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Design of a Pneumatics System Learning Material with AR Technology for Vocational Education Students

Tanit PHETCHAKAN [a,b*],Suppachai HOWIMANPORN [a] & Sasithorn CHOOKAEW [a]
[a]*Department of Teacher Training in Mechanical Engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand*
[b]*Rayong Technical College, Thailand*
* datatanit@gmail.com

Abstract: Nowadays, education in industrial engineering places a significant emphasis on pneumatic systems due to their widespread application in conveyor belt systems and various automated industrial processes. Components within pneumatic systems include compressors, air preparation units, directional control valves, actuators, and gripping devices. Therefore, understanding pneumatic systems necessitates having a solid understanding of how to employ these components efficiently. In educational management, the development of learning materials holds paramount importance. These materials play a pivotal role in facilitating enhanced comprehension among students. Integrating augmented reality technology further enriches the learning experience, specifically in understanding pneumatic systems. This technology provides students with a comprehensive system overview before engaging with actual equipment in practical tasks. This study proposed the design of a pneumatics system learning material with AR technology for vocational education students. It encourages the student's motivation in the concept of pneumatic systems. We created a model using 3D and AR application programs to generate learning material to display on mobile devices. The circuits of the function of the cylinder work in various conditions. It has been used to simulate the use of training skills for students or interested people to apply such knowledge to work in the workplace in the future.

Keywords: Augmented reality technology, pneumatics system

1. Introduction

The world is moving towards a new industry of the future. Especially Thailand Industry 4.0. policy focused on the technicians or workers is a critical force that will dramatically change the pattern of the industry. This group of technicians' development is significant and must come from knowledge, experience, and technology. There are fewer workers in Thailand in the field of professional work with skills that meet the industry's needs. Thus, many vocational colleges attempt to increase the workforce with such produce technical skills to reach a high level, and it is necessary to work together to accelerate the development of vocational students who are professional workers in the system. Innovative technology is becoming increasingly vital in the education system. Mainly engineering education necessitates using technology to assist students in understanding abstract concepts and principles. Augmented reality (AR) is a technology that can be used to create effective and engaging technology-based solutions and instructional materials.

AR is a technology for learning that has significantly increased over a wide range of applications, primarily used in engineering education (Singh et al., 2019; Enzai et al.,2021; Takrouri et al., 2022; Koparan et al.,2023). Many studies presented an augmented reality-based learning experience to teach students in many engineering majors, such as electronics engineering majors identifying AR intervention on students' academic achievement levels, positive learning attitudes toward the subject, and individual attitudes toward AR (Tuli et al., 2022). It provides significant benefits, such as increased engagement and interactivity, and can help to minimize the adverse effects of the disruption of face-to-face education (Criollo-C et al.,2021).

AR technology is categorized into two primary types: those reliant on pictograms and those based on coordinate systems for data analysis to generate virtual world information. Commonly, the symbols employed in these systems are referred to as "Markers" or sometimes AR Codes. These markers are detected using a webcam, and when the software processing the image identifies a specified symbol, it renders the 3D image information programmed for that marker. Users have the capability to freely rotate the displayed image in all directions, a feature often described as a 360-degree rotation.

Pneumatic systems are used extensively in industrial applications, regulating machinery operations across a spectrum ranging from small to large industries. Employing pneumatic systems for control aims to streamline work processes with simple circuit design and control mechanisms. Additionally, pneumatic systems boast a high level of safety (Wang et al.,2021; Montalvo et al.,2021). Now commonly utilized, these systems are automatic control systems and are controlled electrically. Presently, numerous factories have established production bases in Thailand, leading to the emergence of multiple industrial estates. This trend is attributed to government policies promoting the growth of small and medium-sized enterprises. Consequently, there is intense competition in the marketing and pricing of products. This study designed a pneumatics system learning material with AR technology for vocational education students. It encourages the student's motivation in the concept of pneumatic systems. We created a model using 3D and AR application programs to generate learning material to display on mobile devices. The circuits of the function of the cylinder work in various conditions. It has been used to simulate the use of training skills for students or interested people to apply such knowledge to work in the workplace in the future.

2. Related work

2.1 Mobile Application for Learning

Technological innovation will transform the teaching and learning process with new types to enhance students' development and contextual understanding. Most students are focused on mobile screens in the classroom, and they will all be viewing holographic 3D objects surfaced from a table while the teacher explains the visuals (Hadgraft & Kolmos, 2020). The modern engineering educational environment ensures an extensive application of AR on mobile device technology to memorize graphic material successfully (Zhylenko et al., 2021). Arulanand et al. (2020) presented an AR-based application with Android studio on a topic in the Engineering Graphics course for engineering drawing. Several steps are involved in creating the application, and the below block diagram shows how to create and deploy the application. Wongwatkit et al. (2018) presented the context of an educational institution focusing on developing student learning outcomes throughout the curriculum. The learning outcome is and determines how students will be after the teaching and learning process.

3. Conceptual Framework

3.1 Development AR mobile application

This study proposed the development of a pneumatics system learning material using AR to promote vocational students based on the learning factory. Pneumatics system concepts should be learned based on the subject's learning outcomes so that the student can understand the principle of the pneumatics system. Thus, the conceptual framework of the study is shown in Figure 1.

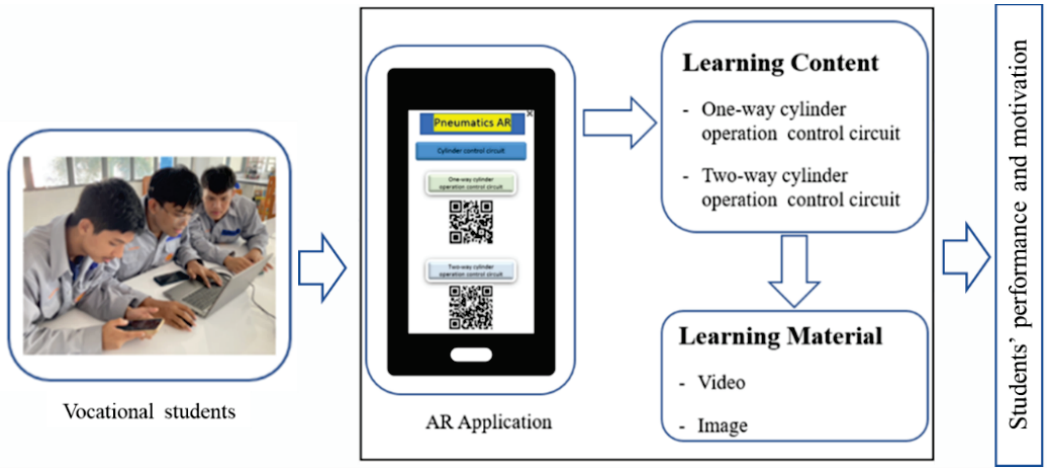

Figure 1. Augmented Reality technology conceptual framework

3.2 ADDIE instructional development model

ADDIE model is a well-established framework for creating and delivering educational media, backed by published research. It serves as an excellent guideline for instructional designers, lesson planners, and training course developers in designing effective and engaging learning experiences.

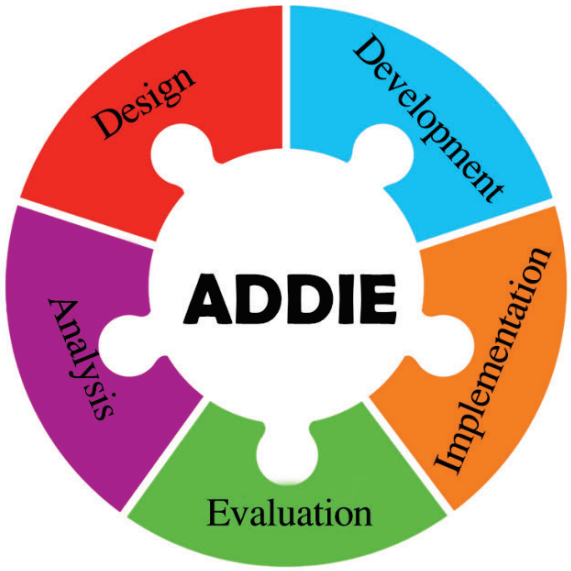

Figure 2. ADDIE model

In this development process, we use ADDIE instructional development model (Chookaew et al., 2014) to create effective AR learning material as follows:

- *Step 1 Analysis:* The analysis clarifies the instructional problems and objectives and identifies the learning environment and student's existing knowledge and skills. We analyzed the content and concept of control circuits in pneumatics systems in the diploma program.
- *Step 2 Design:* This step is designing the learning material based on the learning objectives of control circuits in pneumatics systems. It is guidelines for presenting the lesson as content details of the pneumatics systems. In this study, the student can scan the QR code as a maker for a selection of cylinder control circuits in the worksheet, as shown in Figure 3.

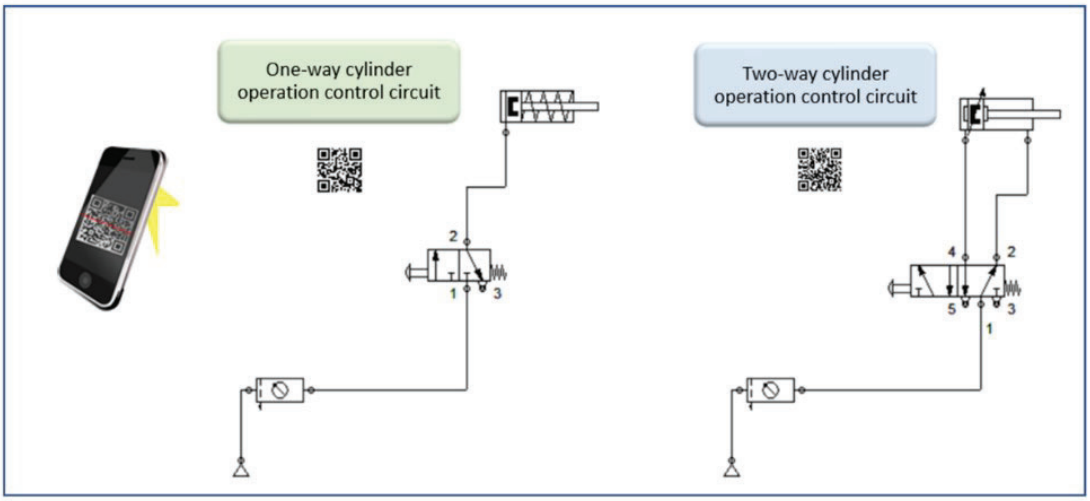

Figure 3. Scan the QR code in the worksheet to select the cylinder control circuits.

- *Step 3 Development:* The conceptual development of the learning material on the mobile application. In this step, the design of the application screen is to match the content and be appropriate for the students. Figure 4 shows the content of the cylinder control circuit. We created an AR application for the pneumatics systems course, including four sections as follows:
  1. The entrance to the instruction is to scan the QR Code to select the cylinder control circuit worksheet. The student can select the One-way cylinder operation control circuit or the Two-way cylinder operation control circuit.
  2. The entrance to the AR application are content pages, and the students can click details of pneumatic equipment.
  3. The student can see symbols and images of pneumatic equipment.
  4. The students click the RUN button; they can see a video of the working process of the pneumatic system.

Figure 4. Examples of instrumental material of cylinder control circuit on mobile device

- *Step 4 Implementation:* After developing the learning material is complete. This step can be implemented with students in target groups that are vocational education to achieve based on learning outcomes and prepare evaluation procedures.
- *Step 5 Evaluation:* This step consists of two sections. First, we design the evaluation of students in the cognitive domain, which is students' understanding of pneumatics system concepts. Second, we designed to evaluate student motivation for AR learning materials.

4. Conclusion and Future work

This paper presents designing a pneumatics system learning material using augmented reality technology for vocational students. We focus on simulated circuits of the function of the cylinder work in various conditions. It has been used to motivate the use of training skills for students or interested people to apply such knowledge to work in the workplace. This proposed AR application of learning a pneumatics system is used to motivate and promote the students' understanding of pneumatic circuits before implementing them in actual situations. We plan to implement it with the students in future studies to ensure this learning material can encourage students to improve their learning performance and motivation.

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