The Design of Sensor and Transducer Learning Media based on Augmented Reality

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Abstract. This study aimed at determining the design stage of the augmented reality-based learning media for sensors and transducers course. This study employed the Research and Development method with the ADDIE model with the stages of analysis, design, development, implementation, and evaluation. This article focuses on the design stage during the process of media development. The developed learning media can be used among vocational students by visualizing the sensor and transducer components like in the real laboratory setting. The design of the developed learning media contained application storyboards and animation storyboards for practicing the six sensors. This augmented reality learning media is designed to support online learning and students’ autonomous learning in the practical course of sensors and transducers.

1. Introduction

COVID-19 has changed human activities including the whole educational system into online learning from elementary to tertiary level. This radical shift demands a reconstruction in the teaching and learning process [1]. The obstacles of online learning are mostly in the practical courses that emphasize skills development since it requires specific tools and equipment in the labs or workshop which is quite impossible to be done during the pandemic. The inadequate online learning media for practical activities has been another major issue that hinder the material mastery among students. The low quality of learning media will hamper the online learning process, especially the practical course since the existence of learning media can attract students’ learning motivation [2].

This condition is widely open an opportunity to develop a learning media for the practical course. One of the gadget-based technologies that can be put forward is augmented reality (AR) that has been widely used in the game world where it can provide real experiences to gamers. Augmented Reality (AR) refers to an interactive technology that combines the physical environment with virtual elements where a virtual layer is placed between the physical environment and the user who can add images, textual information, videos, or other virtual components [3]. AR is suitable for the teaching and learning process because students can have the same virtual form that allows them to interact or work together on the same target [4]. AR technology can be used in the world of engineering education since it can make virtual objects like real objects and the results are displayed interactively in real-
time. AR can also be a beneficial media for learning process, especially in practical activities [5], [6] and it can support autonomous learning since it can be used anytime and anywhere [7], [8].

Besides, the use of virtual technology allows students to develop critical thinking skills, innovation, and teamwork [9]. It indicates that AR is appropriate to be applied in the sensor and transducer course to provide a better learning experience among students during their online learning. Sensors and transducers are important components in electronic circuits. The sensor is a device that receives a stimulus or signal and can respond to the stimulus in the form of an electrical signal [10]. The sensor is a system element that functions to measure a variable and produce output in a certain form [11]. The output signal is in the form of an electrical signal, such as a voltage or current. The results of the sensor readings are still in the form of electrical quantities based on the variables being measured so that these quantities need to be converted into electrical forms to be processed by the electronic system. This article aims to discuss the designing process of the Sensor and Transducer learning media based on the augmented reality technology.

2. Research Method
This study employed the Research and Development method based on the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) development model according to Lee and Owens [12]. The ADDIE model began with an analysis phase consisting of a need assessment and front-end analysis. The data were obtained through observation and interviews. A needs analysis was done to determine the gap between the real situation and the expected state as well as determine the following action. Meanwhile, the front-end analysis was to obtain more detailed information including technical analysis, student analysis, situation analysis, task analysis, current issue analysis, objective analysis, media analysis, cost analysis, and data analysis.

Furthermore, the design stage was carried out by arranging the implementation schedule and the content plan to be included in the learning media. The development and implementation stages in the development of learning media were based on the plan and validated by the material and media experts. Meanwhile, the implementation stage was the field testing of the developed learning media. The last stage, the evaluation stage, was done to assess the effectiveness of the product. The flow of the ADDIE model development process can be seen in Figure 1 below.

![Figure 1. Development Stage of ADDIE Model](image)

3. Research Results and Discussion
This research began with the analysis phase consisting of needs assessment and front-end analysis. The needs assessment was carried out in the form of observation to find out the gaps in the sensor and
transducer courses. The current gap was that the students’ competencies that were below the expected results due to the online learning system in the practical course. The gap indicated that, during their online learning, the students only carried out simulations that were different from the real practicum settings. Meanwhile, the front-end analysis involved technology analysis of which most students had already used smartphones. It means that the development of smartphone-based augmented reality applications can be applied in the learning process. The students’ analysis included background identification, learning characteristics, and students’ prerequisite skills. The analysis of the current situation indicated that the sensor and transducer practicum was carried out online which resulted in a lack of real practical experience or the condition that resembled the real situation. Task analysis contained the learning outcomes of sensors and transducers where students can assemble and operate sensors and transducers.

The analysis of the latest issues related to the current conditions of the Covid-19 outbreak urged educators to be more creative in preparing the learning media. The objective analysis was to identify the target to be achieved in the sensors and transducers learning where students must understand the various working principles of both components. Media analysis referred to the strategies for distributing media to students which can be implemented using the cloud and social media. The cost analysis was the development of augmented reality-based software which was cheaper than the procurement of practicum trainers. The data analysis employed the identification of learning materials, worksheets, syllabus, sensor, and transducer references. Based on the description above, it is clear that the development of augmented reality-based learning media can be realized to support online learning of sensors and transducers course.

The design stage was carried out through content planning including application design, animation design, and material content design. The contents of the material in the application included reed switch sensors, flame sensors, MQ-7 sensors, sound microphone sensors, PIR sensors, and soil moisture sensors. The animation needs to be added to make the display more attractive. The application design was done by making storyboards as presented in Table 1 below.

### Table 1. Storyboard of Augmented Reality Applications for Sensors and Transducers

| No | Interface | Explanation |
|----|-----------|-------------|
| 1  | ![Application Start](image) | **“Application Start”**  
A. Application icon containing an overview of the application.  
B. Application name “Sensors and Transducers”. |
| 2  | ![Loading](image) | **“Loading”**  
A. Application logo.  
B. Loading process to provide information to users that the application can be run on the device. |
| No | Interface | Explanation |
|----|-----------|-------------|
| 3  | ![Interface Image] | **“Menu Display”**  
A. Small size logo of Ristekdikti and UNY on the top left of the screen.  
B. Cross logo to exit from the application.  
C. Application Title “Sensors and Transducers”.  
D. Logo “Scan Augmented Reality” with a text explanation at the bottom.  
E. A logo that describes the developer or researcher with the text of “Over View” at the bottom.  
F. A logo that explains the instructions for the use of the Augmented Reality application with the text of “Instructions for Use” at the bottom.  
G. The music logo is crossed out and when the user presses the logo, the music will turn off and the logo changes to music without streaks. |
| 4  | ![Interface Image] | **“Cross logo to exit from the application”**  
A. The question “Are you sure you want to exit”.  
B. “Yes” statement. When the user presses the button, the application will be closed.  
C. “No” statement. When the user presses this button, it will return to the last open page. |
| 5  | ![Interface Image] | **“Scan Augmented Reality”**  
A. Small size logo of Ristekdikti and UNY on the top left of the screen.  
B. Cross logo to exit the application.  
C. Title of application “Sensors and Transducers”.  
D. The text of "Sensor Menu Options".  
E. “Reed Switch Sensor”.  
F. "Flame Sensor".  
G. “MQ-7 Sensor”.  
H. "Sensor Sound Activation".  
I. “PIR Sensor”.  
J. “Soil Moisture Sensor”.  
K. The music logo is crossed out and when the user presses the logo the music will turn off and the logo changes to music without streaks.  
L. Logo Home to return to the start page of the application. |
| 6  | ![Interface Image] | **“Reed Switch Sensor, Flame Sensor, MQ-7 Sensor, Sound Sensor Activation, PIR Sensor, and Soil Moisture Sensor”**  
A. Small size logo of Ristekdikti and UNY on the top left of the screen.  
B. Cross logo to exit the application.  
C. The music logo is crossed out and when the user presses the logo, the music will turn off and the logo changes to music without streaks.  
D. Logo Home to return to the Augmented Reality scan page.  
E. The “View Information” button displays information about the scanned AR.  
F. The “Rotation” button rotates the displayed 3D object rotates 360 degrees.  
G. The “Simulation” button simulates the displayed 3D object with the detecting 3D object. |
3.1. Reed Switch Sensor Animation

The animation of the reed switch sensor is shown in the form of a storyboard in Table 2. The animation of Reed Switch Sensor is for a safety indicator of motor rotation. When the motor stops, the indicator (light) will turn off. If the motor is on, there will be a magnetic field around the motor and the indicator will turn on to warn the workers around the working area.

**Table 2. Storyboard of Reed Switch Sensor Animation**

| No | Action | Duration | Explanation |
|----|--------|----------|-------------|
| 1  | ![Image](image1.png) | 00:00:03 | There are 3 objects in the first state, i.e., the motor is off, lights, and sensors. |
| 2  | ![Image](image2.png) | 00:00:05 | The motor starts (marked by the movement of the motor rotation) and it produces a magnetic field around the motor. |
| 3  | ![Image](image3.png) | 00:00:04 | The sensor detects the magnetic field around the motor, then the indicator is on (lamp). |
| 4  | ![Image](image4.png) | 00:00:04 | The motor is getting slow down. |
5.00:00:02 The motor stops rotating, and the indicator light turns off showing the loss of the magnetic field generated by the rotation of the motor.

3.2. Flame Sensor Animation

The concept of the animation of the Flame Sensor is to show the indicator of the sparks in a room. If there is a spark in the room, the indicator will light up. Table 3 shows the storyboard of the sensor flame animation.

**Table 3. Storyboard of Sensor Flame Animation**

| No | Action | Duration | Explanation                                                                 |
|----|--------|----------|-----------------------------------------------------------------------------|
| 1  | ![Sensor Installing](image) | 00:00:02 | The sensor is installed on the roof of the room and the indicator light on the walls of the room, and the water sprayer on the ceiling. |
| 2  | ![Sparks Appearance](image) | 00:00:05 | The sparks appear, and the sensor detects the incidence in the room.         |
| 3  | ![Spark Detection](image)  | 00:00:04 | Along with the sensor that detects a spark, it immediately turns on the indicator in the form of a lamp and water spray. |
| 4  | ![Fire Diminishment](image) | 00:00:04 | The fire began to be diminished and going out.                               |
| 5  | ![Indicator and Sprayer](image) | 00:00:02 | The indicator light and water spray turn off, and the sensor goes back in standby mode. |

3.3. MQ-7 Sensor Animation

The animation of the MQ-7 sensor is presented in the form of a storyboard as shown in Table 4. The animation concept is a gas cylinder storage warehouse. When the sensor detects a leak from the gas, it will turn on the indicator and blows a warning sound.
### Table 4. Storyboard of Sensor MQ-7 Animation

| No | Action | Duration | Explanation |
|----|--------|----------|-------------|
| 1  |        | 00:00:02 | The sensors detect gas leaks in a storage warehouse. |
| 2  |        | 00:00:04 | The gas comes out due to a leak in the tube. |
| 3  |        | 00:00:01 | The gas leak has been detected and it signals the indicator and warning lights. |
| 4  |        | 00:00:05 | The indicator and warning lights are getting on. |
| 5  |        | 00:00:04 | The officers handle the leak in the gas cylinder. |
| 6  |        | 00:00:02 | After all has been handled, the indicator light and siren turn off, and the sensor goes back in standby mode. |

#### 3.4. Animation of Sound Activation Sensor

The animation of the sound activation sensor is presented in the form of a storyboard as shown in Table 5. The concept is a room equipped with a sound activation sensor that detects hand clapping to turn on or turn off the room lights.

### Table 5. Storyboard of Sensor Sound Activation Animation

| No | Action | Duration | Explanation |
|----|--------|----------|-------------|
| 1  |        | 00:00:02 | The sensor is installed on the wall with the lamp as the output of the sensor. |
| No | Action | Duration | Explanation |
|----|--------|----------|-------------|
| 2  | 00:00:02 Hand clapping. |
| 3  | 00:00:03 The sensor detects the sound and gives a signal to turn on the room lights. |
| 4  | 00:00:02 The following hand clapping is to turn off the lamp. |

### 3.5. Animation of PIR Sensor

The animation of the PIR sensor in the form storyboard is presented in Table 6. The concept of this animation refers to the application of PIR sensors in hotel hallways that detects human movement. The lights will be on when a person is passing through the hallway. On contrary, if the PIR sensor does not detect any movements, the lights remain off.

**Table 6. Storyboard of PIR Sensor Animation**

| No | Action | Duration | Explanation |
|----|--------|----------|-------------|
| 1  | 00:00:02 The sensor is installed in the hotel hallway. |
| 2  | 00:00:03 Someone appears and the sensor detects a movement. |
| 3  | 00:00:04 The lamp is turning on. |
| 4  | 00:00:05 The person moves away from the hallway and no more movement are detected, so the sensor signals the light to turn off. |
3.6. Animation of Soil Moisture Sensor

Animation of soil moisture sensor is presented in Table 7. The concept of this sensor is to monitor the humidity level in plants. When the plant lacks water, the soil color becomes light brown (dry). If it is watered and getting wet, the moisture level is good, and the soil color will be dark brown. The humidity level on this plant can be known from the given indicator in the upper right corner.

Table 7. Storyboard of Soil Moisture Animation

| No | Action | Duration | Explanation |
|----|--------|----------|-------------|
| 1  |        | 00:00:03 | The sensor detects that the humidity decrease based on the indicator (from 80% to 20%), and the color of the soil becomes light brown (dry). |
| 2  |        | 00:00:08 | The water sprinkler comes out and pours water on the soil, and this indicator level changes (from 20% to 80%), so the soil color that was light brown (dry) becomes dark brown (wet). |
| 3  |        | 00:00:02 | The sprinkler moves away from the plant and back to its place. |

4. Conclusion

The design of augmented reality-based learning media on the sensors and transducers course can be developed to support the practical learning. The design of this learning media is in the form of application display storyboards and animation storyboards. The designed storyboard will be used as a reference for the following stage. Further research is the development stage of the augmented reality-based learning media.

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