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UI/UX Design Prototype for Enhancing User Experience using User-Centered Method

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Abstract.
Purpose: The teaching matrix often relies on conventional methods involving explanations on a board. It makes students easily bored and relatively focused for only a short period. Integrating multimedia features such as text, colors, and sound might enhance students' comfort and engagement in the learning matrix. In this study, we discuss how to design low-fidelity and high-fidelity prototypes to enhance the comfort of the learning matrix and give a solution to manage course and communication between teachers and students.
Methods: We employed the User-Centered Design method, focusing on users as the central design consideration. The User-Centered Design process involves the analysis of user needs and context, followed by requirements identification, design solutions, and solution evaluation.
Results: Based on the testing results, we scored 86.25%, categorizing it as "acceptable" with a grade of A and an adjective rating of "excellent." Meanwhile, the usability testing resulted in a score of 85.6%.
Novelty: The main contribution to this research is proposing a new design for the UI/UX of the matrix learning application. The generated design can be recommended for implementing a matrix learning application.

Keywords: Matrix, Design, User-centered, Prototype
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INTRODUCTION

Matrix and vector are the subjects covered in Computer Engineering or Computer Science. In the field of the study program in Computer Science, these topics are introduced in courses like Linear Algebra, Numerical Methods, Graphics and Multimedia, and various fields of specialization like Computer Graphics, Image Processing, Data Science, and more. The problem with these courses is that students tend to get bored and need more enthusiasm when the lessons are delivered in conventional teaching methods. One of the advancements in educational technology is the use of games as an alternative solution [1].

At this time is an era of technological development that can improve the quality of human life technologies [2], one of which is in the field of software development.. The use of technology must be carried out optimally to help processes and activities [3]. The development of software applications involves several stages, including analysis, design, implementation, and testing [4]. The analysis and design phases are crucial to the success of application development. Design comprises several stages, namely architecture design, database design, and interface design. Nowadays, the field of interface design is closely related to user experience (UX) studies. UI/UX design involves various disciplines that bridge academia and industry [5]. The measurement of UX maturity levels in several studies has been researched in [6]. These studies evaluate how UX practitioners work with clients with low UX maturity and then attempt to enhance their clients' UX maturity in an agile environment. The User Experience (UX) method [7] involved 13 UX professionals from various industries and two countries working with agile. They employed a qualitative approach and thematic analysis to address research questions. The results indicated that professionals frequently used prototyping, user testing, user journeys, and workshops in their UX work.

UI/UX development has also been carried out in research for application designs [8]. Furthermore, in the study [9], they conducted research on the Child Computer Interaction UX Playbook, which is engaging and

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aligned with the interests of children. Another related study on UI/UX involving children is [10], which discusses Arabic language learning. They also employed the UCD method but primarily focused on children as the main subjects and parents as additional subjects.
In the user interface and user experience design methods, three approaches can be utilized: design thinking (DT) [11]–[13], user-centered design (UCD) [14]–[16], and human-centered design (HCD) [17]–[19]. This study adopts the user-centered design method because it involves users as the primary focus in the design process. User-centered design road mapping is evident in the study [20], which is also related to the evolving innovation strategies. This approach aims to discover better solutions that balance feasibility, viability, and desirability. The research relevant to user-centered design methods is found in [21], which discusses improving real estate CRM user experience and satisfaction. Meanwhile, in [22], a prototype is built using the UCD method for a Clinical Decision Support System for Glaucoma. Study [23] addresses adequate data protection through design. This study involves an interdisciplinary research method that utilizes user-centered UX design methods. On the other hand, research is also conducted on the adverse effects of interface design and its impact on user experience [24].

Many researchers have conducted several studies on design methods and their evaluations. For instance, in the research conducted in [25], User-Centered Design and usability testing methods were employed involving 23 participants to examine user perspectives on blockchain technology. In another study, the human-centered design method [26], with a broader scope than UCD, is employed. This research discusses advanced services for both industry and academia. Lean UX is employed in the study [27] to integrate every process at each stage to enhance startup valuations and attract additional investor funds. On the other hand, a study [28] discussed serious games as a potential learning tool. In this research, we aim to design a learning game application related to matrices and vector spaces. Providing a learning game will enhance the connection between students and the course, fostering a more substantial engagement and interest.

METHODS

The research method used in this study is the user-centered design method, as shown in Figure 1 below.

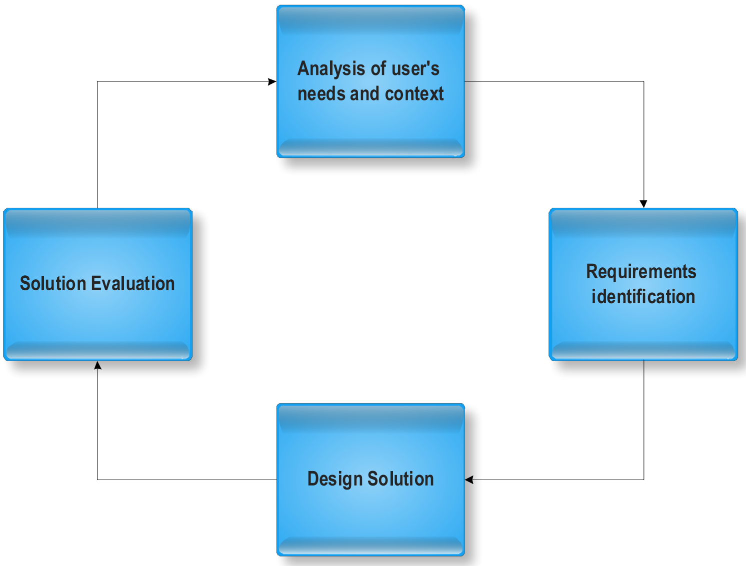

Figure 1. User centered design

Based on Figure 1, there are four stages in the user-centered design method. Choosing this method can help users achieve results that are easily understood and maximally usable. UCD is a method that prioritizes users as the primary focus in the design of the built application.

The application design in this research begins with conducting user research to recognize user characteristics and develop a deep understanding of the users. The design of mockup user interfaces, based on user experience analysis using the UCD method, focuses on introducing the characteristics of students, which can be done through observation, interviews, and questionnaires. Observation is done by directly observing the main subjects that students taking courses in matrices and vectors to understand user characteristics and needs by immersing directly in the field. Interviews are conducted through direct question-and-answer sessions with students as the main subjects. Questionnaires are created by making a questionnaire form with questions directed at students, aiming to obtain information and data from the user's perspective. By conducting this user characteristic recognition, we can narrow down the usage context and identify the problems faced by users. This user research can guide and support all design decisions, as well as create relevant user personas.

After recognizing the user characteristics, we proceed with collecting and aligning information for the design that will be developed. We address user issues while considering the identified user characteristics from the collected data. The collection and alignment of the design are depicted as shown in Figure 2.

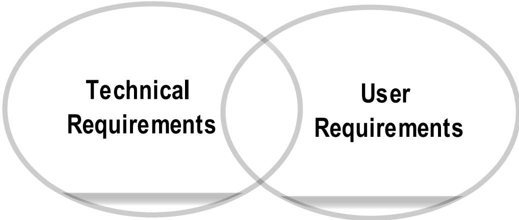

Figure 2. Design allignment

Figure 2 illustrates the alignment between technical and user requirements, which can be achieved by exploring and finding common ground. This way, the designed project or application can meet the needs of both designers and users by the technical aspects outlined in the methodology employed in this research.

The user characteristics and the design alignment from user to designer have been identified. We generate an idea as a solution for the design to be developed. In this research, we employ an iterative design process that can be used to manage risks in user interface design. This iterative design process refines the design through repeated cycles in the design journey.

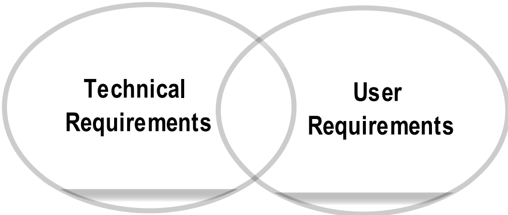

Figure 3. Iterative design model

In Figure 3, the design represents the initial step to visualize imagination or ideas. Next, an implementation is carried out as a physical representation of the designed outcome, such as mockups and prototypes. Subsequently, an evaluation is conducted to test the UI/UX outcomes against user characteristics. If not aligned, the process is iterated continuously until a usable interface result is achieved. In this design solution, we create a low-fidelity representation in the form of design sketches on paper, which serve as a basis for crafting mockups by exploring and visualizing those ideas. Following that, we generate a high-fidelity prototype that closely resembles the final product. This prototype includes colors, transitions, illustrations, and more.

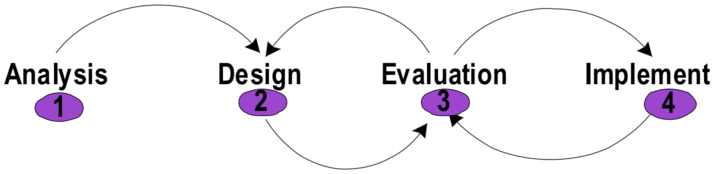

Figure 3. Design solution steps

Validation needs to be conducted after the design is completed. Figure 4 depicts the steps of the design solution, which begins with analysis, followed by design creation, evaluation, and finally, the implementation of the designed solution. The arrows indicate the direction of the step-by-step process, showing that a user-centered design approach is a constant back-and-forth process by testing new design aspects against user characteristics. If it does not meet user characteristics, a thorough understanding is required; it can utilize previous data to identify the errors.

The low-fidelity and high-fidelity design phases have been completed in the previous stages. Next, a reevaluation is necessary to compare the prototype with the gathered requirements. This testing is conducted using the System Usability Scale (SUS). The System Usability Scale (SUS) is a widely used questionnaire-based method for assessing the perceived usability of a system or software. It comprises a 10-item questionnaire that participants respond to using a Likert scale. Several relevant studies that have employed the SUS include [29], which has discussed evaluating the usefulness of Microsoft Teams as an online learning platform during COVID-19. On the other hand, [30] discussed the concept of "questionnaire experience" (QX), introducing an innovative approach to assess a novel instrument.

The System Usability Scale (SUS) consists of 10 questions, where participants are provided with a 1-5 scale to respond based on their level of agreement with each statement regarding the tested product or feature. In calculating the SUS score, a 5-point Likert scale is employed, following specific rules: for odd-numbered questions, the score answered in the questionnaire is subtracted by 1 (formula 1). For even-numbered questions, their value is subtracted from 5 (formula 2). Then, the values of both even and odd-numbered questions are added. Subsequently, the sum is multiplied by 2.5 (formula 3).

$$Odd\ numbered\ score = (x-1) \tag{1}$$
$$Even\ numbered\ score = (5-x) \tag{2}$$
$$SUS\ score = \sum [(odd-numbered\ score + even-numbered\ score) * 2.5] \tag{3}$$

The questionnaire's score range is 0-100, with the standard average SUS score being 68. Scores above 68 indicate good usability, while scores below 68 suggest a need for improvement in the usability of the designed product or feature. The following is a general guideline for interpreting the SUS Score scale, which will be presented in Table 1.

Table 1. SUS Score Scale

SUS Score	Grade	Adjective Rating
>80,3	A	Excellent
68 – 80,3	B	Good
68	C	Okay
51 – 68	D	Poor
<51	E	Awful

RESULTS AND DISCUSSIONS

From the collected data, 70 records were analyzed to recognize user characteristics and needs. We meticulously analyzed these data entries using the employed methods of observation, interviews, and questionnaires. The outcomes of the data analysis can be utilized as the initial or foundational step in the User-Centered Design (UCD) process. This step involves comprehending the user context and placing ourselves in the user's shoes through empathy, allowing us to understand the challenges users face. Subsequently, after analyzing the data, we understand the necessity for appropriate placement of user experience aligned with their characteristics.

We conducted data collection and design alignment to discover commonalities between user characteristics and the designed solution. It is done to ensure compatibility with the technical aspects outlined in the employed methodology and to align with the needs of both designers and users. Table 2 presents the outcomes of the data collection and design alignment by user characteristics.

Table 2. Design alignment

User Characteristics	Design Solution
Energetic and Active	An educational application is needed that requires students to engage in movement, similar to music and video interactions.
Adventurous Spirit	A design with captivating visuals, icons, and illustrations is essential to spark students' interest and engagement, ensuring that they are motivated to explore and use the application.
Curious by Nature	The adventurous spirit of students can be implemented through a game-based approach featuring levels or stages. This way, students can learn while playing, engaging in an educational adventure.
Imaginative	An application is needed to cultivate students' imagination, fostering their creative and innovative spirit.
Enjoy Interaction	A system is required that enables students to interact with the application, such as practicing speaking or engaging in dialogues.
Short Attention Span	Students' focus can easily be diverted, so it is essential to employ diverse methods to prevent them from getting bored and losing concentration. These methods should be engaging and captivating to regain their interest.

The process of design solutions involves implementing user needs and issues. In the design solution phase, we create both low-fidelity and high-fidelity designs.

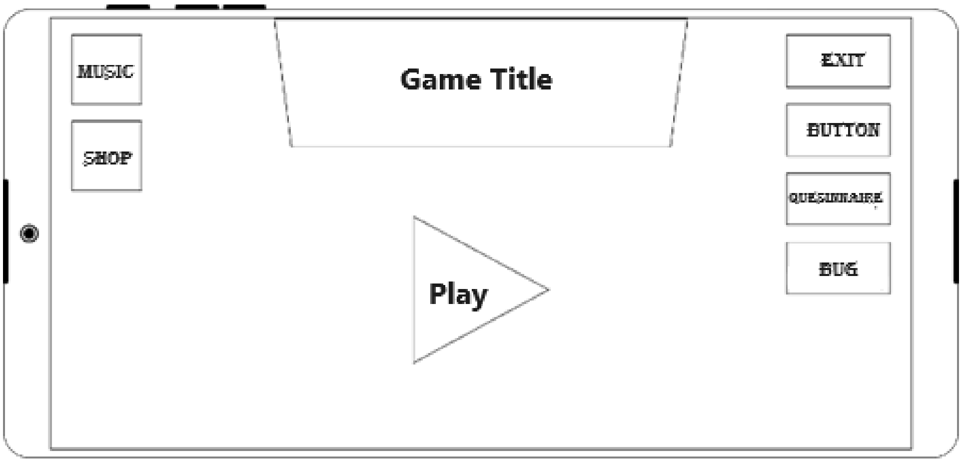

Figure 5. Low-fidelity main page

Figure 5. High-fidelity main page

Figure 5 depicts the low-fidelity main page, while Figure 6 illustrates the high-fidelity main page. The main page includes buttons for play, exit, survey, bug report, music, shop, unlock all worlds, and reset data.

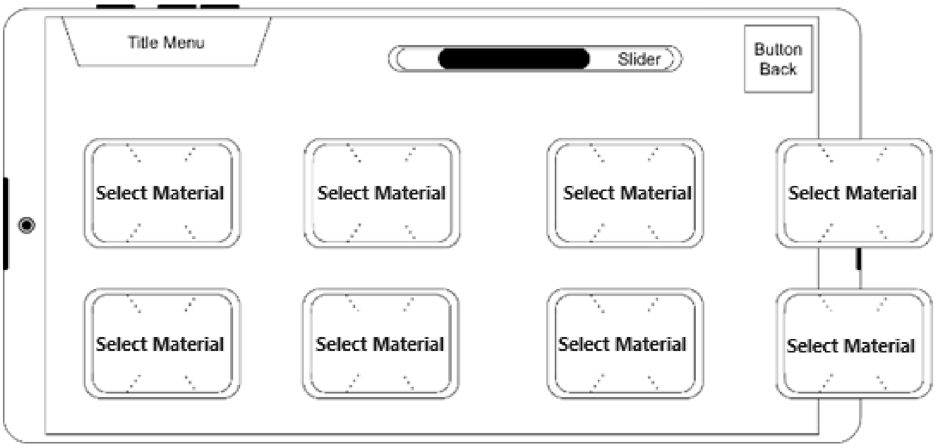

Figure 7. Low-fidelity learning material page

Figure 8. High-fidelity learning material page

Figure 7 and Figure 8 represent the low and high-fidelity designs for the learning material page. On this page, there is a "back" button to return to the main menu, as well as buttons for different topics related to matrix learning, such as matrix definitions, types of matrices, and matrix operations.

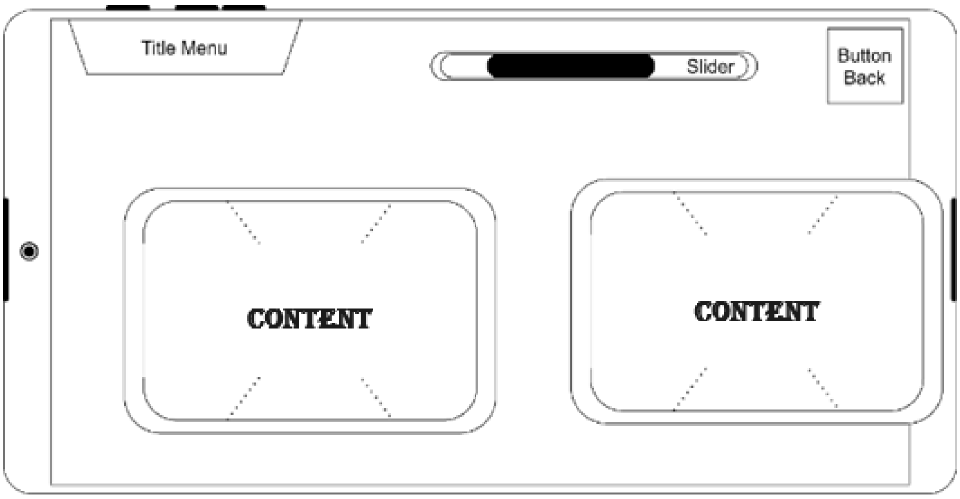

Figure 9. Low-fidelity material content page

Figure 10. High-fidelity material content page

Figure 9 and Figure 10 depict the design for the content page that contains information about matrix concepts. On this page, there are a "back" button and content scrolling options.

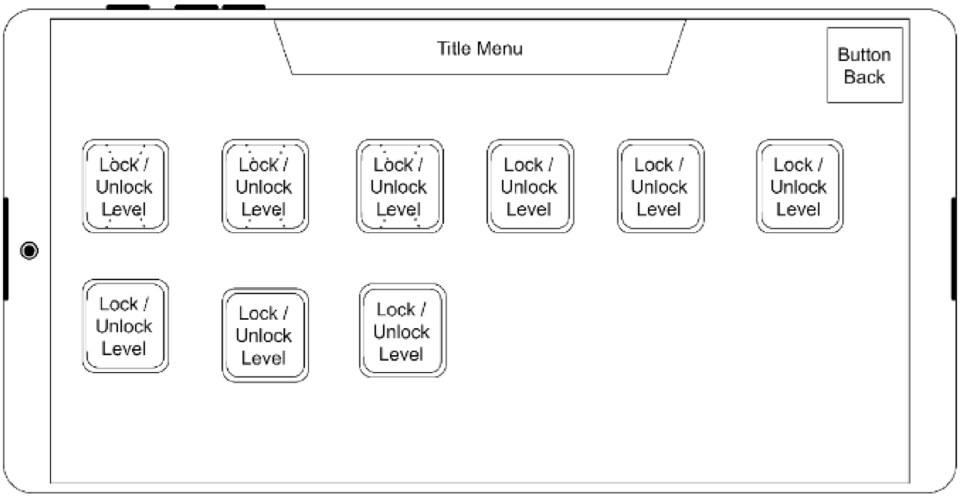

Figure 11. Low-fidelity level selection page

Figure 12. High-fidelity level selection page

Figure 11 and Figure 12 provide a comparison between low and high-fidelity designs for the level selection page. On this page, levels are unlocked as the player completes the previous ones. Each level comes with its difficulty level. The page also includes a "back" button to return to the world selection.

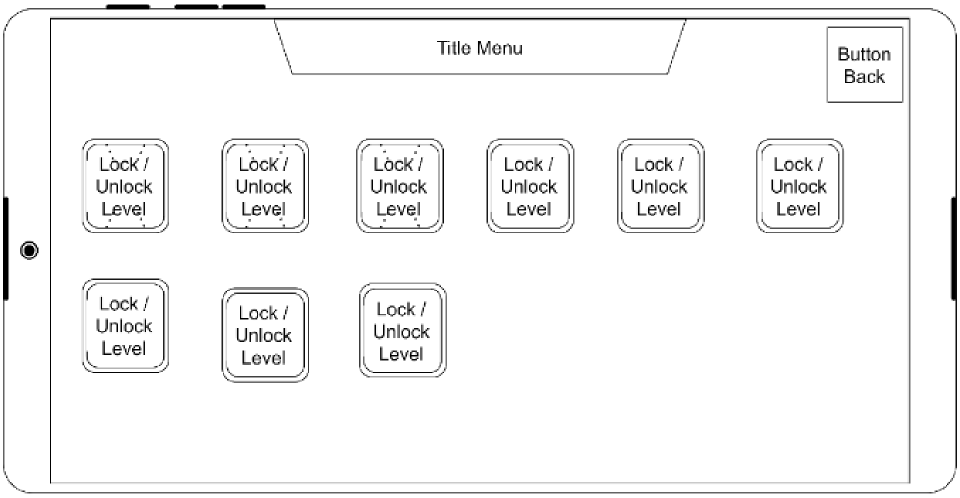

Figure 13. Low-fidelity level selection page

Figure 14. High-fidelity level selection page

Figure 13 and Figure 14 illustrate the low-fidelity and high-fidelity designs for the in-game page interface. In this game, there is a character that will move to the right and answer questions when encountering a question mark symbol. There are obstacles and aids in the game, along with arrow directions, to determine the character's movement in the specified direction.

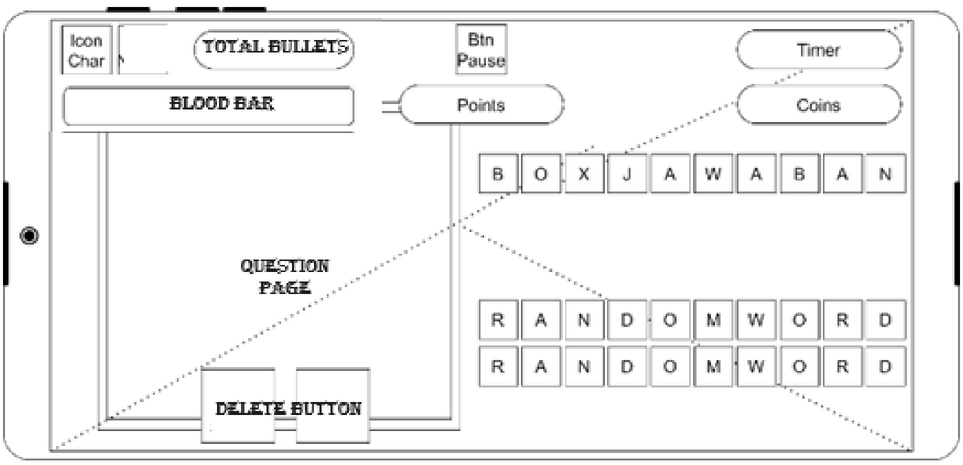

Figure 15. Low-fidelity question page

Figure 16. High-fidelity question page

Figure 15 and Figure 16 represent the design of a question page, which displays questions related to matrix material. Each question includes points that will increase if the answer is correct, and there is also a countdown timer to answer the question.

The next step is to conduct design solution testing involving relevant respondents. We use a Likert scale ranging from 1 to 5, in which 1 represents "very inefficient," 2 is "inefficient," 3 is "fairly efficient," 4 is "efficient," and 5 indicates "very efficient" responses. We present ten pairs of opposing attribute variables. These ten attribute variables cover efficiency, effectiveness, difficulty level, learning capability, tidiness, clarity, satisfaction level, accessibility, error anticipation, and expectations. These variable pairs are expected to represent the user's perceptions. We divided the testing into two parts: persona testing and usability testing. Table 3 displays the results of persona testing from the user's perspective.

Table 3. The SUS testing score

Odd Items	Even Items	SUS Score	Grades
18	17	87,5	A
19	18	92.5	A
17	19	90	A
17	16	82,5	A
18	17	87,5	A
16	15	77,5	B
19	18	92,5	A
14	18	80	B
16	19	87,5	A
18	16	85	A
Average SUS Score		86,25	A

The user persona testing yielded an average score of 86.25. Therefore, the design solution can be categorized as acceptable with an "A" grade, and the adjective rating falls within the "excellent" range. The next stage involved usability measurements, encompassing effectiveness, efficiency, and satisfaction. Figure 17 illustrates the usability testing results, covering these three aspects.

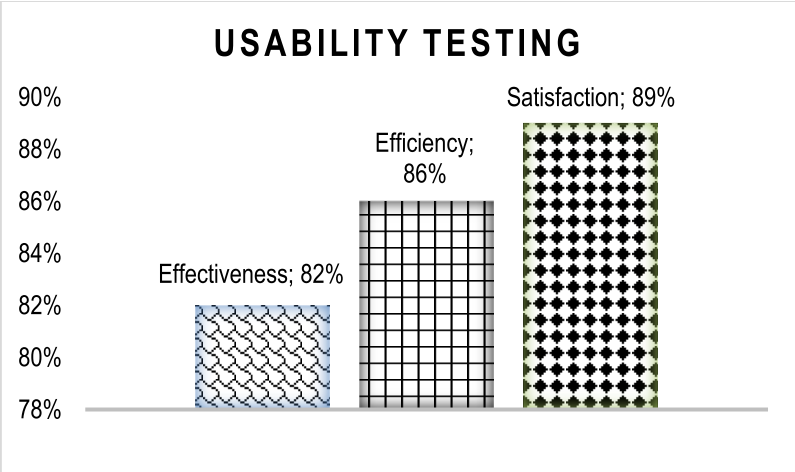

Figure 17. Usability testing results

The figure demonstrates the analysis outcomes of testing the prototype design for the matrix learning game application, with an efficiency score of 82%, effectiveness at 86%, and a satisfaction rating of 89%.

Table 4. Comparison of usability testing results

Study by	Usability score
[31]	75.75%
[32]	83.11%
This Study	85,60%

Table 4 illustrates a comparison of usability testing results for several application designs. In the study conducted by [31], the focus was on the analysis and UI/UX design for a local medicine and medication mobile application using the task-centered design process. The usability testing yielded a result of 75.75%. The results of another study [32] discussing the design of a prototype for a mobile community based at the Catholic Church of Mary Mother of Carmel in Jakarta yielded a usability result of 83.11%. The testing results in this study, however, achieved a higher outcome, precisely 85.6%. Despite the [33] research obtaining a User Interface effectiveness of 100% for all tasks, improving usability scores makes it a preferable outcome. Based on the average usability score of 85.6%, the design solution created can be recommended as the UI/UX design for the matrix learning application. In a study by [34], the focus was on aesthetic semantics, in which user experience (UX) designers often prioritize beauty over the intended impact on end users. This inverted priority order contradicts the sequential UX design process, leading to unexpected perceptions and responses from end users. The study involved 1,782 participants worldwide, evaluating affective user responses to 43 aesthetic atoms using 153,252 data points presented as Affect Ratings (ARs).

CONCLUSION

The UI/UX design for the matrix learning application has been created as the result of the research. The user-centered design method was systematically followed, from analyzing user needs and context to requirements identification, design solutions, and solution evaluation. We have developed both low-fidelity and high-fidelity designs. These designs were subjected to user evaluations through persona testing and usability testing. The persona testing yielded a score of 86.25%, classifying it as "acceptable" with a grade of A and an adjective rating of "excellent." On the other hand, the usability testing resulted in a score of 85.6%. It might indicate that the design can be recommended for implementation. The future study involves the implementation of the design outcomes into a matrix learning game application.

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