Can Mixed Reality (MR) Make a Difference in Service Learning?

Y.M. Tang, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University
C.Y. Tang, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University
Ernest Wong, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University
Yohana Leung, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University
Gary C.P. Tsui, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University
W.C. Law, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University
Karen Cheng, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University
Edward Cheung, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University

7. ABSTRACT AND KEYWORDS

Service-learning (S-L) is one of the important educations that combines academic study with community service and reflection elements in tertiary. Service learning projects can benefit many different areas such as the public sector, non-profit and government agencies, etc. Despite the Hong Kong Government now putting much effort into promoting STEM education, carrying out S-L in local secondary schools is not common in Hong Kong, especially in teaching Secondary School students in science, technology, engineering and mathematics (STEM) knowledge. Mixed

---

Y.M. Tang, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China, Email: mfymtang@polyu.edu.hk; C.Y. Tang, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China; Ernest Wong, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China; Yohana Leung, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China; Gary C.P. Tsui, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China Email; W.C. Law, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China; Karen Cheng, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China; Edward Cheung, Department of Industrial and Systems Engineering and Industrial Center, The Hong Kong Polytechnic University Hong Kong, China

reality (MR) is known as hybrid reality which not only merges the real and virtual worlds into a new environment, but also allows users to interact with the digital content dynamically in real time. This study aims to investigate whether the use of MR can make a difference in service learning by measuring students' learning performance in secondary schools. We measure their ability in understanding three-dimensional (3-D) geometric and fundamental geometric mathematics. The results have shown that with the aid of MR, secondary students not only show a stronger motivation in participating in the S-L lesson, but the test results on basic geometric mathematics were also improved.

Keywords: Mixed reality, Service learning, HoloLens, STEM, Geometry

8. Introduction

Service-learning (S-L) is a pedagogy that combines rigorous academic study with meaningful community service and reflection. Service-Learning aims to help students develop into competent professionals with the heart to serve the community. Since 2010, S-L has been one of the major subjects in Hong Kong universities. Through a S-L subject and a significant service component, university students can apply the knowledge and skills acquired from learning to deal with complex service issues. The students are not only able to reflect on their own roles and responsibilities in both a professional and responsible manner, it can also help students to develop a stronger empathy for people in need and a stronger sense of civic responsibility. Figure 1 shows the service learning components involved at The Hong Kong Polytechnic University (PolyU), which is one of the local universities promoting S-L, that requires students under the new 4-year undergraduate degree programmes to complete a 3-credit S-L subject for graduation. The first batch of S-L courses were piloted in the 2011/12 academic year, with support from different academic departments and social agencies. In Figure 1, S-L components have grown to 60 approved courses, involving 171 teachers from 26 departments, involving 4,000 students in the 2016-17 academic year.

Figure 1: The service learning components at The Hong Kong Polytechnic University

More attention has been focused on the virtual reality (VR) technologies due to mixed reality (MR) being known as hybrid reality that encompasses both VR and augmented reality (AR). It not only merges the real and virtual worlds into a new environment which combines physical and digital content, but also allows users to interact with the digital content dynamically in real time (Milgram 1994). This study aims to investigate students' learning performance by making use of MR in delivering service learning to secondary school students. We measure the learning performance of secondary school students by making use of a pre-test and a post-test on their ability in understanding three-dimensional (3-D) geometric and fundamental geometric mathematics. The results have shown that, with the help of MR, the tests results and students' motivation in S-L can be improved.

9. Literature review and theoretical framework

S-L is a learning pedagogy that require students to integrates community service with academic study and reflection to enrich their learning experience. It enhances students' sense of civic responsibility and engagement on the one hand, and benefits the community at large on the other. Although S-L can benefit many different areas such as the public sector, non-profit and government agencies, etc., there have only been a few examples of delivering service learning in the school curriculum for secondary school students (Mueller, 2011).

S-L is one of the important education elements nowadays but carrying out S-L in local secondary schools is not common in Hong Kong, although some S-L projects can be conducted to serve primary and secondary schools. Some project examples are illustrated in (NYLC, 2004). Science, technology, engineering and mathematics (STEM) education has become an important issue in primary and secondary education, and a number of projects have been proposed to deliver S-L related to STEM worldwide. Lockeman et al. (2012) applied GreenSTEM which integrates STEM education with a focus on energy and the environment using service-learning techniques for middle school. Baumann (Baumann, 2013) used service-learning as an instructional strategy and investigated the relationship between students' interest and performance in STEM-related courses. It was found that service-learning is a powerful pedagogy for schools to drive student performance and interest in STEM fields. The service was conducted in the secondary schools and Lego kits were used to support the delivery of STEM knowledge. Tang et al. (Tang, 2016) used STEM as a vehicle for supporting service learning in a local university. To the authors' best knowledge, not much work has been conducted to apply latest mixed reality in service learning for STEM education.

10. Methods and analysis

In this project, we have designed an MR application for secondary students to experience 3-D geometric mathematics and learn basic geometry in mathematics in a S-L subject. We used a basic cube model to illustrate the basic relationship between the projection lines and angles. Figure 2 shows the cube model for the MR application. The MR application was developed based on the Microsoft HoloLens system. HoloLens uses MR head-mounted display smart glasses. It is a self-contained, holographic computer that can engage with digital content and interact with holograms (Microsoft, 2018). To allow secondary students to look at the model clearly from different angles, we provided several functions in the application to allow students to change the scale, position and orientation of the model. Students can signal the system and interact with the digital model using either voice commands or gestures.

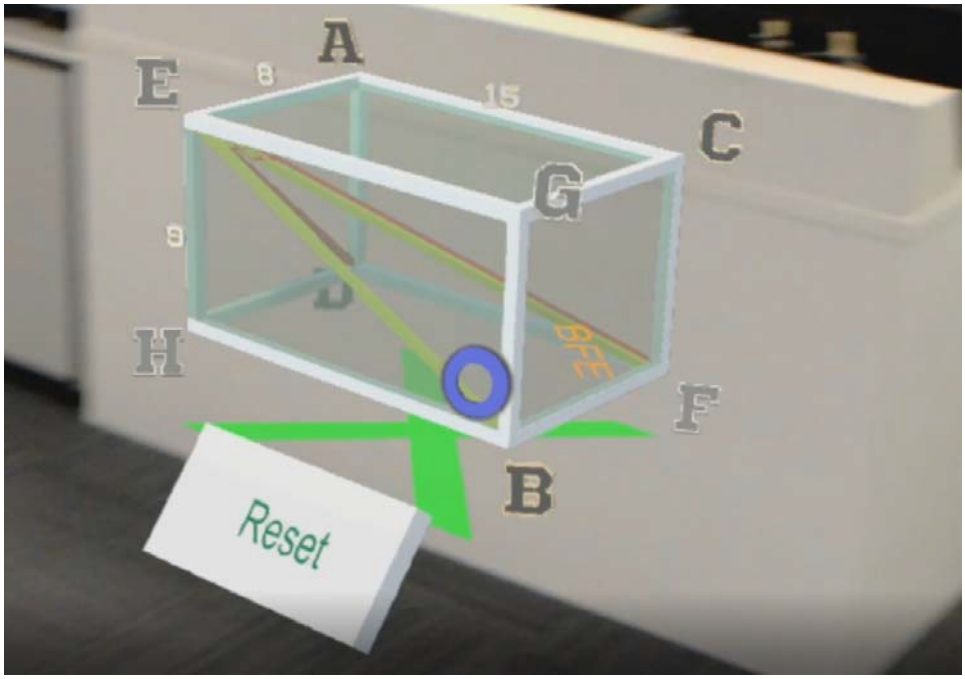

Figure 2: The digital cube model on the MR application

In order to investigate the secondary students' learning performance by making use of the MR application, we conducted the investigation in S-L subject. In this S-L subject, we delivered the service learning to local secondary school students in STEM education. This S-L was selected as our case study because the designed MR application and model can align with the theme of the S-L subject in teaching STEM. In this subject, university students are divided into a group of 4-6 students. Each group of university students is required to guide 3-4 secondary students and prepare their own materials to teach basic STEM knowledge. At the beginning of the investigation, secondary students are required to participate in a pre-test to measure the quantitative result that the students can achieve in respect to a certain level of understanding in basic geometry. The pre-test is conducted in the first service day of the S-L subject. On the second service day, we go to the classroom to introduce the MR HoloLens system to each student. The students are invited to play the MR application voluntarily. Around 5 minutes is given to the secondary school students to familiarize with the operation of the HoloLens system. Then, the students are allowed to view the digital cube model, and study the relationships between the angles and projection lines on the cube. With the aid of the MR application, the students are then required to complete a post-test and a questionnaire to collect feedback in learning with MR in the S-L subject. The tests are mathematical type questions with diagrams. We mark the tests based on student's final answer and the calculation steps.

We conducted our investigation in a S-L subject called "Comprehending and Overcoming Learning Hurdles in Science, Technology, Engineering, and Mathematics (STEM) for Local Schools". This subject is offered to the students at The Hong Kong Polytechnic University as an elective subject. The class size of this

subject is 140. We conducted the service at a local secondary school. In the investigation, secondary school students could experience the MR voluntarily. There were 92 Form 1 to Form 3 students and 53 of them experienced the MR application on the HoloLens, accounting for 59.8% of the secondary students enrolled the S-L subject. Among all the students in using MR HoloLens, 66.0% were Form 1, 15.1% were Form 2 and 18.9% were Form 3 (see Table 1).

Table 1: Number of students experience the MR HoloLens

Students Group	Number of Participants	Percentage
Form 1	35	66.0%
Form 2	8	15.1%
Form 3	10	18.9%

In order to determine the test results for different levels of students, we divided the students into two groups: Form 1 and Form 2-3. The tests used for the two groups of students were different. For the Form 1 group students, the investigation was mainly focused on their sense of geometric relationships. For the Form 2-3 group students, both the sense of geometric relationships and basic geometry calculations were investigated.

11. Results and Discussion

For the performance of Form 1 group students, it was found that the average score in the pre-test was 26.0% and the post-test was 54.6%, while for the students in the Form 2-3 group, the average scores in the pre-test and post-test were 12.8% and 20.0% respectively (see Table 2). It was found that both groups of students showed a positive improvement in the basic geometry mathematical skills after experiencing the MR HoloLens. To compare the performance between Form 1 and Form 2-3 group students, Figure 3 shows the average scores between the two student groups in the pre-test and post-test. Since the tests for the two groups of students were different, the average scores for Form 2-3 group students were lower than those of Form 1 group students in general.

On the other hand, we collected feedback from the students. Most of the students participated in the MR HoloLens because there were very interested in MR applications. Some of them expressed the view that MR can enhance their motivation to learn in the S-L.

Table 2: Average scores for different groups of students in the pre-test and post-test

Group	Pre-test	Post-test
Form 1 students	26%	54.6%
Form 2 and 3 students	12.8%	20%

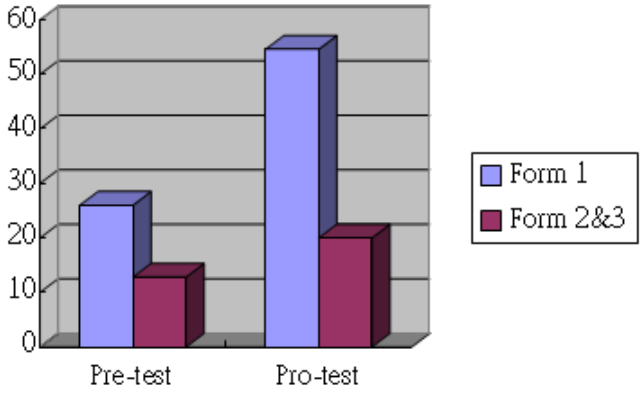

Figure 3: Average scores between two student groups in the pre- and post-tests.

12. Conclusions and contributions to theory and practice

In this article, we report the use of mixed reality (MR) teaching in S-L for STEM education. We investigated the learning performance of secondary school students in a pre-test and a post-test in answering questions on three-dimensional (3-D) geometry and fundamental geometric mathematics. With the aid of MR, the secondary students not only showed a stronger motivation in participating in the S-L lesson, but the test result on basic geometric mathematics was also improved. It may be because the MR HoloLens not only increased their motivation in their study, but also made them more confident and willing to try the best in answering the questions. It is believed that MR can make a positive impact in S-L education in local secondary schools. In the future, local secondary schools should adopt more VR and MR technologies to support their teaching. A larger sample size should also be used to validate the results. It is difficult to motivate passive and shy students to experience MR applications, more effort can be made by class teachers and classmates to motivate them in the future.

Acknowledgement

The author(s) received financial support by the Learning and Teaching Development Grant (LTG16-19/SS/ISE1) from the Hong Kong Polytechnic University, the Hong Kong Special Administrative Region, China for the research, authorship, and publication of this article.

References

Baumann P (2013) High-Quality Service-Learning Opens the Door for Students' Entry into STEM Fields, Education Commission of the States.

Lockeman K, Kirk S, Pelco L, Brown EMB, (2012). Engaging Teachers and Students in STEM Instruction through Service-Learning, VCU Scholars Compass.

Microsoft. Mircrosoft HoloLens, https://www.microsoft.com/en-us/hololens (2018)
Milgram P., Kishino F. (1994). Taxonomy of Mixed Reality Visual Displays, IEICE
Transactions on Information and Systems, E77-D(12), 1321-1329.
Mueller, M.K., Phelps, E., Bowers, E.P., Agans, J.P., Urban, J.B., & Lerner, R.M. (2011). Youth development program participation and intentional self-regulation skills: Contextual and individual bases of pathways to positive youth development. Journal of Adolescence, 34(6), 1115–1125.
National Youth Leadership Council (2004), Service-Learning Project Examples Middle School.
Tang CY, Tang YM, Ho GTS, Tsui GCP, Lo DKC, Law WC (2016). Science, Technology, Engineering, and Mathematics (STEM) as a vehicle for supporting service learning, Proceedings of The 2nd International Conference on Service-Learning 2016, the Hong Kong Polytechnic University, 1-2 Dec 2016
What is Service-Learning ? (n.d.). Retrieved from https://www.polyu.edu.hk/osl/index.php?option=com_content&view=article&id=88&It emid=218