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# *Analysis and Design of Differentiated Swimming Learning Media Based on Intelligent Systems (Case Study: Sports Coaching Education Study Program, Universitas Jambi)*

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## *Abstract*

*Swimming instruction in the Sports Coaching Education Study Program at Universitas Jambi is still predominantly based on a direct instruction approach, which has not fully accommodated the diverse initial swimming abilities of students, ranging from aquaphobia to advanced levels. In addition, the limited lecturer-to-student ratio reduces the effectiveness of individualized attention during the learning process. To address these challenges, this study proposes the design of an intelligent-system-based swimming learning media that applies a differentiated learning approach. This study employs a combination of Design Thinking and the Successive Approximation Model (SAM) The novelty of this study lies in combining the Successive Approximation Model (SAM) and Design Thinking as an integrated approach to designing differentiated swimming learning media. Based on the literature reviewed in this study, no previous research was identified that specifically integrates these two approaches for the design of swimming learning media that adapts learning materials to students' proficiency levels. The objective is to design a media prototype that supports the implementation of differentiated learning and assists both lecturers and students in the learning process. The results indicate that students possess diverse swimming abilities and therefore require learning materials that are adapted to their respective skill levels. The prototype provides initial assessment, level-based learning materials, learning evaluation, progress monitoring, and discussion features. Remote usability testing with five participants across 12 task scenarios produced an overall task success rate of 98.34%. The design therefore demonstrates promising interaction feasibility as a prototype, but it requires further validation through implementation in real classes, larger and more diverse samples, and learning-outcome evaluation. Practically, the proposed media can serve as a blueprint for technology-supported differentiated swimming instruction and as a basis for subsequent system implementation.*

***Keywords: swimming learning, differentiated learning, intelligent system, SAM, design thinking***

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## INTRODUCTION

In the Sports Coaching Education Study Program (SCE Study Program) at the Universitas Jambi, one of the courses that is an important part of the curriculum is swimming. Swimming is an aquatic sport in which body movements are performed in water using the arms and legs as the primary means of propulsion (Qinthara and Supriyono, 2024). Due to its distinct nature compared to land-based sports, swimming proficiency is a critical competency that SCE students, as future physical education teachers and sports coaches, must master. Consequently, the effectiveness of swimming instruction is significantly influenced by the delivery of instructional content and the implementation of appropriate technical drills.

Swimming has four main competitive strokes: freestyle (front crawl), breaststroke, backstroke, and butterfly (Harmoko and Sovensi, 2021). Herfiandi and Masrun (2020) note that the breaststroke is often the first swimming stroke a person masters when learning to swim (Herfiandi and Masrun, 2020). This is also supported by the results of interviews with swimming instructors from the SCE program, who stated that the breaststroke is generally recommended for beginner swimmers before learning more complex strokes. In the SCE program itself, the breaststroke is the first swimming stroke students learn in their swimming course. Thus, this study will focus on the breaststroke as a basic stroke in swimming instruction.

The swimming instruction model currently used in the SCE program is direct instruction. In practice, this model faces various challenges, primarily due to the wide range of students' initial abilities. In fact, some students experience fear when in the water (aquaphobia). They feel anxious and afraid of the depth of the pool, making them reluctant to practice swimming strokes (Haryanto et al., 2022). This condition makes it difficult for them to correctly understand basic swimming techniques (Lutfianto et al., 2021). Consequently, instructors need to provide special attention to ensure that every student can achieve optimal swimming proficiency.

One solution to this problem is to use a differentiated instruction model. Differentiated instruction is an effort to adapt the teaching and learning process to meet the individual learning needs of each student (Fitriyah and Bisri, 2023). This means that instructors no longer use a one-size-fits-all approach but instead accommodate differences in students' readiness, interests, and learning styles. However, based on the interview results, it was also found that another factor to consider is the student-to-instructor ratio, which is disproportionate. This also poses a challenge as it can limit the ability to provide individualized attention to students' competency development. In higher education, recent research also indicates that differentiated instruction is increasingly used to respond to learner diversity, although implementation can require substantial time, planning, and instructional resources (Subban et al., 2025). This concern is particularly relevant in swimming classes, where instructors must simultaneously manage practical skill demonstrations, safety, corrective feedback, and differences in students' readiness. In this context, a digital support system is not intended to replace instructor guidance, but to reduce routine classification and content-delivery burdens so that instructional attention can be directed toward practical coaching.

This situation highlights the need for more interactive, adaptive, and personalized swimming instructional materials to support the teaching and learning process in swimming courses. One way to achieve this adaptability is through the implementation of an intelligent system. In this study, the term intelligent system refers specifically to a rule-based decision mechanism represented as a decision tree, it does not refer to machine learning or generative artificial intelligence. The system automatically maps responses to an initial questionnaire into four proficiency levels (aquaphobia, beginner, intermediate, and advanced) and uses the resulting classification to determine the learning materials presented to the student. This design reflects the broader direction of personalized technology-enhanced learning, in

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which learner characteristics or prior knowledge are used to determine differentiated content and scaffolding (Hooshyar et al., 2024).

This study adopts the Successive Approximation Model (SAM) and Design Thinking approaches. The pedagogical aspects were developed using the SAM method to structure iterative development, while Design Thinking was used to understand user needs and translate them into user-centered interface and experience decisions. SAM is suitable for iterative educational product development because it emphasizes repeated design and review rather than a strictly linear sequence (Salsabila and Putra, 2024). Design Thinking complements this approach by emphasizing empathy, problem framing, ideation, prototyping, and testing. The combination is particularly appropriate for a learning medium in which pedagogical requirements and interaction design must be considered together.

In addition, design considerations must also be taken into account in the development of learning materials, particularly for technology-based materials that require an optimal user interface and user experience. In this context, the Design Thinking method is implemented to produce interface and user experience designs that meet user needs. The integration of these two approaches has not yet been widely applied in swimming instruction.

A broader review of recent literature indicates that personalized and adaptive technology-enhanced learning can improve learning outcomes in higher education, but the evidence base is concentrated in general academic domains and diverse digital learning environments (Hooshyar et al., 2024). In swimming education, prior mobile-learning research has mainly emphasized the development and validity of Android-based instructional media rather than differentiated routing of learning content according to initial swimming proficiency (Lutfianto et al., 2021).This leaves a practical and design-oriented gap, there is limited evidence on how a swimming learning medium can operationalize learner-level differentiation through an interpretable classification mechanism while simultaneously addressing the interface needs of students and instructors. Therefore, the contribution of this study is not the introduction of artificial intelligence in a general sense, but the design of an integrated prototype that connects user needs analysis, rule-based proficiency classification, differentiated breaststroke content, and iterative user-centered interface design within a SAM-based development process. The study consequently focuses on design feasibility rather than claiming effectiveness of learning outcomes.

This study aims to produce a design for swimming instructional materials that can serve as a reference for further development. Specifically, the study seeks to identify user needs related to differentiated swimming instruction, design a rule-based mechanism for initial proficiency classification, translate the classification into differentiated breaststroke learning pathways and supporting features, and evaluate the prototype through remote usability testing in terms of task effectiveness and completion-time efficiency. Thus, the study contributes a design blueprint rather than a fully implemented learning application or evidence of improved swimming performance.

## METHOD

This study uses a design-oriented development approach that integrates SAM and Design Thinking. Because the study is limited to the media design stage, only the Preparation Phase and Iterative Design Phase of SAM are applied. Design Thinking activities are mapped to the SAM phases as shown in Table 1. SAM functions as the overarching development framework for the learning product, whereas Design Thinking is used to operationalize user-centered inquiry, ideation, prototyping, and usability-oriented refinement. This separation clarifies that the two methods are complementary rather than interchangeable.

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Table 1. Integration of SAM and Design Thinking

| | SAM | Design Thinking |
|---|---|---|
| **Preparation Phase** | Information Gathering | Empathize |
| | | Define |
| | Savvy Start | |
| **Iterative Design** | Project Planning | |
| | Additional Design | Ideate |
| | | Prototype |
| | | Test |

The Empathize and Define phases are combined with the Information Gathering activity in SAM because they focus on gathering information and understanding user needs. Furthermore, the Ideate phase in Design Thinking aligns with the Design iteration in the Additional Design phase of SAM, as both produce outputs such as information architecture, user flows, and wireframes. The Prototype phase in both Additional Design and Design Thinking shares a similar objective: to produce a product prototype for validation. Finally, the Test phase is implemented in the Review phase of SAM's Additional Design, which emphasizes a process of repeated evaluation and refinement until the solution meets user needs. Overall, the research flow can be seen in Figure 1 below.

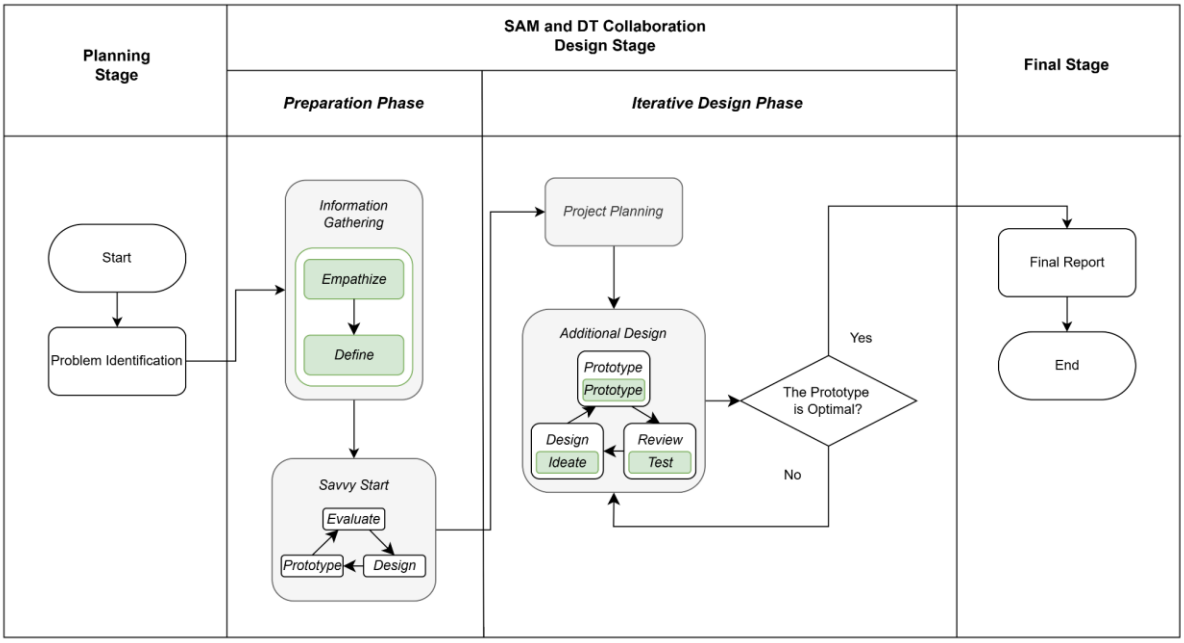



Fig 1. Research flow

Data collection consisted of interviews and direct observation for needs analysis, followed by prototype usability testing. The needs-analysis participants were two instructors and nine swimming students from the SCE program. These participants were selected purposively because they represented the two primary user groups identified in the system requirements: instructors and students. The objective at this stage was not statistical generalization but the identification of recurring instructional problems, user needs, and functional requirements that could inform the prototype. For usability testing, five participants were used in a small-scale formative evaluation. A five-user round is commonly used

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in iterative usability work to expose a substantial proportion of common interaction problems, although the adequacy of five users depends on user homogeneity, system complexity, evaluation type, and the purpose of testing (Borsci et al., 2013). Therefore, the five participants in this study are treated as an exploratory usability sample rather than a representative statistical sample.

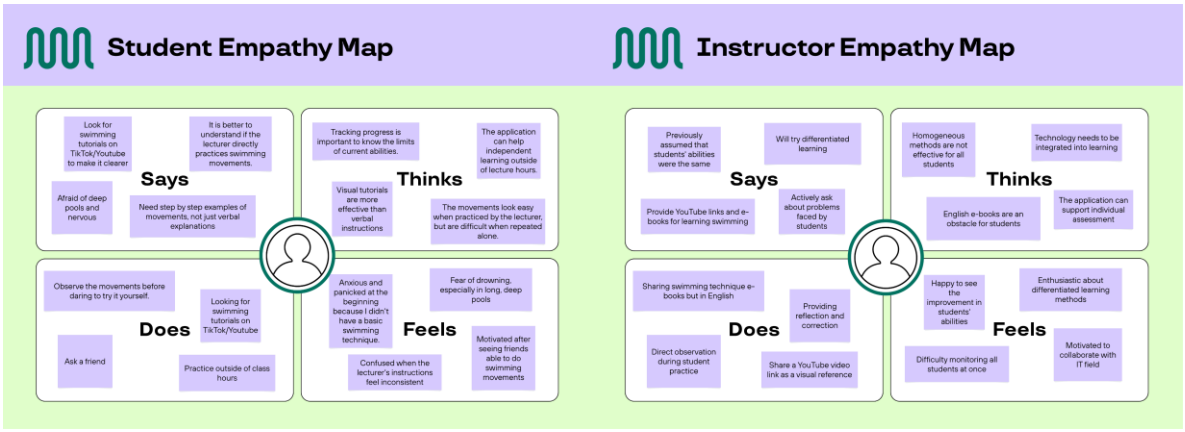
The research instruments consisted of interview and observation guides for needs analysis, a diagnostic questionnaire containing 10 binary-response items (Q01-Q10) used as design inputs for the proficiency-classification rules, and 12 task scenarios for prototype usability testing. The task scenarios were derived from the functional requirements (FR01-FR10) and represented the core interactions expected from the prototype, including assessment, access to level-specific materials, evaluation, forum interaction, and profile-related functions. Instrument validity was considered primarily through content alignment with the stated research objectives, user requirements, and functional requirements. No formal psychometric validation of the diagnostic questionnaire was conducted because it was developed as a prototype decision aid rather than as a validated clinical or standardized swimming-proficiency instrument. This distinction is important when interpreting the resulting proficiency labels.

## RESULTS AND DISCUSSION

Preparation phase

1. Information Gathering
    a. Empathize

The empathize phase is conducted to understand the users' circumstances, experiences, and needs. Activities carried out in this phase include conducting interviews and observations, which are then mapped out in empathy maps, as shown in Figure 2 below.




(a) (b)

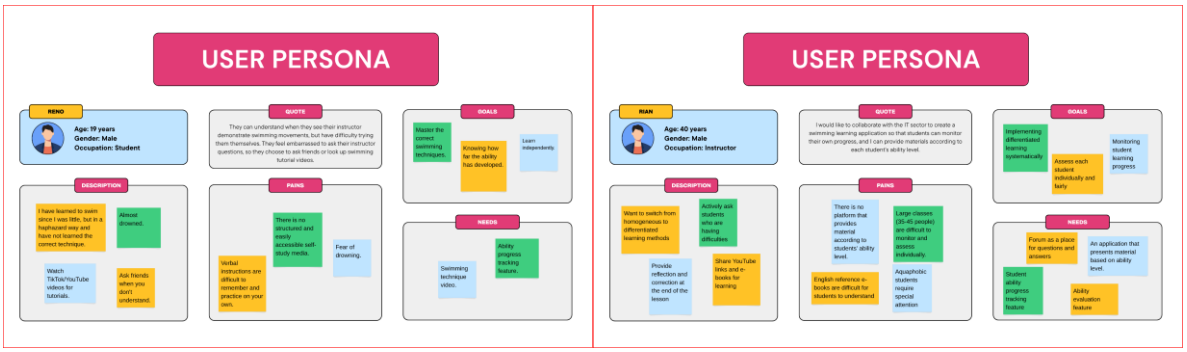
Fig 2. Empathy map: (a) Student; (b) Instructor

    b. Define

At this stage, various findings regarding the needs, challenges, and expectations of students and faculty members are synthesized into a problem statement that reflects the users' actual circumstances, thereby serving as the basis for determining the appropriate solution. The results of the empathy map are then represented in the form of user personas and points of view to deepen our understanding of user characteristics. The user personas are shown in Figure 3 below.

Based on these user personas, it can be concluded that users want a platform that supports self-directed swimming instruction. Users want a platform that not only provides basic swimming materials tailored to their skill level but is also capable of tracking learning progress and supported by a more effective assessment system. Furthermore, the points of view are presented in Table 2.

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(a) (b)

Fig 3. User persona: (a) Student; (b) Instructor

Based on these point of views, a common need emerged for a platform that offers differentiated swimming instruction with measurable progress, a forum for discussion, and self-directed student assessment. This finding is consistent with recent work on differentiated instruction in higher education, which shows that learner diversity is a central reason for differentiation but that implementing differentiation can be demanding in terms of educator preparation and resources (Subban et al., 2025). The proposed media addresses this tension by shifting part of the differentiation process, initial classification and access to level-specific resources, from a manual instructor task to a system-supported process. However, the design should be understood as instructional support rather than a substitute for the instructor, particularly because swimming includes safety-critical practical activities that require direct supervision and feedback. The contribution of the present study therefore lies in operationalizing differentiation within the learning medium, not in automating the full instructional process.

Table 2. Point of view

| User | Needs | Insight |
|---|---|---|
| **Student** | Structured swimming materials and videos, along with a self-accessible feature to track skill progress | Students struggle due to the lack of learning materials suited to their skill level and feel hesitant to ask instructors for help |
| **Instructor** | An app that delivers content based on students' abilities, discussion forums, and features for tracking and evaluating student performance | In large classes with students of varying proficiency levels, it is difficult to tailor the material and monitor each student individually |

2. Savvy Start

At this stage, data was compiled to serve as the basis for classifying users' skill levels, ranging from aquaphobia to advanced. In addition, questionnaire items were designed to serve as data inputs, and a decision tree was developed as a model to determine skill levels based on the responses provided.

Table 3. Proficiency level data

| Proficiency Level Code | Proficiency Level |
|---|---|
| L01 | Aquaphobia |
| L02 | Beginner |
| L03 | Intermediate |
| L04 | Advanced |

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Tabel 4. Diagnostic questionnaire data

| Question Code | Question |
|---|---|
| Q01 | I feel very anxious, afraid, or panicked just thinking about getting into a swimming pool (even a shallow one) |
| Q02 | I can enter a shallow swimming pool (waist- or chest-deep for an adult) without feeling panicked, and can play in the water comfortably. |
| Q03 | I can float (on my back or stomach) for at least 5 seconds without the aid of any equipment. |
| Q04 | I can glide from the edge of the pool (from a standing position) for at least 2 meters without assistance. |
| Q05 | I can swim breaststroke or freestyle for 25 meters (one standard pool length) without stopping. |
| Q06 | I can breathe regularly and relax while swimming freestyle or breaststroke. |
| Q07 | I can swim using the correct breaststroke or freestyle technique for at least one pool length (25 meters). |
| Q08 | I can perform a proper dive from the starting block or the edge of the pool and immediately start swimming. |
| Q09 | I am able to swim continuously for at least 200 meters using the breaststroke or freestyle. |
| Q10 | I am confident swimming in deep water (adult pool) and know how to tread water or float vertically to rest. |

The data from these questions will be presented in the form of a questionnaire with “Yes” or “No” answers for each question. Swimming proficiency levels are identified based on the predefined decision rules shown in the decision tree in Figure 4. The use of explicit rules provides an interpretable pathway from learner responses to content selection. For a prototype intended to be transparent to instructors, the decision-tree approach makes it possible to inspect why a learner is routed to a particular level. At the same time, the rule set is only a design hypothesis and should not be interpreted as a validated assessment of swimming ability or aquaphobia. Its validity needs to be examined against instructor judgments and observed practical performance in future implementation studies.

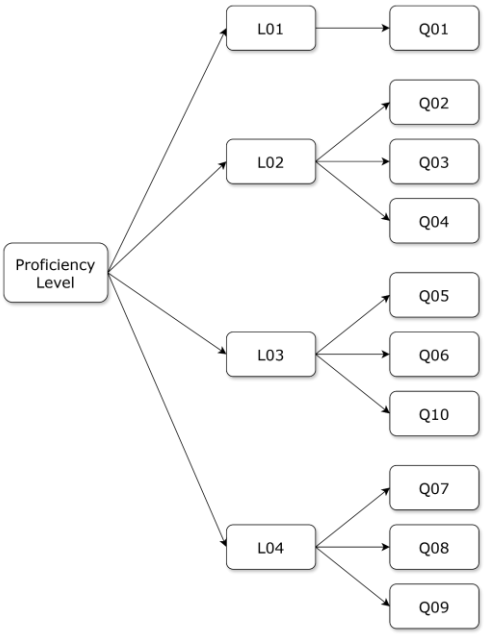



Fig 4. Decision Tree

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Iterative Design Phase

1. Project Planning

In this phase, a project development plan is formulated, which includes determining the activities and deliverables to be produced. Some of the deliverables will be completed in this phase, while the rest will be addressed in subsequent phases. One of the deliverables in this phase is user requirements, functional requirements, and non-functional requirements. User requirements are shown in Table 5 below.

Table 5. User Needs

| No | User Needs | Primary User | Priority Level |
|---|---|---|---|
| **1** | Determination of proficiency level | Student | High |
| **2** | Learning Materials | Student | High |
| **3** | Learning Evaluation | Student and instructor | High |
| **4** | Forum | Student and instructor | Medium |
| **5** | Manage Data | Instructor | High |

After user requirements have been identified, the next step is to determine the system's functional requirements. Functional requirements describe the primary functions that the system must possess to support user and administrator activities in accordance with the application's development objectives. Details of the system's functional requirements are presented in Table 6 below.

Table 6. Functional Requirements

| Functional Requirements | |
|---|---|
| **FR01** | The system displays the initial assessment questionnaire. |
| **FR02** | The system places the user in a skill level based on the assessment results. |
| **FR03** | The system displays materials for each level |
| **FR04** | The system locks the next material and level until the current material is completed. |
| **FR05** | The system provides questions to identify comprehension and practical skill challenges |
| **FR06** | The system provides a video upload feature. |
| **FR07** | The system provides a discussion forum for students and faculty. |
| **FR08** | The system provides questions for self-assessment by users |
| **FR09** | The system provides a feature for assessment by the admin |
| **FR10** | The system has an admin dashboard for managing materials, questions, and users. |

In addition to functional requirements, the system also requires non-functional requirements to ensure that the system operates effectively and performs well. The system's non-functional requirements are listed in Table 6 below.

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Table 6. Non-Functional Requirements

| **Non-Functional Requirements** | |
|---|---|
| **NFR01** | The system has a user interface that is easy for users to understand and use |
| **NFR02** | The system requires users to log in to access features. |
| **NFR03** | The system securely stores user data, assessment results, evaluations, and videos. |
| **NFR04** | The system can be accessed via mobile devices. |
| **NFR05** | The system is easy to update to add materials and questions, as well as for user verification. |
| **NFR06** | The system can be accessed at any time as long as you are connected to the internet. |
| **NFR07** | The system can be accessed by multiple users simultaneously without any disruption. |

2. Additional Design
    a. Ideate

In this phase, a solution is designed by defining features based on the user needs identified earlier. Next, the system is modeled using use case diagrams to illustrate the workflow and functions of the system to be developed, ensuring it aligns with user needs. Additionally, during the Ideate phase, an information architecture is developed as an initial design for the application's interface and navigation structure before moving on to a more detailed design phase.

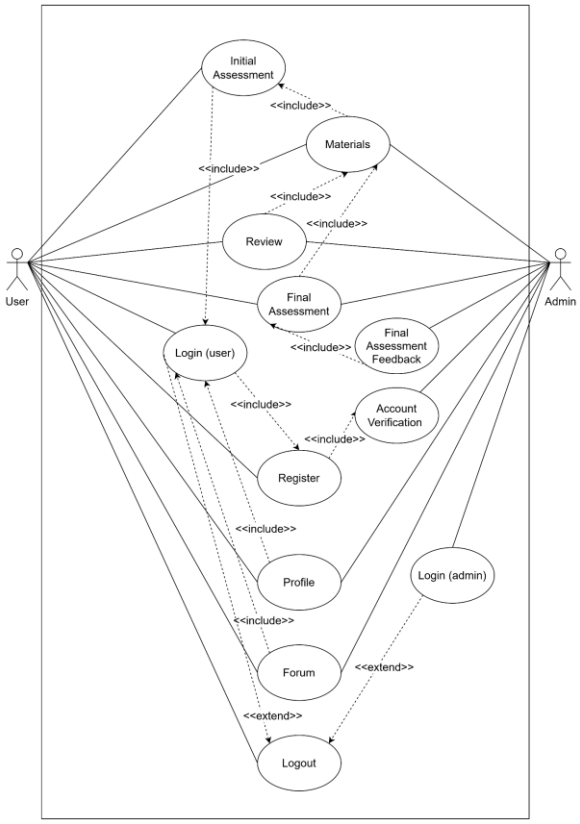



Fig 5. Use case diagram

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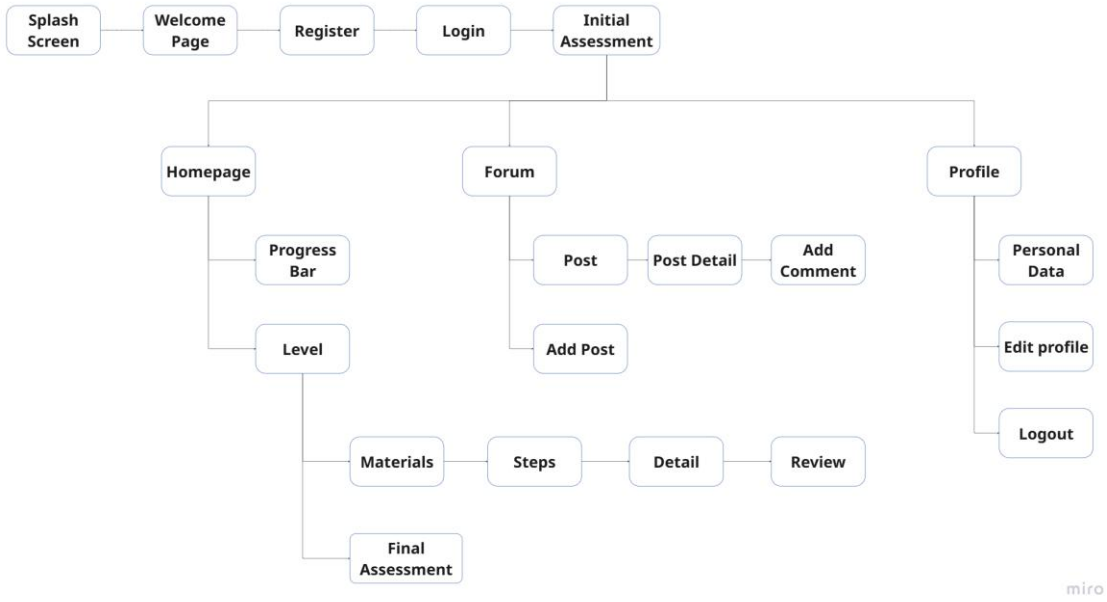
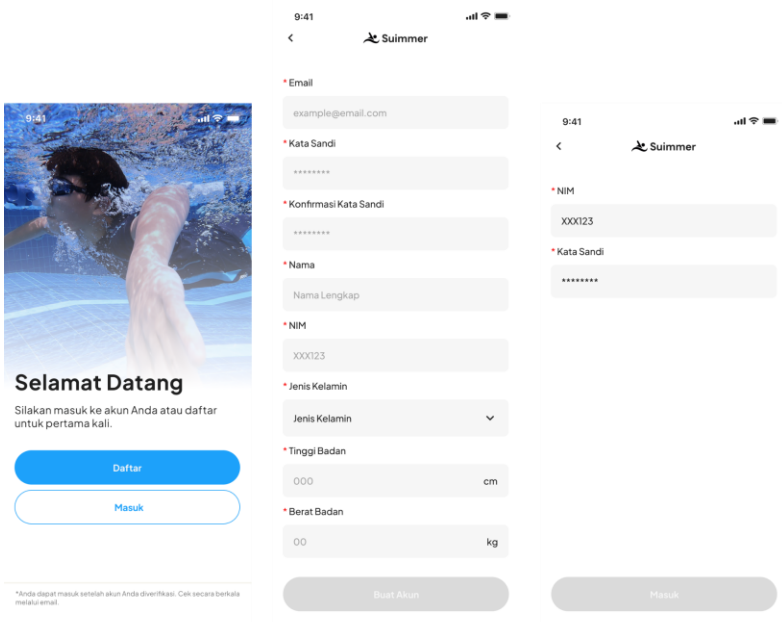



Fig 6. Information architecture

*b. Prototype*

The process continued with the design of a prototype based on the diagrams that had been created. The prototype was designed to provide a more concrete visualization of the application's navigation structure and user interface, so that it could be used as a tool for evaluation and testing in the next phase. A notable design characteristic is that the home and assessment outcomes vary by proficiency level, making the differentiation visible at the user-interface level rather than only in the underlying rule set. This connects the pedagogical objective of differentiated instruction with the interaction design objective of presenting only the resources that are relevant to the learner's initial level.




(a) (b) (c)

Fig 7. (a) Welcome Screen; (b) Register; (c) Login

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The approach is aligned with evidence that personalized technology-enhanced learning is most useful when learner characteristics are connected to concrete adaptive support, such as differentiated resources and scaffolding (Hooshyar et al., 2024). Compared with the Android swimming learning media developed by Lutfianto et al. (2021), which emphasized the validity of a general swimming learning application, the present prototype contributes a more explicit learner-classification and level-routing mechanism. Nevertheless, the comparison should be interpreted cautiously because the two studies used different objectives, methods, and evaluation designs. The prototype design can be seen in Figures 7 through Figure 13.

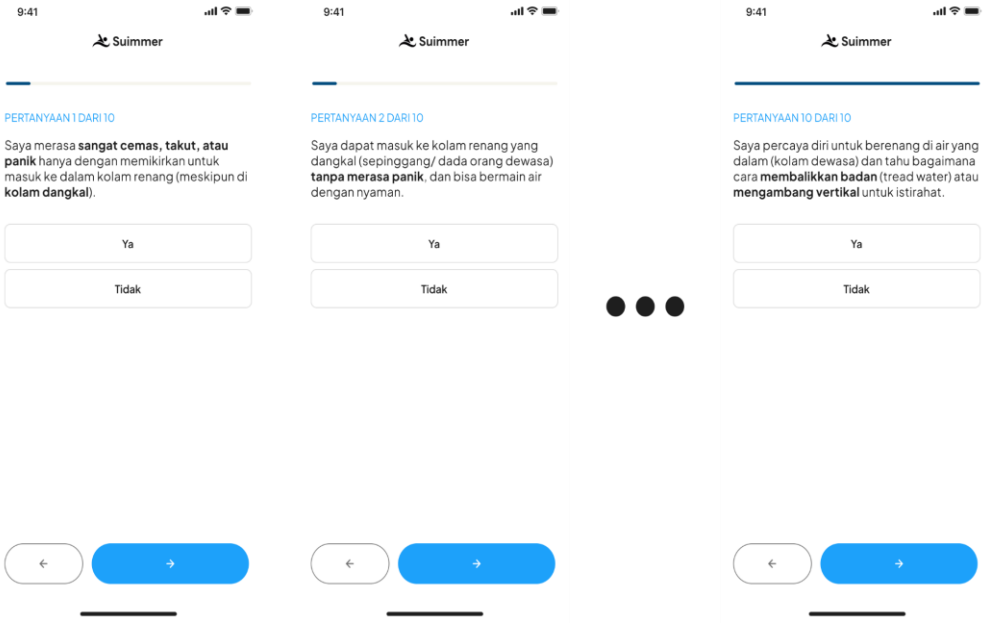
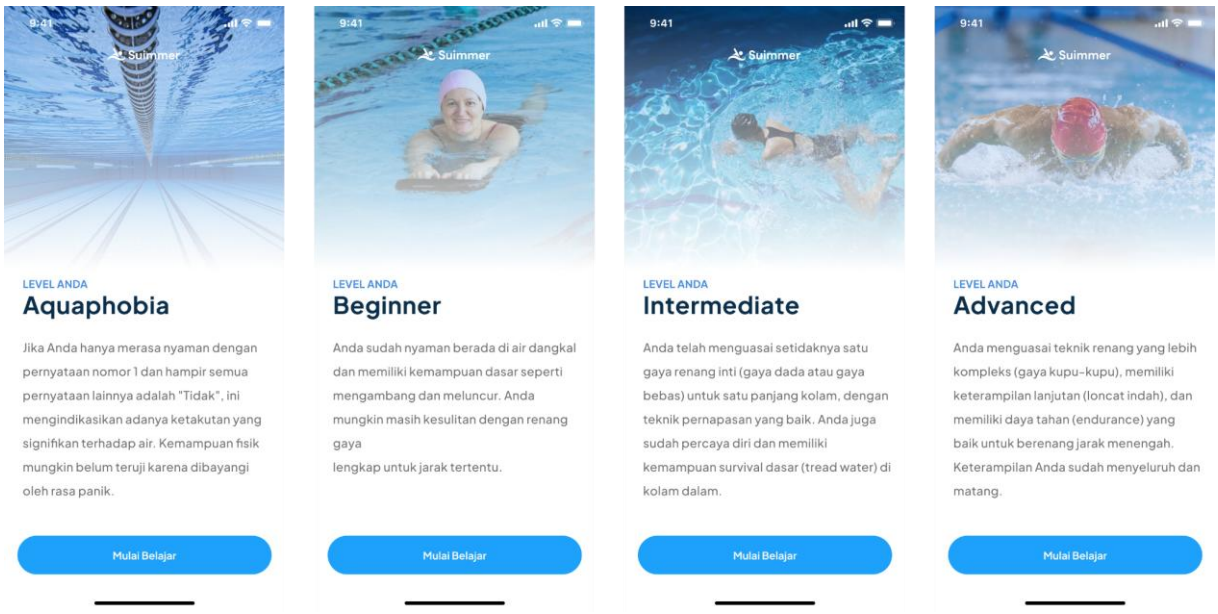


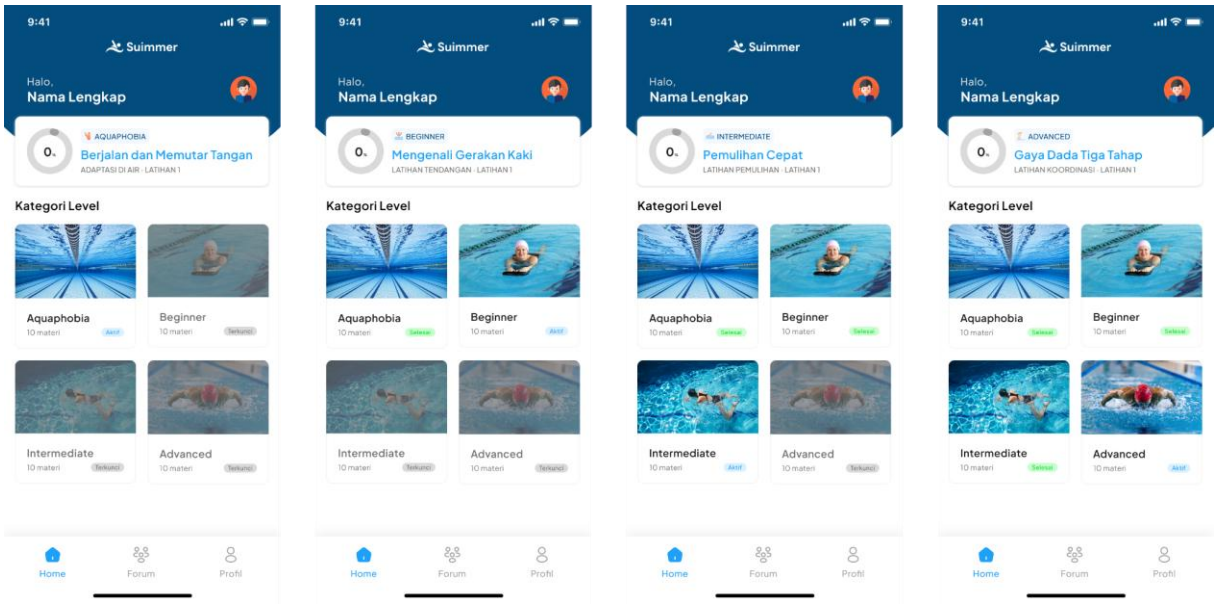

Fig 8. Initial assessment page




(a) (b) (c) (d)

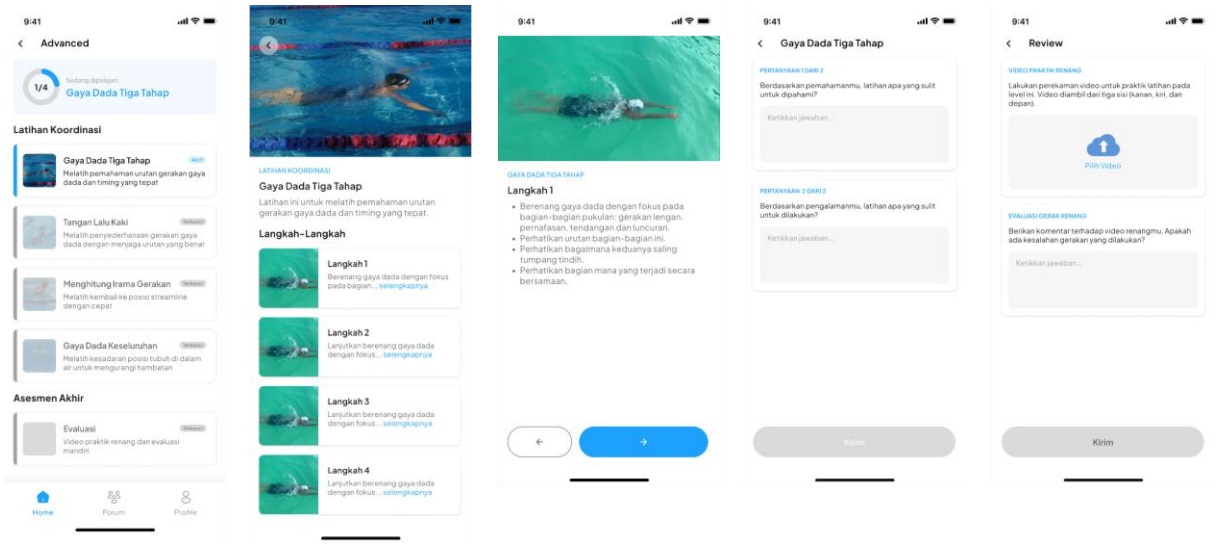
Fig 9. Assessment result page: (a) Aquaphobia; (b) Beginner; (c) Intermediate; (d) Advanced

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(a) (b) (c) (d)

Fig 10. Home page: (a) Aquaphobia; (b) Beginner; (c) Intermediate; (d) Advanced




(a) (b) (c) (d) (e)

Fig 11. Materials page: (a) Materials category; (b) Steps category; (c) Materials detail; (d) Review; (e) Final assessment

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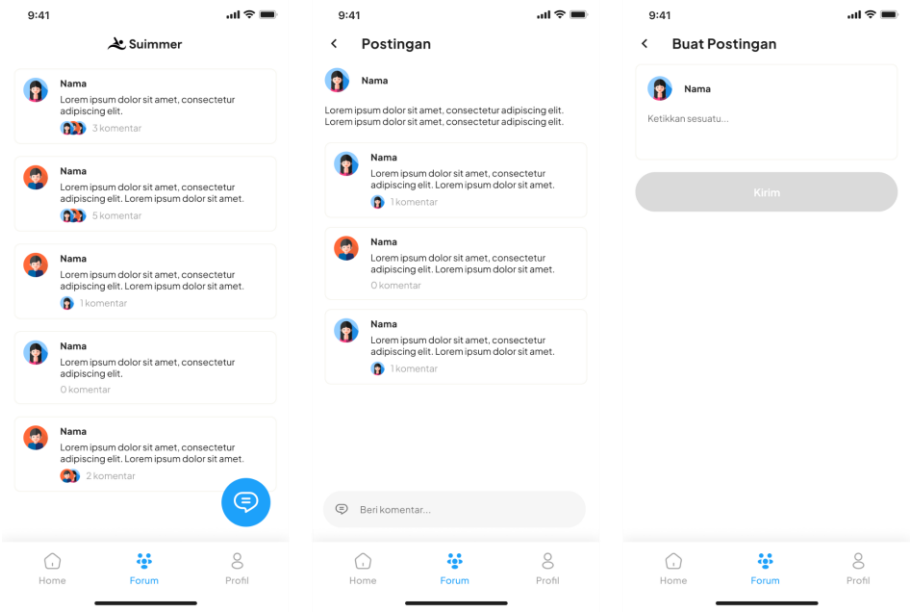



Fig 12. Forum page

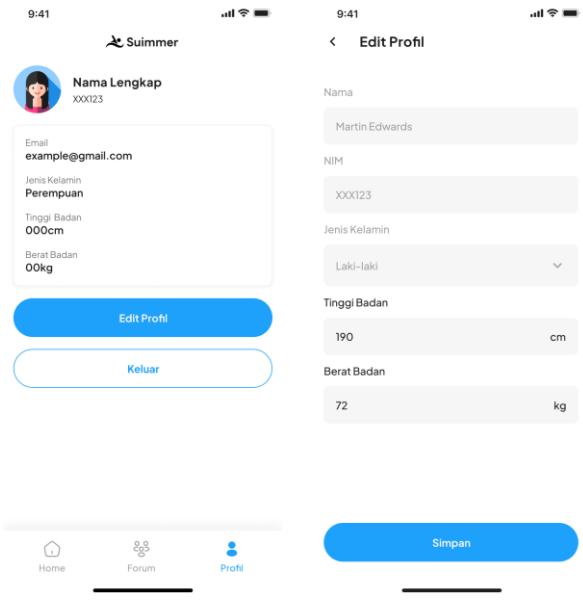



Fig 13. Profile page

c. Test

Testing was conducted using the Remote Usability Testing method via the Maze platform to measure the prototype's effectiveness and efficiency. The effectiveness test was conducted to measure users' success rates in completing each assigned task. The test involved 5 participants who were asked to complete 12 task scenarios. The results of the effectiveness test are presented as follows (Table 7). Based on the Table 7, it was found that there was one failure in a task performed by a respondent. The failure occurred because the button to add a post did not appear during the test. This issue was experienced by Respondent 2, who was using an iOS device, whereas for other respondents using Android devices, the button appeared and functioned as intended.

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Table 7. Effectiveness test results

| Respondent Code | Success Task | Failed Task | Total Task | Success Rate | Failed Rate | Average of Success Rate | Average of Failed Rate |
|---|---|---|---|---|---|---|---|
| **R01** | 12 | 0 | 12 | 100% | 0% | 98,34% | 1,66% |
| **R02** | 11 | 1 | | 91,7% | 8,3% | | |
| **R03** | 12 | 0 | | 100% | 0% | | |
| **R04** | 12 | 0 | | 100% | 0% | | |
| **R05** | 12 | 0 | | 100% | 0% | | |

Next, efficiency was measured by calculating the average time it took respondents to complete each task scenario. The process of measuring task completion time was conducted using Maze's analytics feature, which automatically records the duration of user interactions from the start to the completion of a task. The data obtained from Maze was then used to analyze the design's efficiency in helping users complete tasks quickly and easily. The following are the results of the efficiency testing that has been conducted.

Table 8. Efficiency test results

| Task Skenario | Respondent Code | | | | | Average |
|---|---|---|---|---|---|---|
| | R01 | R02 | R03 | R04 | R05 | |
| **T01** | 35 | 221 | 545 | 197 | 77 | 215 |
| **T02** | 117 | 182 | 561 | 49 | 54 | 193 |
| **T03** | 71 | 245 | 59 | 61 | 54 | 98 |
| **T04** | 36 | 68 | 50 | 74 | 43 | 54 |
| **T05** | 33 | 70 | 55 | 69 | 34 | 52 |
| **T06** | 67 | 118 | 125 | 71 | 98 | 96 |
| **T07** | 83 | 87 | 84 | 87 | 93 | 87 |
| **T08** | 114 | 189 | 83 | 68 | 65 | 104 |
| **T09** | 21 | X | 36 | 37 | 35 | 52 |
| **T10** | 18 | 114 | 57 | 67 | 37 | 59 |
| **T11** | 15 | 9 | 25 | 29 | 22 | 20 |
| **T12** | 25 | 19 | 29 | 38 | 25 | 27 |

Based on the table above, it can be seen that the time required by respondents to complete each task varies. These differences are influenced by the devices used during the testing process, as some respondents experienced longer loading times when accessing each design screen. This resulted in variations in task completion times among respondents.

Overall, the usability results show strong task completion in the tested prototype, but they also reveal important conditions that limit the strength of the conclusion. The 98.34% success rate suggests that the main interaction flows were generally understandable to the participants, while the single iOS failure identifies a concrete compatibility issue requiring refinement. Similarly, the variation in completion time indicates that technical loading conditions can affect the observed efficiency measure.

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Therefore, the prototype can reasonably be described as demonstrating promising usability under the tested conditions, rather than as having established definitive effectiveness and efficiency across the wider target population. This distinction is important because usability testing with a small formative sample is intended to identify interaction problems and guide iteration, not to provide population-level estimates of user performance (Borsci et al., 2013).

## CONCLUSIONS

Based on the results of the needs analysis, students in the Sports Coaching Education Program at Universitas Jambi have varying levels of swimming proficiency, necessitating instruction that can adapt the material to each student's individual capabilities. Instructors also require tools that can help identify students' initial abilities, organize learners into skill levels, and support the learning process without replacing direct practical supervision. The study therefore designed an intelligent-system-based swimming learning medium by integrating SAM and Design Thinking and applying a differentiated learning approach. The resulting prototype provides an initial assessment, rule-based proficiency classification, level-specific breaststroke materials, learning evaluation, progress monitoring, discussion, and instructor-oriented data management. In usability testing yielding an overall effectiveness rate of 98.34%. The results demonstrate promising prototype-level usability, while the device-specific failure and variation in loading time indicate that further technical refinement is required.

Practically, the proposed media can be implemented as a complementary tool in a real swimming class through a staged workflow, students complete the initial assessment before or at the beginning of the course, the system assigns an initial learning level, students access the corresponding practice materials, and instructors use progress records, student reflections, and uploaded performance videos to target face-to-face feedback. Such implementation could reduce repetitive classification and content-distribution work, while preserving instructor authority for safety decisions and practical skill assessment. However, the current study does not yet demonstrate improvements in swimming learning outcomes. The prototype is limited to breaststroke instruction and a rule-based initial classification mechanism, its questionnaire has not undergone formal psychometric validation, the usability test involved only five participants, and the evaluation did not compare the prototype with an existing learning medium or a control condition. Future research should therefore validate the decision rules against instructor and performance-based assessments, test the prototype with larger and more diverse groups across multiple iterative usability cycles, implement the media in an actual course, and measure learning, engagement, and skill outcomes longitudinally. More advanced intelligent features, including computer-vision-based movement analysis, may be considered only after the core instructional and assessment rules have been validated.

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