IIAI Open Conference Publication Series
IIAI Letters on Informatics and Interdisciplinary Research
Vol. 004, LIIR139
DOI: https://doi.org/10.52731/liir.v004.139

The Research of Using STEM-6E Teaching Model in AR Technology Learning: System Development and Evaluation

Fang-Chuan Ou Yang*

Abstract

In recent years, the application of AR/VR/MR in various fields has gradually risen, and the popularization of 5G has driven the vigorous development of AR-related products in various application fields. This study mainly proposes an AR learning system that combines STEAM-6E teaching model to enable learners to understand the application of cross-domain technology in the process of "learning by doing", and also understand the current technical principles of AR and the main applications in the industry. This system is mainly divided into four thematic learning units. The design of each unit uses STEAM-6E as a scaffold for learning and implementation to guide students from cognition, understanding, verification to implementation step by step to understand AR technology. The learning content conforms to the core literacy and learning goals of mathematics, natural sciences, arts and technology fields in the 108 curriculum for elementary, junior high and high schools in Taiwan, and has academic contributions and practical promotion value for K-12 science literacy education.

Keywords: Augmented Reality(AR), STEAM-6E, learning by doing.

1 Introduction

Due to the gradual rise of AR/VR/MR (collectively known as XR) and Metaverse, applications on smartphones, AR glasses, AR 3D storybooks, AR Pokemon-like mobile games, and interactive hologram projection boxes have become more and more common. There are also many examples of using AR technology in educational settings, however, is still a novelty to most people, and they usually have misconceptions about the principles and applications of AR technology. AR technology has multiple branches and each branch technology has different visual effects and user experience. However, it's difficult for students to understand the differences between these branches of AR technology because most of the AR learning materials focus on teaching students how to make AR applications, and there is often no systematic and in-depth introduction to the principles and knowledge of AR technology. Before being able to use AR technology in various fields, there should be a clear understanding and understanding of the various branch technologies of AR so that it can be used appropriately and achieve the expected results. Moreover, due to the interdisciplinary nature of AR, it is suitable for teaching AR in combination with STEAM education[1]. Active learning method is good for encouraging students to participate in the learning process and take responsibility for their learning experience[2]. It provides students with a curious environment where teachers act as facilitators, guiding students to use inquiry, critical thinking, and problem-solving skills while learning through practical, hands-on, project-based activities.

* Department of Digital Multimedia Design, National Taipei University of Business, Taipei, Taiwan

This study mainly proposes an AR learning system based on the STEAM-6E model, which allows students to have a clear understanding of different AR technologies and applications and apply interdisciplinary knowledge in the learning process. The purpose of this learning system is not to teach students how to create AR programs, but to give them a deeper understanding of the emerging AR technologies around them. Therefore, this system is not designed for students with IT background, but is more suitable for beginners who want to enter the field of learning AR technology. In addition, in order to promote active learning among students, the STEAM-6E model has also been integrated into this learning system, allowing students to learn AR knowledge step by step from principles to hands-on through the spirit of exploration and practice.

2 Literatures

2.1 Augmented Reality

Augmented Reality (AR) is a technology that overlays computer-generated information on the real-world view and presents it to the user. Today, AR technology is not only used in military and engineering fields, but also widely used in entertainment, marketing, manufacturing, medicine and education [3]. The presentation of virtual information in AR includes two key technologies: localization and mapping. Localization refers to marking the three-dimensional coordinate position where virtual information is to be presented in space, while mapping places virtual information objects on the display and adjusts the orientation of the three-dimensional coordinates of the space. In AR technology, localization and mapping are simultaneous mechanisms, often referred to as Simultaneous Localization and Mapping (SLAM). The main technologies for computer calculation of SLAM are mainly divided into three categories: image-based, location-based and object-based. Image-based AR technology mainly requires a visual image as a marker to trigger SLAM, so it is also called marker-based AR. When the input device (e.g., camera) detects the marker, the computer uses the three-dimensional coordinate points of the marker as a reference to locate and map the orientation and alignment of virtual information objects on the display relative to the real world. Location-based AR technology uses GPS and electronic compass system information as input. When it meets the parameter values set by the software in advance, it triggers the display of mapped virtual information objects on the display. The well-known mobile game Pokémon Go uses this technology. Since Location-based AR technology does not require markers to trigger, it is also called marker-less AR. The object-based AR is currently the most promising and eagerly anticipated AR technology in the industry. It does not require physical markers but uses algorithms that mix three-dimensional spatial image recognition data and multi-camera or multi-sensor input data for SLAM calculations. Hologram technology is another related application of AR. Its operating mechanism is different from that of SLAM technology. It mainly projects virtual images into the real environment by projection to achieve the effect of AR. It can be regarded as a manual SLAM operation mode and is also called projection AR. The AR technology introduced above is currently widely used in mobile games, interactive multimedia in museums, tourist factories, AR 3D storybooks or holographic projection concerts. In this study, the scope of AR learning system is mainly based on the above four AR technologies.

2.2 STEAM-6E Model

The STEAM-6E teaching model is proposed by ITEEA's STEM CTL™, a student-centered teaching model in response to the implementation of the STEM education curriculum, mainly to strengthen design and inquiry capabilities. The teaching steps are (1) Engage: to stimulate students' interest and participation; (2) Explore: to provide students with the opportunity to understand the topic; (3) Explain: students make reasonable explanations and confirm the meaning of what they have learned; (4) Engineer: through conceptual application practice and attitude deepen students' understanding of problems and apply them to design; (5) Enrich: allow students to further explore the knowledge they have learned and apply concepts to more complex problems; (6) Evaluate: continuous assessment during the entire teaching process can enable teachers to confirm the learning effectiveness of students' knowledge or concepts. These six steps are not rigid or rule-based but have cyclical characteristics. Combining this teaching model with the Standards for Technological Literacy (STL) curriculum can further confirm student participation, positive learning experiences, and achieve good learning goals and effectiveness[4]. Love and Deck also pointed out that the 6E teaching model is a dynamic curriculum because it integrates design and inquiry with engineering characteristics and is very suitable for science education [5]. In the AR learning system proposed in this study, in addition to the development of software and hands-on learning kits, it also includes learning manuals and videos, incorporating STEAM education literacy and combining 6E teaching steps for content design.

3 System Development

In this study, we propose a AR learning system, called "Understand AR in One Go (一次搞懂AR是什麼)" with four learning units about image-based AR, object-based AR, location-based AR and projection-based AR. In the four learning units, there will be 8 major learning themes: refraction and reflection of optics, art design, geometric shapes, 3D spatial positioning, image recognition technology, voice recognition technology, mechanism design (hologram) and augmented reality computer technology (SLAM technology), etc. In the process of completing the project implementation of each learning unit, students will use science, technology, engineering, art and mathematics knowledge interactively. Therefore, it can enhance students' cross-domain integration, inquiry knowledge and hands-on learning effectiveness. Each of the four units contains sections of theoretical, verification and hands-on project. The theoretical content focuses on the introduction of AR concepts and principles and is presented in the learning manual. The verification and hands-on projects require the use of tablets/phones in conjunction with an app and DIY kits (all of them are developed by this study). Below is a brief introduction to the content of the 4 learning units.

(1) **Learning Unit #1**: In this unit, students will learn the basic theory of color and the concept of three-dimensional space in geometry. The verification section mainly guides students to understand the conversion relationship between 2D and 3D, and uses the interactive game of the dice coloring to enable students to have geometric concept and understand the relationship between AR 3D object models, materials and textures. In the project section, users need to use AR avatar cards and use colored pens to color the character. After the drawing is completed, use a mobile device to scan the avatar card, and the students will be able to see the completed 3D character displayed on the mobile device (see in Figure 1).

(2) **Learning Unit #2**: In this unit, students will learn about three-dimensional coordinates and geometric shapes, image recognition technology, and augmented reality computer technology. This unit mainly responds to the more common AR storybooks on the market, so a special story plot is designed to attract students to use AR cards to play. In the verification section, students mainly understand the technical principles of AR SLAM, and understand the correspondence between virtual coordinates and the real world and how virtual objects are triggered through interaction. In the project section, players need to find two related cards for combination and pairing through the prompts of the plot (see in Figure 1). In this unit, teachers can let students practice the technical principles of how AR triggers in 3D space and think about possible life applications.

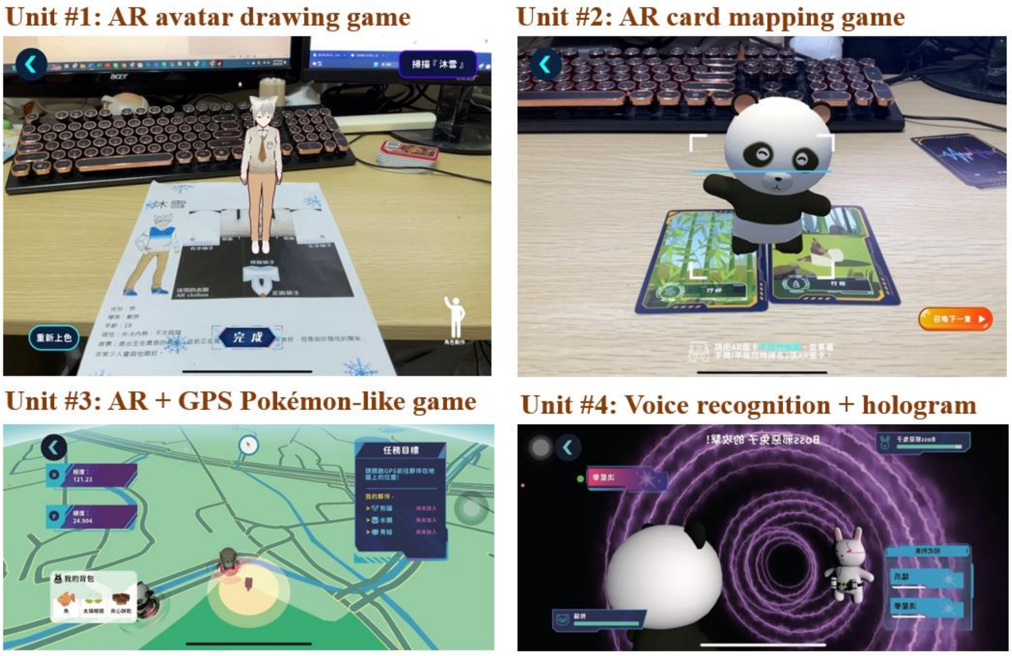

Figure 1: Hands-on projects in learning unit 1~4

(3) **Learning Unit #3**: In this unit, combined with the story plot, students need to learn GPS knowledge and use GPS coordinates to find partners in the story. In the verification section, students need to have a cognitive understanding of the longitude and latitude of Taiwan's attractions, and use the clues in the game to drive a virtual car to find treasures in the game. In the project section, the system will randomly locate attractions within 50 meters of the student's location, and they need to actually go outdoors to find the place to find partners in the game (see in Figure 1). In this unit, teachers can guide students to know the operating principles of GPS and the concept of longitude and latitude, and also let students understand how AR works when combined with GPS technology and how Pokémon-like games are made.

(4) **Learning Unit #4**: It's the unit with the most STEAM characteristics in this system. It will comprehensively apply knowledge such as refraction and reflection of optics, voice recognition technology, three-dimensional space, and mechanism design to make a voice recognition hologram projection box. In the verification section, students are mainly provided with transparent PVC sheets to teach them how to make a simple pyramid-shaped hologram box and guide students to verify the refraction principle of optics. In the project section,

students are provided with a 3D printed Z-shaped hologram box to deepen their understanding of the engineering design of hologram through DIY. Finally, place the tablet or mobile phone on the hologram box with the app, students can interact with the game in a voice manner (see in Figure 1).

This AR learning system proposed in this study includes an app, manual, DIY hologram boxes, AR cards, etc., is made into a product package for the convenience of promotion and teaching, as shown in Figure 2. In terms of software, the Unity Engine is mainly used for App development, which can be installed and run on Android and iOS tablets or phones (with gyroscope and GPS functions). It is currently available on Google Play and the AppStore for students to download for free.

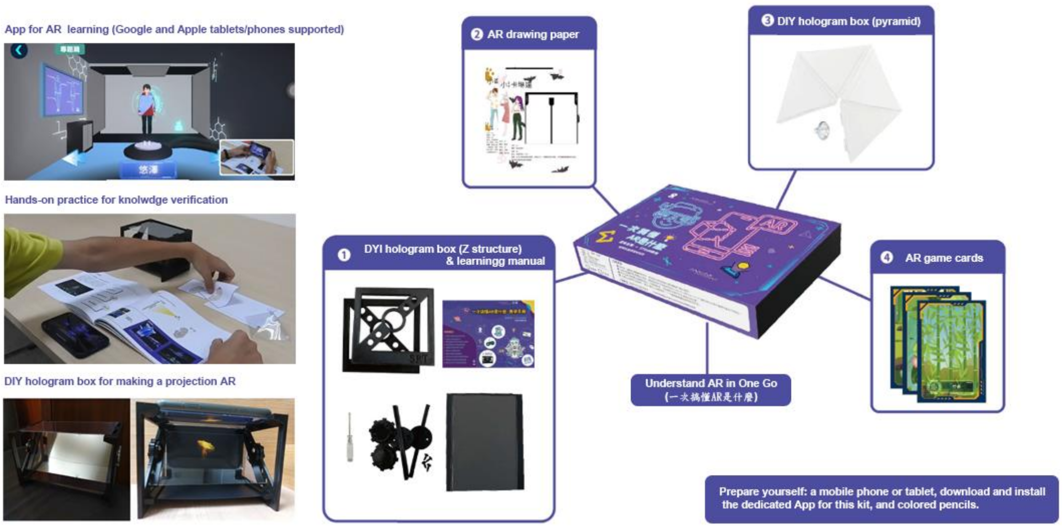

Figure 2: The AR learning system (Understand AR in One Go)

4 Teaching Promotion and Preliminary Evaluation

In order to evaluate the teaching effectiveness of the system, this study conducted teaching promotion from August 2021 to July 2022 and collected feedback from students participating in the activities. Each teaching activity lasted between 3 and 6 hours. The participants included 20 elementary school students, 100 high school students, and 54 university students, for a total of 174 people, as shown in Figure 3. Data collection methods included observation and random selection of students for interviews.

Figure 3: Teaching promotion of "Understand AR in One Go"

The data from the teaching feedback was summarized as follows: (1) Students felt that they could complete a creative work using this package, (2) During the production process, they could learn how to apply interdisciplinary thinking, (3) Students found the content of the package to be rich and fulfilling, and it could stimulate their creativity, (4) This approach allowed students to participate more actively in the course, (5) The feedback also showed that female students were more engaged in class, and would discuss and explain the knowledge of each topic.

5 Conclusions

This study mainly developed a learning system that combines AR promotion and STEAM education. Although there are already many AR learning kits on the market, the exploration and implementation of different AR principles in AR learning is very rare. In particular, this research system is not only suitable for promoting the application of AR technology, but also very suitable for educators in cross-disciplinary teaching such as mathematics, nature, and art as an auxiliary teaching tool.

Acknowledgement

This study was supported by the National Science and Technology Council, Taiwan, R.O.C (Grant number: NSTC 110-2511-H-141 -001 -MY2).

References

[1] J. Jesionkowska, F. Wild, and Y. Deval, "Active Learning Augmented Reality for STEAM Education—A Case Study," Education Sciences, vol. 10, no. 8, p. 198, 2020. [Online]. Available: https://www.mdpi.com/2227-7102/10/8/198.

[2] F. D. Koch, A. Dirsch-Weigand, M. Awolin, R. J. Pinkelman, and M. J. Hampe, "Motivating first-year university students by interdisciplinary study projects," European Journal of En-

gineering Education, vol. 42, no. 1, pp. 17-31, 2017.

[3] M. Uygur, T. Y. Yelken, and A. Cenk, "Analyzing the views of pre-service teachers on the use of augmented reality applications in education," European Journal of Educational Research, vol. 7, no. 4, pp. 849-860, 2018.

[4] S. Bartholomew, T. Loveland, and V. Santana, "Writing standards-based lesson plans to Standards for Technological and Engineering Literacy," 2020.

[5] T. S. Love and A. Deck, "The ocean platform engineering design challenge: Flooded with STEM content and practices," Science Scope, vol. 39, no. 3, p. 33, 2015.