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Collaborative Learning in Elementary Science Supported by Learning by Inquiry and Augmented Reality

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Abstract: The significance of science in the development of technology is undeniable and had proven its importance in the advancement of today's technology. Hence it had result in the strong emphasis of science in the educational field. Elementary science consists of having students learning and understanding scientific concepts and knowledge. With the teacher-centered teaching method commonly adopted in schools, it would be difficult for students to fully understand and apply the learnt concepts and knowledge in real life. This research designed an application that utilized collaborative learning in the learning process, allowing students to solve problems by discussing with peers through the strategy of learning by inquiry by working on hands-on activities in augmented campus environments. The results of this research found that collaborative learning supported by learning by inquiry and augmented reality technology had positive impact on the learning performance of students in the subject of science.

Keywords: Collaborative learning, learning by inquiry, augmented reality

1. Introduction

In recent years, the development of science and technology played an important role in providing limitless opportunity for the progression across all fields and industries. Researchers and educators had took noticed of its importance, and had made relevant changes on the subject of science in various levels of curriculum. While newer student-centered methods are being explored, most classrooms are still adopting the teacher-centered method whereby teachers share the knowledge of the subject by lecturing in the classroom (Murphy et al., 2012). Since science concepts are typically expressed in an abstract and descriptive manner, teacher-centered method would require students to visualize these concepts after they have comprehended what was delivered to them in the classroom (Meijer et al., 2006).

As one of the essential 21st century skills, collaborative learning has shifted the education spectrum from teacher-centered to student-centered (Kay et al., 2011; Mishra et al., 2011). Collaborative learning requires students to work in small groups, "mutually searching for understanding, solutions, or meanings, or creating a product" (Smith et al., 1992, p. 11). It had enabled students to explore new learning topics together, delegating tasks among the group, knowledge sharing and conducting discussions to enhance the understanding of the group members (Dillenbourg, 1999; Smith, et al., 1992). Furthermore, past research has proven that for the subject of science, the learning by inquiry approach provides an excellent opportunity for students to solve problems, try out new ideas, and understand new scientific concepts more effectively (Ann Haefner et al., 2004; Roussou, 2004; Tamir, 1990). With the current technology development, augmented reality could assist students to visualize new scientific concepts to facilitate their understanding (Chiang et al., 2014; Lu & Liu, 2015; Hwang et al., 2016). In addition to that, augmented reality play a significant role in improving students' learning engagement, and enhance their interest and understanding regarding the subject as augmented reality technology can portray concepts and ideas more clearly to students (Lu & Liu, 2015; Hwang et al., 2016).

With past research indicating that collaborative learning would enhance students' academic performance, social and generic skills along with the benefit of learning by inquiry in learning science,

this research aimed to improve the learning process and enhance the learning performance of students in elementary science. This research designed an application to assist students in learning elementary science via collaborative learning, using the strategy of learning by inquiry and the technology of augmented reality. The research question for this research is "How does the use of inquiry support and augmented reality in collaborative learning affect students' learning performance in science?"

2. Research Design

2.1 System Design

An application, ScienMon, was designed, operating on Android tablets and utilized augmented reality to assist in answer or task validation. ScienMon application was designed for students to collaborate with members of their group while learning about source of energy, transfer of energy and force, and electric circuits. Each group was equipped with a tablet along with a box of items required for the completion of various hands-on activities (including galvanometer, solar boards, wires, card boards, wheels, wheel axle, scissors, motor, buzzer, a set of gearwheels and gear belts). The application began with six pieces of puzzles hiding the image of the final assignment (i.e., building a solar energy car). In order to retrieve and complete their final assignment, students were required to complete two tasks assigned to disclose each piece of the puzzle. The first task for each puzzle consisted of a multiple-choice question about the aboriginal culture around the school with unlimited number of attempts allowed. After providing the correct answer to the question of the first task, students were required to scan the landmark mentioned in the question by using the camera function of the tablet. This function was built using augmented reality whereby the landmark itself were the marker. After completing the question of the first task and scanning the designated landmark, the second task of the puzzle would be disclosed which consist of questions or tasks on the source of energy, transfer of energy and force, or electric circuits (i.e., multiple choice questions, fill in the blanks, and hands on activity). Students could retrieve the answers of the questions by completing some hands-on activities. For example, for the task on "What is a parallel circuit?" the group would use items provided to build a parallel circuit and verify their work by using the tablet's camera to scan their work. As the parts of the items provided are being marked, the application using augmented reality technology will identify each component, verifying the group's work and provide them with their result instantaneously. For the second task of the puzzle, each group would be given one attempt to answer the question. If they are unable to answer the question correctly, the group would lose that piece of the puzzle. After completing all the tasks for one puzzle, the group would move on to completing the next puzzle.

2.2 Research Process

The participants of this research were students from two elementary schools (Grade 4 to Grade 6) in Kaohsiung, Taiwan, with 19 males and 20 females. The participants from both schools were gathered at one of the school located in the rural area. They were assigned into ten groups with a mixture of gender and school of origin. Before commencing with the research, students completed a pretest individually, with a total of 12 questions covering the topics of source of energy, transfer of energy and force, and electric circuits. Questions in the pretest and posttest were selected from past examination questions on these topics and were verified by teachers for their difficulty level and appropriateness for the students. Thereafter, an introduction session of the interface and functions of the application (ScienMon) and a briefing for the form of the activities expected ahead were conducted in order to familiarize students with the research. Each group was provided with a tablet and a box of items required for the completion of hands on activities. Students began the session by using ScienMon and moving around the school, seeking for the landmark or location. There were total six puzzles, each containing a cultural question with answers located at six different landmarks (Task 1), and six hands-on questions or tasks to be completed by each group (Task 2). After completing all the six puzzles, students were required to complete the final assignment, where they were required to use the knowledge they learnt to build a solar car individually with the materials provided. Finally, students were then required to complete a posttest, which was similar to the pretest. The total time of the experiment was five hours.

3. Results and Discussion

This research's objective was to improve elementary students' learning process and performance in science by using collaborative learning, supported by learning by inquiry strategy and augmented reality. A *t*-test was conducted on the scores of the pre-test and the posttest of the students for this study with results $t(38) = 6.57$ ($p < .05$), indicating that there was significant difference between the results of the pre-test and the posttest score. With the average score of the posttest (= 8.69) being higher than the pre-test (= 7.13), it can be concluded that the students' performance had improved and the system designed could assist students in their learning performance. It was observed that students were more excited and eager to participate in learning as compared to learning in the classroom. Students would take on responsibilities to help the group move forward, playing different roles to ensure that their group could progress. However, during collaborative learning, there would be free riders of the group who contribute the minimal effort to the group. Hence, for collaborative learning to be successful, individual accountability and responsibility should be considered. It was observed that students would work better in groups of two or three; with clear task for each rotated role they were assigned. For future research, it is suggested that the designed application could record and monitor each student's activity and contribution during the learning process, and take necessary actions to encourage students to participate.

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References

Ann Haefner, L., & Zembal-Saul, C. (2004). Learning by doing? Prospective elementary teachers' developing understandings of scientific inquiry and science teaching and learning. *International Journal of Science Education, 26*(13), 1653-1674.

Chiang, T. H. C., Yang, S. J. H., & Hwang, G. J. (2014). An Augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities. *Educational Technology & Society, 17*(4), 352–365.

Dillenbourg, P. (1999). What do you mean by collaborative learning? *Collaborative-learning: Cognitive and computational approaches, 1*, 1-15.

Hwang, G.-J., Wu, P.-H., Chen, C.-C., & Tu, N.-T. (2016). Effects of an augmented reality-based educational game on students' learning achievements and attitudes in real-world observations. *Interactive Learning Environments, 24*(8), 1895–1906.

Kay, K., & Greenhill, V. (2011). Twenty-first century students need 21st century skills. In *Bringing schools into the 21st century* (pp. 41-65). Springer Netherlands.

Lu, S.-J., & Liu, Y.-C. (2015). Integrating augmented reality technology to enhance children's learning in marine education. *Environmental Education Research, 21*(4), 525–541.

Mishra, P., & Kereluik, K. (2011, March). What 21st century learning? A Review and a synthesis. In *SITE Conference* (pp. 5-236).

Meijer, J., Veenman, M. V., & van Hout-Wolters, B. H. (2006). Metacognitive activities in text-studying and problem-solving: Development of a taxonomy. *Educational Research and Evaluation, 12*(3), 209-237.

Murphy, C., Varley, J., & Veale, Ó. (2012). I'd rather they did Experiments with us…. Than just Talking: Irish Children's Views of Primary School Science. *Research in Science Education, 42*(3), 415-438.

Roussou, M. (2004). Learning by doing and learning through play: an exploration of interactivity in virtual environments for children. *Computers in Entertainment (CIE), 2*(1), 10-10.

Smith, B. L., & MacGregor, J. T. (1992). What is collaborative learning? In *Collaborative Learning: A Sourcebook for Higher Education* (pp. 10-30). University Park, PA: National Center on Postsecondary Teaching, Learning, and Assessment.

Tamir, P. (1990). Considering the role of invitations to inquiry in science teaching and in teacher education. *Journal of Science Teacher Education, 1*(3), 41-45.