requirements. For example, navigation issues or features that don't work properly can be identified and tracked.

III. Results and Discussion

Result

Face-to-face implementation the implementation of the designed user interface is a program display used by users in learning mathematics which includes learning stages including selecting learning materials, learning materials more interactively, providing opportunities to repeat material, and independently evaluating student understanding related to the material

A. Login page

The login page is used to administer students who enter the application. This data will be used to carry out the administration process and record evaluations gradually to all students who take part in the learning process. The initial display in the application is found in Figure 1,2,3

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Figure 1.

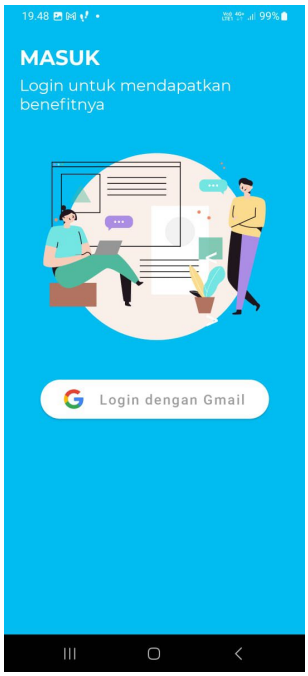

Figure 2.

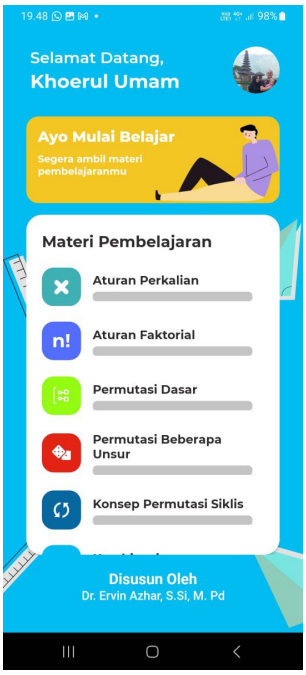

Figure 3.

B. Learning material selection page

This page contains materials studied by students. Students can choose what they want to learn. The learning materials have been combined with realistic math, and interactive quizzes. The material selection menu is shown in Figure 4,5,6.

Figure 4.

Figure 5.

Figure 6.

C. Interactive Learning Process Page.

This page contains an interactive math learning process, where students are asked to listen to a little explanation and then asked to make a selection. This selection menu is used to attract students to learn more interactively and responsively to the material explanation. The menu for the interactive learning process is shown in Figure 7,8,9.

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Figure 7.

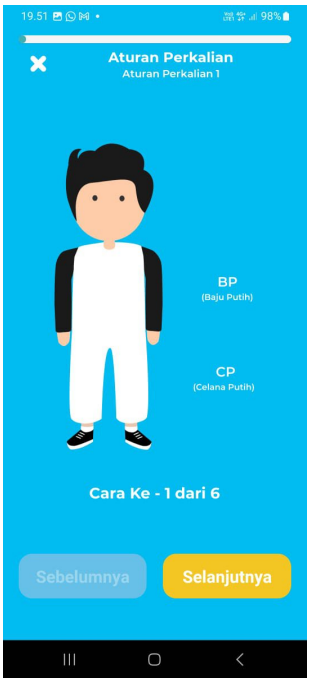

Figure 8.

Figure 9.

D. Student Initial Comprehension Test testing page.

This page provides an opportunity for students to test their initial understanding of the material presented previously. Students are given 3 times the opportunity to answer by filling in the short form on the page according to the question. The display menu for the initial test of students' abilities can be seen in Figures 10,11,12.

Figure 10.

Figure 11.

Figure 12.

E. Learning Completion Page.

This page indicates that students have learned the entire learning sequence. It also provides an opportunity for students to learn the next material. The display of the learning completion page is shown in Figure 13,14.

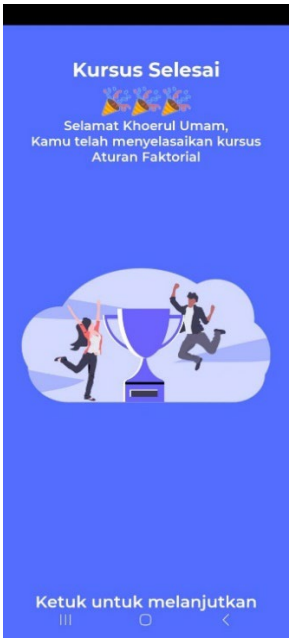

Figure 13.

Figure 14.

F. Stages of the Learning Process that have taken place.

This page marks the material that has been learned, that has not been learned, and that is still in progress. This is needed as a self-evaluation material carried out by students on the learning process of mathematics studied. The display of materials that are still being worked on and those that have not been completed can be seen in Figures 15,16,17.

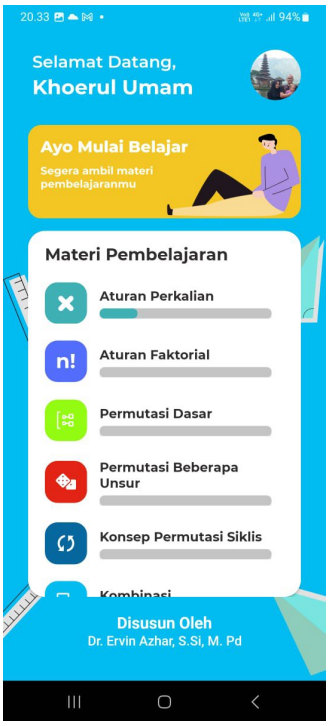

Figure 15.

Figure 16.

Figure 17.

G. *Testing.*

TABLE I.
RESULTS OF THE TEST

No	Fiture	Otherwise	PreConditions	Results	Status
1	User Login	User clicks log in and selects an account to enter the app.	User has never logged in before	User can log in and be registered as a new user	success
2	User Login	User clicks log in and selects an account to enter the app.	User has logged in before	User can log in and be registered as an existing user	success
3	Update Profil	User clicks profile and updates account info	User is logged in	Users can make changes to account information	success
4	Learning	The user selects learning material	User is logged in and has never taken a quiz before	Users can view the corresponding mate-ri from the beginning and answer the quiz exposed.	success
5	Quiz Learning	User selects the material that has been completed.	User is logged in and has completed the quiz before	Users can select sub-materials to relearn the material	success

H. *Problems Identified and Corrective Actions Usability Testing:*

Issue: During the usability testing session, it was found that some students had difficulty navigating the application interface to find the math exercise menu. Corrective Action: The development team redesigned the interface layout by adding clearer navigation buttons and making the exercise menu more accessible from the app homepage. Impact of Improvements: After the improvements were made, subsequent testing showed significant improvements in ease of use, with students reporting that they found it easier to find and use the necessary features

I. *Feedback from Students. Convenience of Use:*

Students stated that the app interface was easy to understand and navigation was intuitive, allowing them to quickly find the content they were looking for. Some students appreciated the interactive features such as math exercises that allowed them to learn in a more interesting and fun way. Effectiveness in Learning: Students report that the app helps them in understanding difficult concepts by providing clear explanations and relevant exercises. The use of realistic learning scenarios in the app helps students to see the app from a perspective relevant to their daily lives. Based on interviews with a total of 50 students, students revealed that the app has increased their interest in learning math due to the use of engaging content and an interactive approach. Teachers can provide feedback on students' improved understanding of difficult math concepts after using the app, such as their ability to solve more complex math problems.
was carried out with a descriptive percentage technique, using the following formula[26]

$$P\frac{\sum x}{\sum x_i}x100\%$$

Description:
P= Percentage of feasibility value
$\sum x$= Average student score before using the application
$\sum x_i$= Average student score after using the application
Improvement in Initial and Final Test Scores,
Initial Test (Before Application Use): The average student score was 80.
Final Test (After Application Use): Average student score increased to 90
Analisis:
Increase in average test score:$\frac{80}{90}x100\% = 88.88\%$
This shows that the app makes a significant contribution in improving students' mathematical understanding. Number of Interactions with Learning Materials Math Exercises: On average students complete 3 math exercises per week. Interactive Simulations: On average, students participate in 1 interactive simulation every 2 weeks.
Analysis: This data shows the level of student engagement with the learning materials in the app, indicating how often students are actively engaged in learning math through the app.

Frequency of App Use Daily Frequency: The average student uses the app 4 days a week. Weekly Frequency: On average, students access the app 8 times a week. Duration of Use: On average students use the app for 30 minutes each time they access it. Analysis: This data reflects how often students use the app and how long they engage in learning math through the app each session.
Comparison with Related Research Previous research, such as that conducted by[26] showed that the use of math education apps significantly improved students' math test scores. They found that students who were actively engaged with the app had an 82% percentage increase in scores from the initial test to the end of using the app. In this study, which implemented a math education app with an interactive and realistic approach, the results found that students scored 88.88% from the initial test before using the app to the final test after using the app for a certain period. This suggests that a more in-depth interactive approach and a focus on realistic learning scenarios may have a more significant impact on students' mathematical understanding.
Research Contribution This research makes an important contribution in broadening the understanding of how math education apps can be designed and implemented to improve student learning outcomes. In contrast to previous studies that may have focused more on the use of apps in general, this research highlights the importance of using realistic and interactive learning scenarios in improving the understanding of mathematical concepts.
With these findings in mind, educational app developers can focus more of their efforts on developing relevant content and engaging learning approaches for students. This can make a valuable contribution in improving the overall effectiveness of math education apps.

Discussion

A. Use Case Diagram

This use case diagram shows how users interact with the system in the context of learning chance and combinatorics. It also shows the relationship between the main use case and more specific sub-use cases, as well as how users can interact with basic features such as login, logout, and editing profile.

Figure 18. Use Case Diagram

B. Activity diagram login

This activity diagram illustrates the flow of the login process using a Gmail account, including the interaction between the user and the system. The diagram shows the steps from the moment the user clicks login to successfully logging in or being redirected for a new account registration if their account is not available in the system. A decision about the user's availability is made by the system, which then determines the next step, which is to direct the user to the main menu or account registration page.

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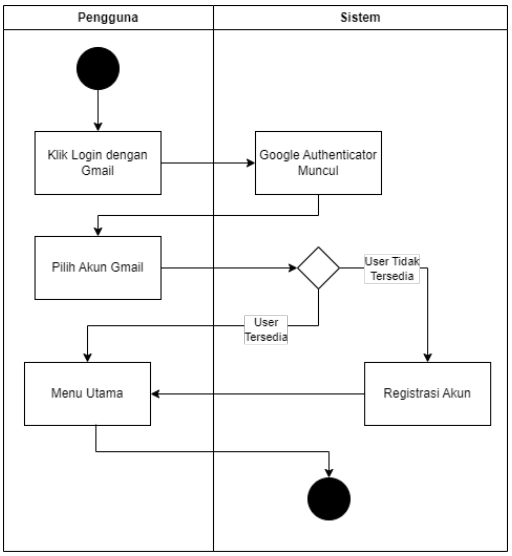

Figure 19. Activity diagram login

C.User log in

This sequence diagram illustrates the flow of user interaction with the system in the profile update process. The diagram shows the steps from when the user opens the profile form page, makes changes, until the system validates and saves the changes into the database. After a successful update, the user gets a confirmation and closes the profile form page. This diagram provides a clear picture of how each component of the system interacts during the profile update process.

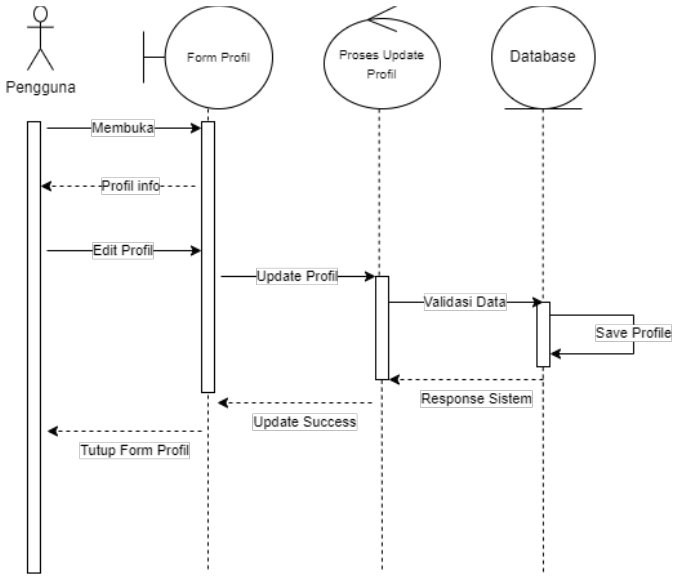

Figure 20. User log in

D. Update Profil

This diagram illustrates the two-way interaction between the user and the system in the process of editing and updating a profile. It shows how user actions trigger system responses, and how the system provides feedback to the user through the updated view.

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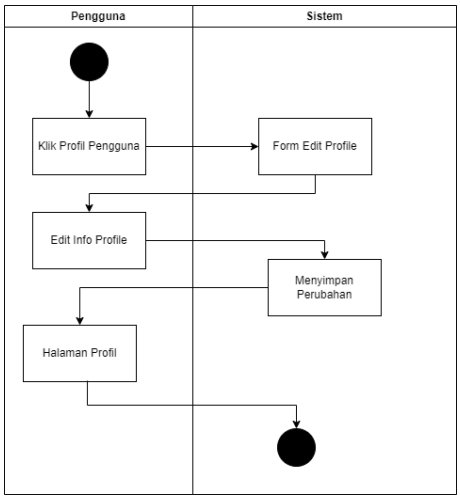

Figure 21. Update Profil

E. Selecting Learning

Activity flow diagram that describes the interaction between users and the system in the learning and quiz process This diagram shows a systematic workflow in the learning and evaluation process through quiz, with clear interactions between users and the system.

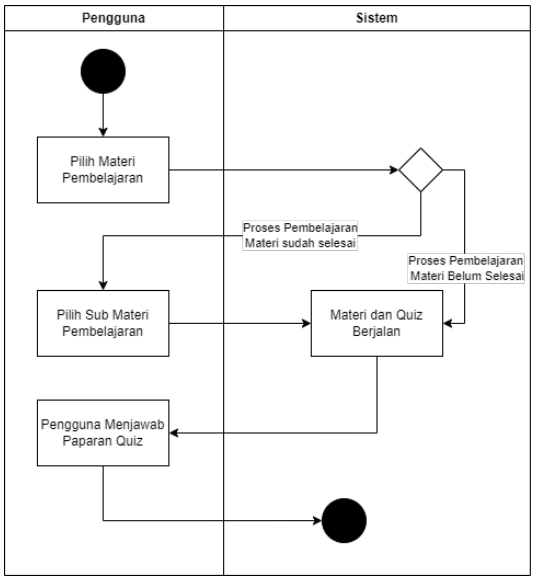

Figure 22. Diagram of Selecting Learning

F. Learning

Sequence diagram that describes the user authentication process using Google Form. This diagram shows the flow of the authentication process involving interactions between the user, Google Form for authentication, the authentication process on the backend, the database for data validation, and finally the home page that is accessed after a successful login.

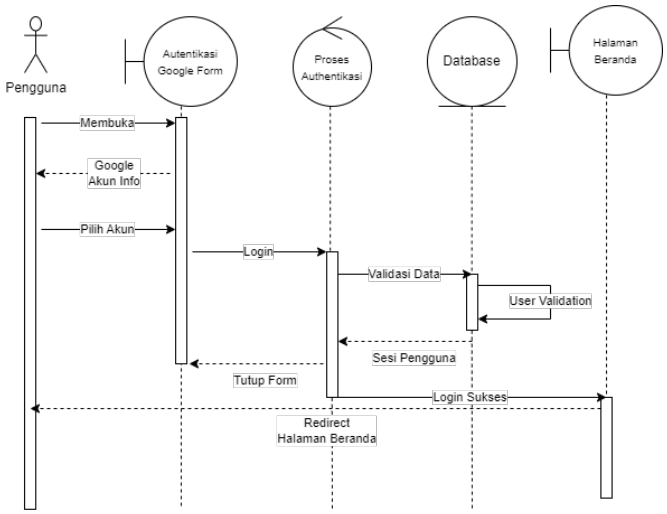

Figure 23. Activity Diagram of Selecting Learning

G. *Learning 1*

Sequence diagram that describes the learning and evaluation process through quiz in an online learning system. This diagram shows a systematic workflow in the learning and evaluation process through quiz, with clear interaction between user, home page, learning process, database, and learning quiz page.

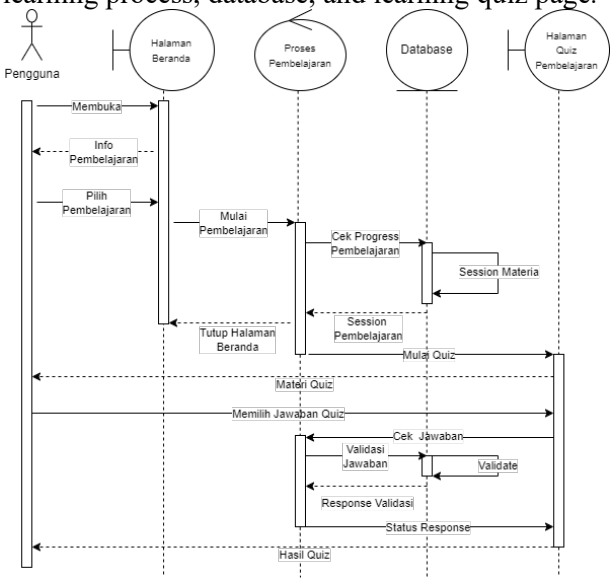

Figure 24. Quiz learning activity diagram

H. *Activity diagram login*

The diagram is an Entity-Relationship diagram (ERD) that describes the relationships between tables in a database that manages course materials and quizzes. This diagram provides a clear picture of the database structure and how the main entities (materials, sub-materials, quizzes and users) are interconnected in the material and quiz management system.

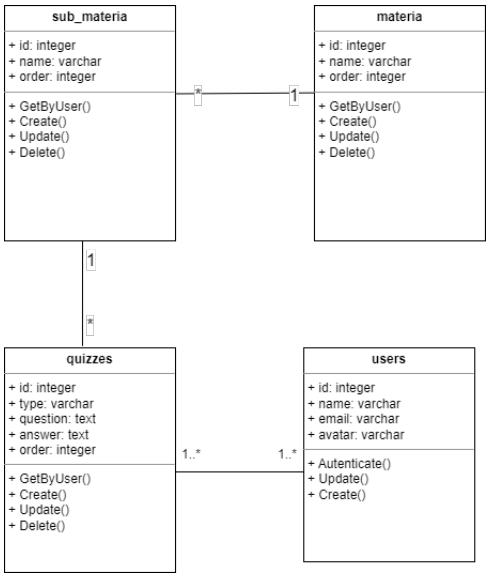

Figure 25. Logical Record Structure of Mutate learning application

IV. CONCLUSION

This application is very helpful for teachers in supporting the learning process of mathematics to be more interactive because it provides all the learning facilities that are realistic to students' lives. Teachers can focus on the learning process and organize the class more effectively. This application helps students in learning math material more easily because it provides an initial evaluation feature. The initial evaluation stage in the math learning process gives meaning to the cultivation of concept understanding. With a good understanding of mathematical concepts, students can provide maximum results in learning achievement. For further research, it can consider broader learning materials not only focusing on one particular class. Thus, this application can provide broader and comprehensive benefits to support more useful mathematics learning.

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