Enhancing the Design and Innovation Capability - A Study on the Effectiveness of Augmented Reality and Big Data Supported Pedagogy for Undergraduate Students in Electronic Information Engineering Major

Xiaobin Lin[a], Jianxing Wang[b], Yingwu Zhou[c] and Chen Lin [d, *]

School of Physics and Electronic Information Engineering, Minjiang University, Fuzhou 350108, China.

[a]lin.xiaobin@mju.edu.cn, [b]171816230@qq.com, [c]353158368@qq.com,

[d, *] linchen1988@foxmail.com

Abstract. In this research, the effectiveness of Augmented Reality (AR) and big data-based pedagogy in the integrated project for undergraduate engineering students was studied. The goal is to identify whether this new pedagogy can enhance students' design and innovation capability to meet the new pedagogical requirements brought by the China's new "Made-in-China 2025" industrialization plan, as well as the underlying factors behind the technologies. The research was conducted based on the students from the Electronic Information Engineering (EIE) major of Minjiang university participating the capstone project. The results indicate that well-designed AR and big data-based pedagogy can apparently reduce the learning curve of students and significantly enhance the conversion from knowledge to design and technology innovation capability.

Keywords: Made-in-China 2025; Augmented Reality; Big data; Undergraduate education; Design and technology innovation capability.

1. Introduction

Over past several decades, China has emerged from an agricultural country to one of the largest industrial countries in the world [1]. As the increase of manufacturing power, the country is in the meantime striving to move up its place in value chain and transform to a world-class industrialized power. In this background, China issued a 10-year plan known as "Made-in-China 2025" in 2015[2]. This ambition has brought up new requirements for the pedagogy for engineering students in the higher education sector. For China, the engineering education at this critical stage is not merely continuing to expand the scale of education, rather, it is to further enhance students' capability to innovate in both design and cutting-edge new technologies. The innovation in engineering design and technology heavily relies on the accumulated in-depth understanding of the existing design and technologies. To help students rapidly possess the necessary theories and practical experiences within the limited course period, a reform on the pedagogical approach is required to further improve the effectiveness and efficiency of knowledge delivery.

In this research, two popular modern technologies, i.e., Augmented Reality (AR) and big data, are integrated into capstone tutoring session for the Electronic Information Engineering (EIE) students in Minjiang university to study the effectiveness of these technologies in converting knowledge to the capability of design and innovation. AR and big data have been used extensively in modern educational systems [3-7], yet the effectiveness of the combination of these two technologies in undergraduate engineering education has not been studied before. The focus of this research are the following two questions: 1) does the two technologies contribute to the improvement of the students' capability of design and innovation? And 2) what are the critical factors behind these two technologies that support the absorption and conversion of knowledge?

One of the main contributions of this research is that it studies the effectiveness of education based on the combination of big data and AR technology in integrating knowledge and converting knowledge from theory to practice at undergraduate stage. The study also reveals the importance of linking the theoretical knowledge to its applications in new and popular hi-tech products and making students understand how a complicated product can be dissembled into unit components that are

related to what they have learned in the university. This is especially effective in stimulating learning passion for the students with relatively weaker academic background.

2. Experiment Setting

The Minjiang university is an application-oriented university located in Fuzhou, China. The EIE major is one of its majors accredited by IEET (Institute of Engineering Education, Taiwan) [8]. For undergraduate students, the IEET accredited majors require them to complete a capstone project as the examination for their application of the knowledge learned in the major in an integrated manner [9]. The capstone project for the EIE major at Minjiang is designed as a group project to be completed by three to four students within a time period of four months. One or more advisors are assigned to each group to oversee the implementation of the project and provide necessary guidance.

In view that the teaching contents for specialized courses are not to be modified at liberty once they are determined, the capstone project becomes an ideal course to add new teaching materials. There are totally 120 students in the EIE major that were taking the capstone project in the year 2018. These 120 students were divided into 40 groups with each group consisting of 3 students. Each group was asked to select a project topic from two available options: 3D scanner or 3D printer. Neither 3D scanner nor 3D printer was taught in the previous courses taken by the EIE students. However, the underlying theoretical foundations of these two devices such as triangulation and Fourier transform were included in the previous course contents. Then 20 groups were arranged to be the control group which were to be instructed with the conventional teaching materials, and the other 20 groups were arranged to be the treatment group which were to be given new big data-based AR teaching courseware. More groups selected the 3D printer topic due to the factor that the creation of a 3D scanner is more complicated compared to a 3D printer.

Table 1. The distribution of groups according to topic selection and teaching material

	Conventional teaching materials		AR teaching materials	
	3D scanner	3D printer	3D scanner	3D printer
Number of groups	9	11	8	12

When designing the AR based teaching contents, the Baidu Zhidao was used as the source of big data to help identify the main difficulty in understanding the working principle of a 3D scanner and a 3D printer. For example, among the over 380,000 questions regarding 3D printers on Baidu Zhidao, major concerns are the controlling of movement in Z axis in LCD 3D printers, the projection of the sliced 3D model in DLP or LCD 3D printers etc. Based on these concerns, a number of virtual assembly systems illustrating the key difficulties were created using the virtual reality software Vizard® from WorldViz.

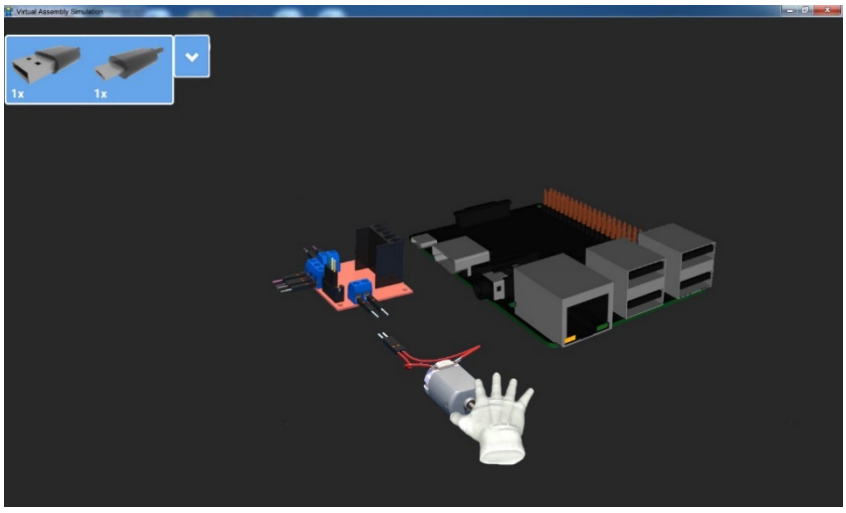

Fig. 1 Screenshot of the virtual assembly system

Vizard is comprehensive virtual reality software which provides the IDE and hardware support facilitates the creation of AR applications [10]. Vizard was used in combination with 3D model author ware Autodesk® Inventor and Anark to create AR applications for virtual assembly practice in this study. An external motion tracking device called precision position tracking wand from WorldViz was used to synchronize the students' actions in the virtual environment and enable them to gain a virtual hands-on assembly experience very similar to a real-world operation.

3. Data and Analysis

The EIE students' capstone project learning outcomes were studied in the following three aspects: the knowledge acquisition from the teaching material, the completeness of the project, the design and technology innovation of the project. The above data were acquired in the manner of expert rating, i.e., each group of students was asked to give a presentation of their capstone project to answer the above three questions as they completed the project and the tutors also posed questions to examine their outcomes in terms of understanding, completeness and innovation. Each criterion was rated in a scale of 1-10 with 1 representing barely meeting the requirement and 10 representing perfectly meeting the requirement.

The results indicate the students offered big data-based AR teaching material performed obviously better than those offered conventional teaching material. Among the groups working on the 3D scanner project, the average rating of knowledge acquisition, project completeness and design and technology innovation are respectively 3.4%, 12.4% and 10.6% higher. For the 3D printer groups, the performance gained are respectively 5.1%, 18.9% and 15.3%.

Table 2. The comparison of the learning outcomes of capstone projects

	Conventional teaching materials		AR teaching materials	
	3D scanner	3D printer	3D scanner	3D printer
Average rating of knowledge acquisition	6.89	6.82	7.13	7.17
Average rating of project completeness	6.67	6.73	7.5	8
Average rating of design and technology innovation	6.67	6.55	7.38	7.55

The above table indicates the most obvious improvement is the project completeness, followed by the design and technology innovation. The performance improvement in knowledge acquisition is relatively less noticeable. The performance gained in the 3D printer project is generally higher than the 3D scanner project. By using the big data-based AR teaching materials, the students' overall average ratings in both projects have been improved from over 6 to over 7, i.e., from pass to nearly good.

4. Discussion

The results of the study mainly reflect two things: 1) well designed AR teaching materials do help students master the teaching goal more quickly and thoroughly, especially when the teaching goal is concerning with working principles in engineering, device assembly or disassembly etc.; 2) big data can be a useful reference to infer the key difficulties confronting the learners in the study of a new comprehensive engineering project.

AR teaching materials help concretize the abstract concepts in engineering, such as the control of motors in the 3D printer project or the identification of the homologous point in the 3D scanner project. The virtual hands-on experience gained from the AR teaching materials had contributed to quicker and clearer understanding of the connection and relationship between different components such as the Raspberry Pi board and the L298N motor controller module, which lead to students' better performance in project completeness and innovation capability. The big data obtained from Baidu

Zhidao had served as a good data source for identifying the essentials and key difficulties of the engineering projects, so as to shorten learning curve and enhance learning effectiveness. The main factors behind the two technologies that support the absorption and conversion of knowledge are the precise target of understanding difficulties, the systematic disassembly of the engineering project and the virtual hands-on experience similar to real-life practice.

The study also reveals no matter the students were taught with conventional teaching materials or AR teaching materials there is no much difference in terms of knowledge acquisition. Conventional teaching materials can also be employed to effectively introduce the engineering concepts, what they are less effective in might be the conversion from conceptual understanding to the capability of practice and innovation.

5. Conclusion

The engineering education usually involves many integrated applications of the learned knowledge. Valuable design and technology innovations appear only when the students have solidly mastered what they have learned and clearly understood the application scenarios. Big data and AR supported pedagogy can effectively direct students' focus to the understanding difficulties and intuitively convey knowledge as well as technology similar to a real-life environment. This has greatly improved learning efficiency and depth hence led to higher probability of valuable design and technology innovation.

Acknowledgements

This work was financially supported by the teaching reform project fund of Fujian provincial department of education (FBJG20170215).

References

[1]. Li, Li, et al. "Estimating industrial and domestic environmental releases of perfluorooctanoic acid and its salts in China from 2004 to 2012". Chemosphere. Vol. 129 (2015), p. 100-109.

[2]. Li, Ling. "China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0"". Technological Forecasting and Social Change. Vol. 135 (2018), p. 66-74.

[3]. Akçayır, Murat, and Gökçe Akçayır. "Advantages and challenges associated with augmented reality for education: A systematic review of the literature". Educational Research Review. Vol. 20 (2017), p. 1-11.

[4]. Martín-Gutiérrez, Jorge, et al. "Augmented reality to promote collaborative and autonomous learning in higher education". Computers in Human Behavior. Vol. 51 (2015), p. 752-761.

[5]. Chen, Peng, et al. "A review of using Augmented Reality in Education from 2011 to 2016". Innovations in Smart Learning. Springer Singapore, 2017, p.13-18.

[6]. Sin, Katrina, and Loganathan Muthu. "APPLICATION OF BIG DATA IN EDUCATION DATA MINING AND LEARNING ANALYTICS--A LITERATURE REVIEW". ICTACT journal on soft computing. Vol. 5 (2015) No.4.

[7]. Huda, Miftachul, et al. "Innovative teaching in higher education: the big data approach". TOJET (2016).

[8]. Hou, Yung-Chi, et al. "Is the Asian quality assurance system for higher education going glonacal? Assessing the impact of three types of program accreditation on Taiwanese universities". Studies in Higher Education. Vol. 40 (2015) No. 1, p. 83-105.

[9]. Fwu, Bih-Jen. "A Total Inspection of College Student Learning Outcomes: Capstone Courses as Summative Courses." Jiaoyu Yanjiu Jikan= Bulletin of Educational Research. Vol. 63 (2017) No.1, p. 31.

[10]. Binaee, Kamran, and Gabriel J. Diaz. "Assessment of an augmented reality apparatus for the study of visually guided walking and obstacle crossing". Behavior research methods. (2018), p. 1-9.