PAPER

Web-Based Virtual Laboratory Design in Class XI Chemistry Subject

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ABSTRACT
Practicum activities are crucial for supporting students' success in the teaching and learning process. To conduct the practicum, several factors are required, which vary depending on the field of practice. Adequate facilities and equipment are also necessary. The purpose of this research is to develop a web-based interactive virtual learning application for chemistry lab experiments. The stages involved in creating an application using the multimedia development life cycle (MDLC) method include planning, designing, collecting material, manufacturing, testing, and distribution. Creating applications using Unity software and designing assets with Adobe Illustrator. Virtual labs can help overcome the lack of costs associated with procuring laboratory equipment and materials, reduce the risk of work accidents, and can be accessed from anywhere.

KEYWORDS
chemistry, virtual lab, multimedia development life cycle, Unity, Adobe Illustrator

1   INTRODUCTION

Learning is the process of attempting to help students acquire knowledge or the act of teaching students [1]. The integration of media in the classroom is a crucial responsibility of the teacher, who plays a key role in guiding all class activities to accomplish their objectives. Therefore, educators need to recognize the importance of learning resources and understand that all educational processes can be optimized, even if learning resources are currently being overlooked. If the school does not have the necessary resources, the teacher should be capable of creating learning materials to support the learning process.

The presence of learning materials encourages students to think expansively in order to acquire more information. Learning media serves as a tool for teachers and also helps students access the information and messages they need. Therefore, the teacher is solely responsible for other aspects of learning activities, such as guidance and counseling. The use of instructional media is expected to provide students

with real-world experiences, stimulating the absorption of material in the learning process appropriately and effectively, according to the method used. The presence of learning media clarifies the learning process, which may not be clear, and allows students to deepen their understanding while studying.

Practicum activities are an important factor in supporting students' success in the teaching and learning process. In certain subjects, students not only need to comprehend basic concepts and supporting theories but also conduct experiments in the laboratory to gain a deeper and broader understanding of these concepts and theories. To conduct the practicum, several factors are required, which vary depending on the field of practice. Adequate facilities and equipment are also necessary. Chemistry is an important science to learn because it is widely used in everyday life. Therefore, it must be taught to children at an age when they are learning. Especially high school students, because in Indonesia, chemistry is only taught to high school students. Chemistry is a subject in high school (SMA) that some students consider difficult because it includes abstract concepts, memorization, and calculations, making it challenging for students to understand [2]. Many students struggle to comprehend and apply numerous formulas during chemistry lessons.

Based on observations at SMA Negeri 1 Sungayang, it was found that there were several obstacles preventing the practicum from being carried out. These included the condition of the chemistry laboratory, which was connected to other subject laboratories, and a lack of adequate practicum equipment.

Such conditions cause students to have low interest in learning because there are no practical activities. Efforts to facilitate practicum activities require innovative development of learning materials. One of the educational tools that can benefit from technological advancements in the field of education is web-based virtual lab media.

A virtual lab is a computer-based learning tool. This requires the use of computer software during design and development. The virtual lab is convenient, highly efficient, and harmless. It minimizes errors, aids student understanding, and provides microscopic images. Another advantage of using a virtual lab is the ability to use the lab repeatedly without incurring any additional fees. Such as damaged tools and safeguarding practitioners from actual direct hazards.

2   THEORY BASIS

2.1   Chemistry

Chemistry comes from the Egyptian word "Keme," which means "earth." It is the study of the composition, structure, and properties of matter, as well as the changes that occur during chemical reactions. Chemistry not only studies non-living materials but also biological materials and the chemical processes that occur in living things, both on Earth and in outer space. Chemistry is the scientific study of the composition, structure, properties, and changes in matter, as well as the energy associated with these changes [3].

Chemistry is defined as a natural science that studies matter, including its structure, composition, properties, and the changes in matter and energy that accompany it [4].

2.2   Enthalpy change

Heat is a form of energy. The heat can be detected using the temperature indicator of the substance. The higher the temperature, the greater the heat of the object.

In the laws of thermodynamics, the principle of the conservation of energy is known, which states that energy cannot be created or destroyed; it can only change from one form to another [5].

2.3   Laboratory

The laboratory is a place where experiments, measurements, and scientific research related to various sciences such as chemistry, physics, and biology are conducted. The laboratory can be a confined space, such as a room, or an open area, such as a garden, among others [6].

The laboratory serves to complement theoretical lessons, bridging the gap between theory and practice. It aims to develop students' scientific work skills, cultivate the courage to seek scientific truth from their natural and social environment, enhance proficiency in using tools and media to pursue truth, stimulate curiosity as a foundational scientific attitude for aspiring scientists, and build self-confidence through acquired skills and findings from laboratory work activities [7].

A well-equipped laboratory should have various facilities to support its activities [8]. Facilities include both general and special amenities. Facilities commonly used by all laboratory users include lighting, water, sinks, electricity, and gas. Special facilities can include tables, chairs, blackboards, tool cabinets, material cabinets, weighing rooms, fume hoods, first aid kits, and fire extinguishers, among others.

2.4   Learning media

Learning media refer to all physical tools that serve as aids, such as electronic devices, pictures, teaching aids, books, and other resources used to deliver lessons or explanations in teaching and learning activities [9]. Learning media encompass tools, environments, and various activities designed to enhance knowledge, alter attitudes, or cultivate skills in those who engage with them [10]. The learning media is an effort to enhance the learning process, formed through the interaction between teachers and students as well as the interaction of students with the environment [11].

2.5   Virtual laboratory

A virtual lab is a virtual practice space or a social platform where scientists interact online [12]. A virtual lab is a computer-based tool that includes simulations of activities to illustrate reactions that may not be observable in real-life situations [13]. The advantages of virtual labs include reducing time constraints, overcoming geographical barriers, being cost-effective, improving the quality of experiments, enhancing the effectiveness of learning, and increasing security and safety [12].

2.6   Storyboard

A storyboard is a graphic organizer, such as a series of illustrations or images displayed sequentially, used for the initial visualization of a film, animation, or sequence of interactive media, including website interactivity [14]. Storyboarding

is a technique used in film production management that involves the creation of a series of images for each scene. These images can then be visualized as sketch drawings if needed [15].

2.7 Adobe illustrator

Adobe Illustrator is software used for creating vector-based graphic designs. With illustrations, you can create amazing designs. In Illustrator, there are tools for professional design [16]. Adobe Illustrator is software used for creating illustrations. Adobe Illustrator is highly compatible with a wide range of other software. Adobe Illustrator is user-friendly and provides access to a wide range of features, particularly through a system of grouped facilities such as menus, toolboxes, and palettes [17].

2.8 Unity

Unity is a game engine developed by Unity Technologies. Unity is a game development tool with integrated rendering capabilities. Unity is a cutting-edge technology that streamlines and simplifies game development for developers [18]. Unity is an integrated development application with features that offer out-of-the-box functionality for creating 2D and 3D interactive content [19].

3 METHOD

The multimedia development life cycle (MDLC) is a software development methodology. The MDLC method can be likened to a waterfall, making it easy to understand and implement based on the stage of the process being carried out. With the development of MDLC technology, there is a need for interactive media such as PCs and Android smartphones to be utilized as effective learning tools for schools and lectures [20]. The MDLC method is illustrated in Figure 1.
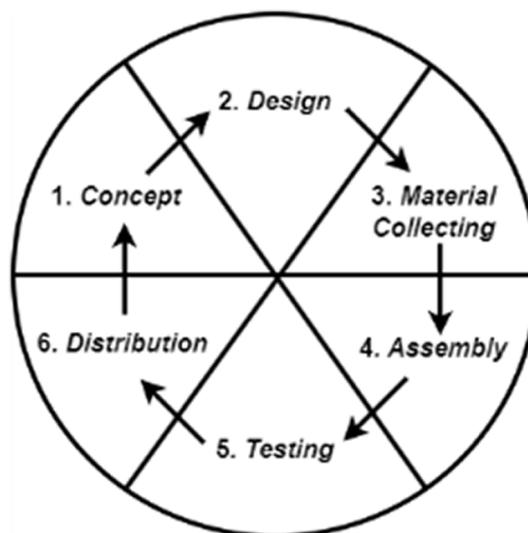

Fig. 1. MDLC method

Software development utilizes the Luther-Sutopo version of the MDLC [21]. The process consists of six stages.

3.1 Concept

The concept stage is where the goals and target audience of the program are determined (audience identification). Additionally, identify the type of application (e.g., presentation and interactive) and its purpose (e.g., entertainment, training, and learning). The purpose and intended use of the program influence the multimedia's tone, serving as a reflection of the organization's identity and its goal of delivering information to the end user.

3.2 Design

The design stage involves creating specifications for the program's architecture, style, appearance, and material requirements. The design will be created using the interface design from the application's menu display. The software used to design the interface is Adobe Illustrator.

3.3 Material collection

During the material collection stage, materials are gathered based on specific needs. This stage can be completed in parallel with the assembly stage. In some cases, the material collection and assembly stage will be carried out sequentially rather than simultaneously. These materials include clip art, animations, videos, audio, and other elements based on the design.

3.4 Assembly

Assembly (manufacturing) is the stage where all objects or multimedia materials are produced. Application development is founded on the design stage. Application development is founded on the design stage, which includes flowcharts and use cases. At this stage, application development utilizes Unity Software.

3.5 Testing

The testing phase is conducted after the assembly stage is completed by running the application or program to identify any errors. Also known as the alpha testing stage (alpha test), during this stage, tests are conducted by the manufacturer.

3.6 Distribution

The stage where the application is stored on a storage medium. At this stage, if the storage media is insufficient to accommodate the application, the application is then compressed.

3.7 System design

System design is conducted to describe, plan, and organize various elements into a cohesive system. The following is the system design:

Use case diagrams. A use-case diagram is a functional description that outlines the interactions within a system and can be accessed by its users. The design use case diagram for the virtual lab media can be seen in Figure 2.
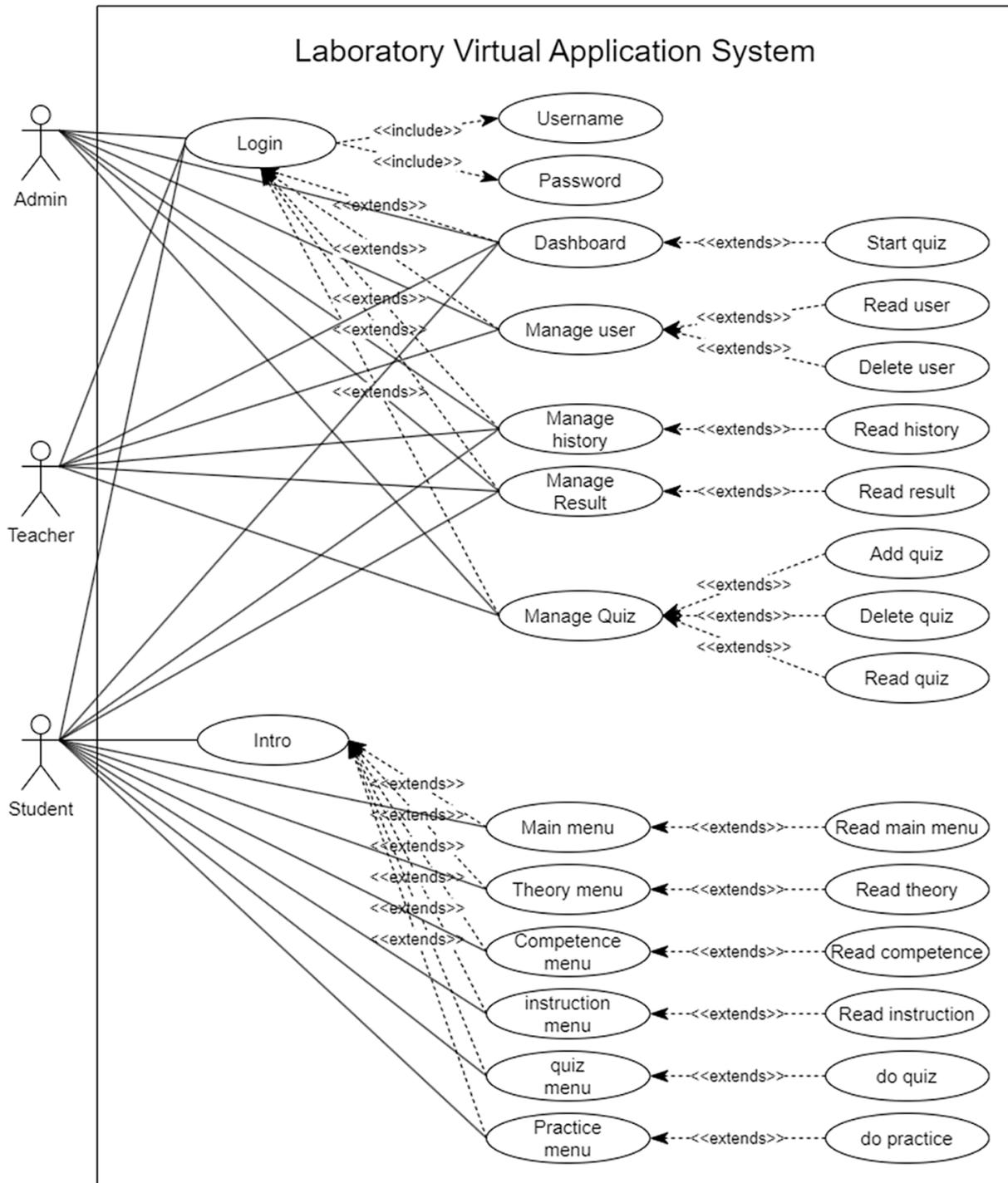

Fig. 2. Use case diagram of a virtual lab

Activity diagrams illustrate the sequence of activities from start to finish. The activity diagram for the water and urea lab page is shown in Figure 3.
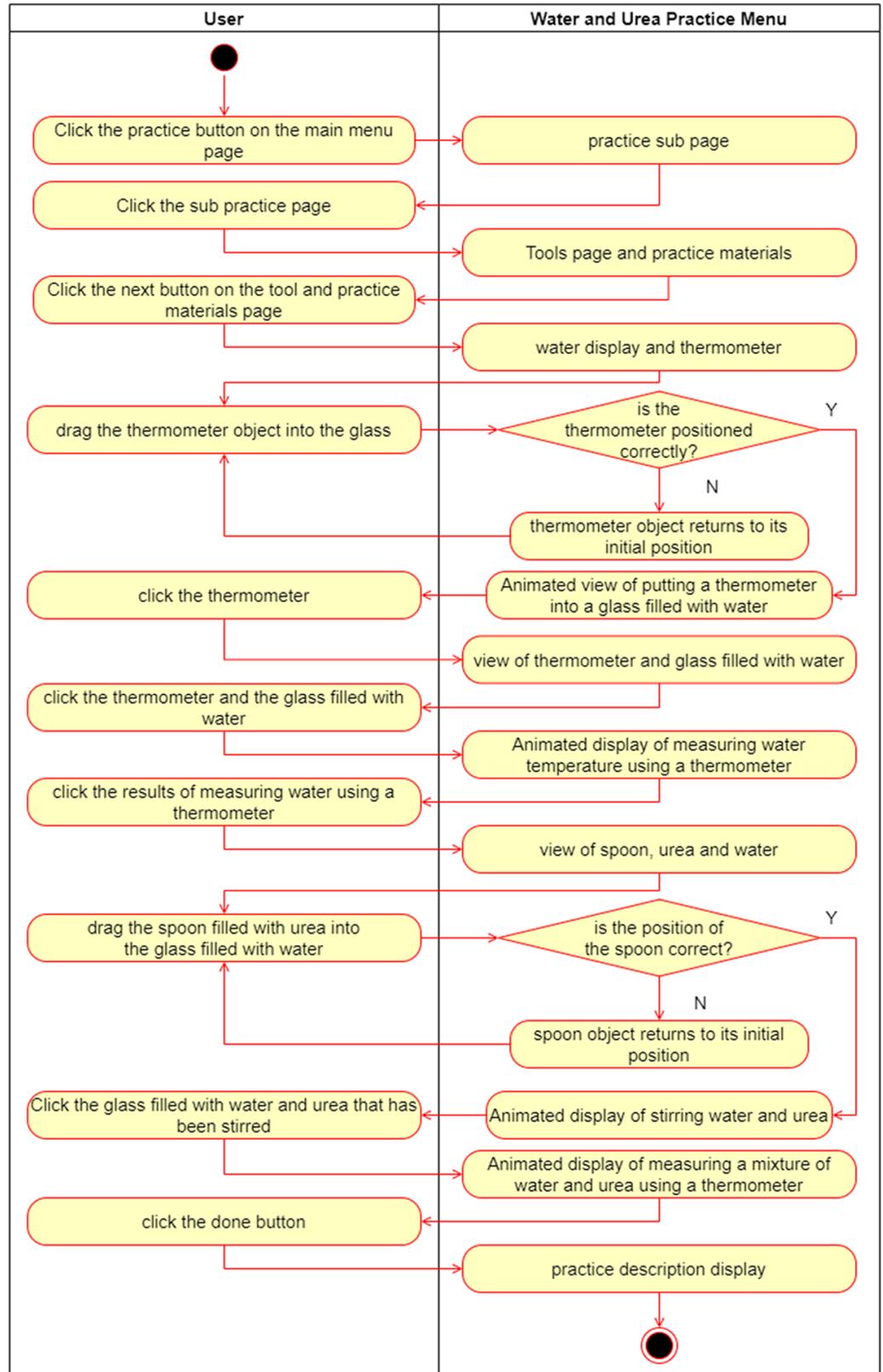
Fig. 3. Practice activity

Sequence diagrams depict the interactions between objects within the system (including users, displays, etc.) in the form of messages plotted over time. The practicum sequence diagram design is displayed in Figure 4.
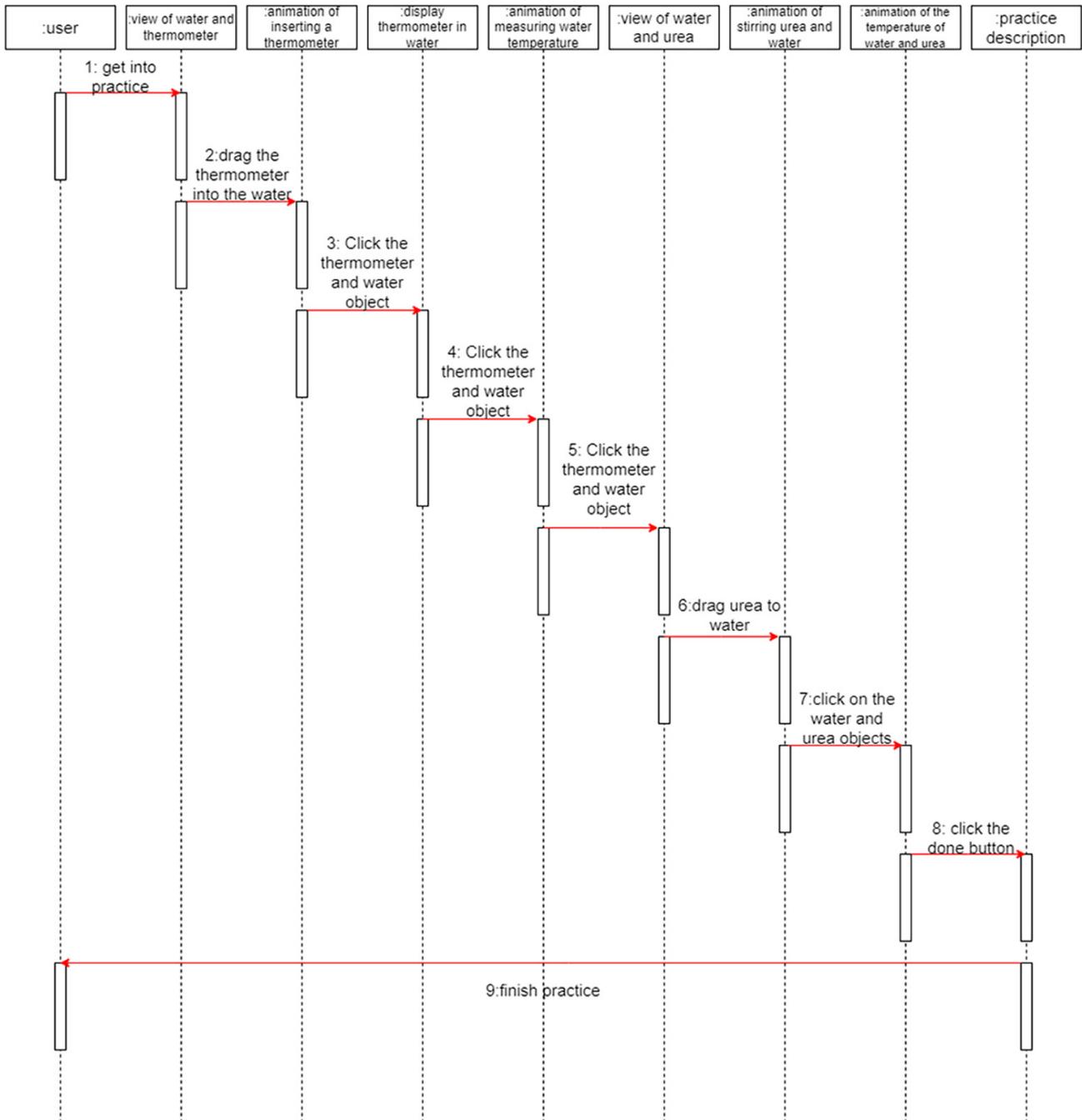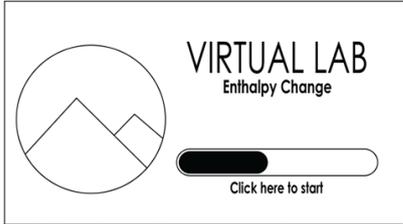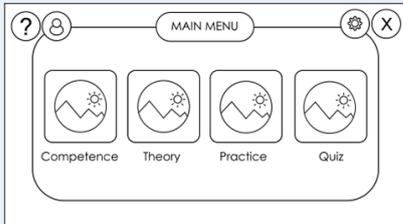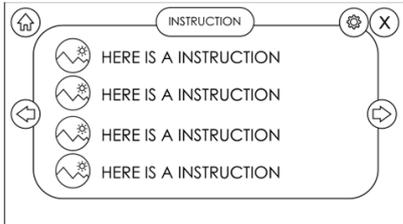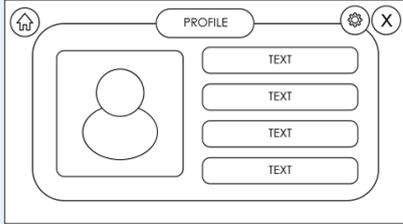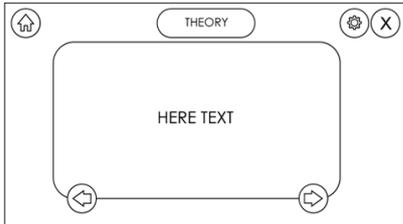

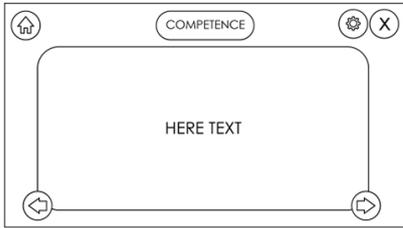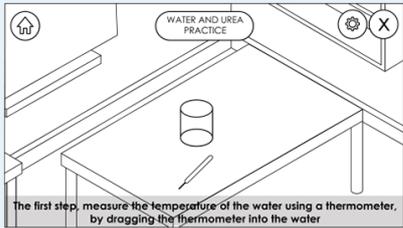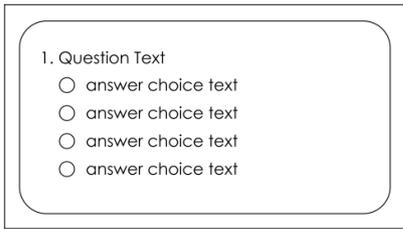**Fig. 4.** Practice sequence diagram

3.8 Storyboard design

Storyboard design serves to visually depict the sequence of a scene through a series of pictures, facilitating the creation of a cohesive storyline for the designer. The storyboard design layout is presented in Table 1.

Table 1. A virtual lab storyboard design

No	Visual	Information	Audio
1.	Intro scene 	The intro scene consists of a loading animation before entering the main menu scene. On loading full fill, text appears under loading. If pressed, the main menu scene appears.	BGM: Learning encouragement music
2.	Main menu scene 	The main menu scene contains buttons to menu competencies, materials, quizzes, practicum, settings and exit.	BGM: Learning encouragement music SFX: Sound when button is pressed
3.	Instruction Scene 	The hint scene contains the button functions of the application.	BGM: Learning encouragement music SFX: Sound when button is pressed
4.	Profile Scene 	The scene profile contains the application maker's biodata.	BGM: Learning encouragement music. SFX: Sound when button is pressed
5.	Theory Scene 	The material scene contains enthalpy change material which consists of understanding the enthalpy change.	BGM: Learning encouragement music. SFX: Sound when button is pressed

(Continued)

No	Visual	Information	Audio
6.	Competence Scene	The competency scene contains core competencies, basic competencies and indicators of material achievement.	BGM: Learning encouragement music. SFX: Sound when button is pressed
7.	Practice Scene	The practicum scene contains a laboratory room and practicum tools.	BGM: Learning encouragement music. SFX: Sound when button is pressed
8.	Quiz Scene	The scene quiz contains multiple choice questions regarding enthalpy change material.	BGM: Learning encouragement music. SFX: Sound when button is pressed

4   RESULTS AND DISCUSSION

4.1   Implementation of the user interface

When you first access the virtual lab media, the initial loading screen will appear before you reach the main menu. The screen appearance is illustrated in Figure 5.

Fig. 5. Intro page

This page displays the application's main menu, which can be accessed by various main menu pages. The main menu features several buttons, including the competency button to display competence, the theory button to access theory, the practice button to navigate to practice, and the quiz button to display quizzes. The display is shown in Figure 6.

Fig. 6. Main menu page

The competency page is a page that contains information about enthalpy change. The appearance is shown in Figure 7.
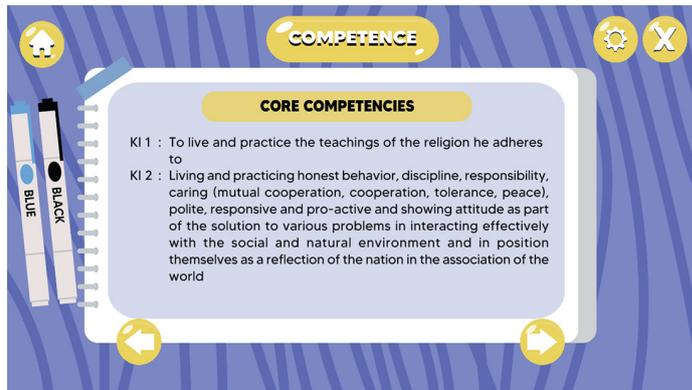

Fig. 7. Competency page

This page contains general instructions for using the application and descriptions of its elements. The display is shown in Figure 8.
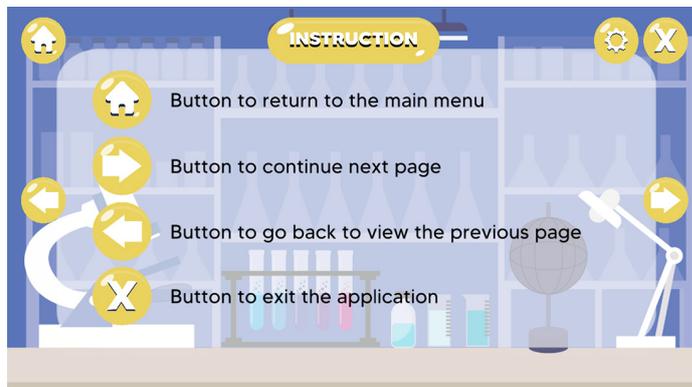

Fig. 8. Instructions page

The materials page contains information about enthalpy change, including text and images. The appearance is shown in Figure 9.
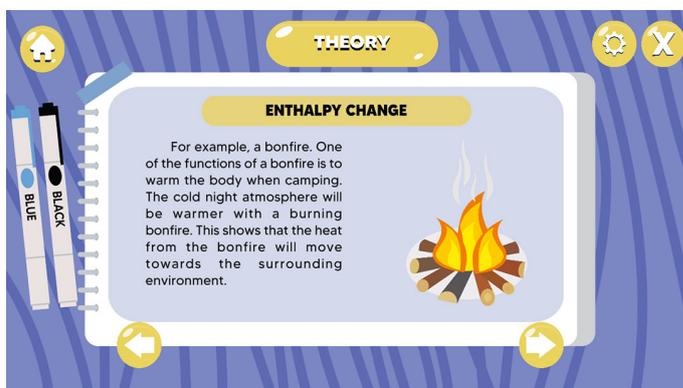

Fig. 9. Theory page

The page contains a series of simulations of practical activities. The appearance is shown in Figure 10.
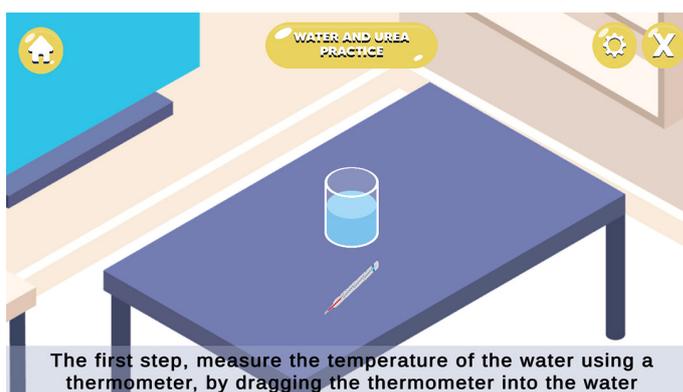

Fig. 10. Practice page

The quiz page displays multiple-choice questions about enthalpy change materials. The display is shown in Figure 11.
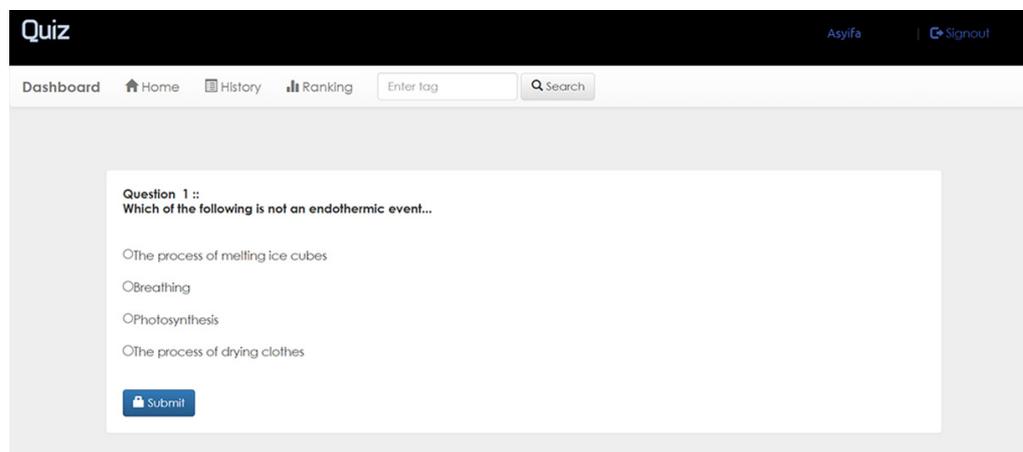

Fig. 11. Quiz page

4.2 Test results

The testing phase involves black box testing, which focuses on the functionality of the application being developed. During the testing phase, all menus have been functioning well, and each menu effectively demonstrates the performance of this application. The test results are displayed in Table 2.

Table 2. Application testing results

No.	Page	Results	Explanation
1.	Intro page	The application displays a loading animation and the text "Click here to start" appears, press the text "Click here to start" to move to the main menu page.	OK
2.	Main menu page	The application displays buttons between menus, settings buttons and exit buttons.	OK
3.	Instructions page	The application displays a help page containing the function of the menu button in the application.	OK
4.	Competency page	The application displays competency pages consisting of core competencies, basic competencies and competency achievement indicators.	OK
5.	Theory page	The application displays a material page containing enthalpy change material.	OK
6.	Practice page	The application displays practical simulations of reacting water and urea, water and NaOH, baking soda and vinegar, magnesium and hydrochloric acid.	OK
7.	Quiz page	The application displays a quiz page.	OK

5 CONCLUSION

The conclusion drawn from the discussion about creating virtual lab applications is that they can help overcome the lack of funds for procuring laboratory equipment and materials. Virtual lab applications can be accessed from anywhere. The virtual lab application can reduce the risk of work accidents because all assets are in virtual form. The system design process involves creating various system requirement designs, such as class diagrams, activity diagrams, sequence diagrams, and storyboard designs.

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