Chang, M. et al. (Eds.) (2019). Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for Computers in Education

Development of Augmented Reality-Based Learning Package for Learning Network Topology via STAD Process

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Abstract: The aims of this study were 1) to develop the learning package for learning network topology by using augmented reality (AR) technology, 2) to investigate students' learning achievement on network topology through the AR-based learning package in conjunction with student team achievement division (STAD) learning process, and 3) to investigate students' satisfaction toward the AR-based learning package with STAD. The participants were 27 grade 10 students. They were divided into three groups: low-achieving group, medium-achieving group and high-achieving group. The experimental instruments consisted of AR application and concrete manipulative board kit. The pre-achievement test, post-achievement test, and satisfaction questionnaires were used for collecting both quantitative and qualitative data. The results revealed that the learning activity was effective for enhancing students' understanding in basic devices of network and topology. After students conducted the activities, we found that the average of posttest score was statistically higher than that of the pretest. The average of students' progress in class was 64.84 percent. In addition, students were satisfied toward this learning activity at the high level.

Keywords: learning package, augmented reality, computer network, topology, concrete manipulative

1. Introduction

Network topology is the shape or design structure of a network representing device nodes and cables. The topology also means how to transfer or exchange information between computers within the network. The secondary schools in Thailand require students to learn the basic of computer network systems such as format of network connection (network topology) and devices used in the network system. However, the network topology is difficult to understand in terms of information exchange between networks. Therefore, teaching topology can be challenging for many teachers to manage learning activity for learners.

However, in real practicing environment of teaching network topology for high school, teachers face many problems in which the most notable one is lack of up-to-date instructional media. Regarding teacher cannot procure genuine equipment to support learning managing due to some devices have high cost and the school has no enough budget for purchasing. The restrictive educational resources including lacking the laboratory room or authentic computer network devices could cause insufficient delivery knowledge and affect students' learning significantly (Chumpagul, 2017). The traditional teaching methods in teaching network topology need to go back to study by looking example 2D pictures in the textbook and the media is often used in learning of topology network such as using of Microsoft PowerPoint but these technologies only put student as a passive element in the learning process (Irwansyah et al., 2018). Moreover, in managing learning activity as a teacher-centered who is a lecturer and students are responsible for receiving information from teachers. From a psychological perspective, the traditional teacher-centered learning activity also often perceived as monotonous and boring, which may reduce the motivation and attachment of students to the learning activity and the student learning outcomes (Faisal, 2017).

To solve the lack of instruction media in high school, teaching topology network which lead to lecturer-centered traditional pedagogical that make student unable to get real understanding in knowledge, using educational technology and learning activity design may encourage students to learn and attend in lesson. The creating of learning package would redress many of the educational deficiencies in the way to increase students' understanding by providing the instructional technology and appropriate learning methodology (Oates & Russell, 1998).

Currently, many educational organization use the benefits of technology in classroom. These trends are making headlines in education because the ways they impacted student learning. Educational technology has been succeeding for making collaborative and interactive learning. Augmented reality (AR) –a technology that merge 3D virtual objects on real-world through digital camera, webcam or smart device which display at real time, has been the most transformative educational technology that enhance teacher instruction while simultaneously creating immersive fun and engaging lessons. Moreover, AR can also "enhance learning motivation", "help students to easily understand contents", "enhance positive attitude", "enhance learning satisfaction", and "assist students in constructing students' knowledge in a natural science course" (Karaçöp, 2016; Wu et al., 2019). In several educational fields, using AR-based learning to support learning management was helpful and appropriate; it was used to help manage learning activity which was more effective at teaching media compared to other media such as books or videos (Iilian, 2012).

In recent years, the cooperative learning is one kind of student-centered approach for managing learning activity considered to increase successfulness of students. Student Team Achievement Divisions (STAD) is one of the cooperative learning approach widely used in 21st century education in which students will be divided into small groups with the different of learning achievement level. The key factors to success of STAD are students working together, and students who have higher level helping members in their group to reach the shared learning goals, where the teacher presents the lessons and the group works together and make sure that all members understand the topic (Pandiangan, 2019). In addition, many studies of learning management based on STAD learning approach indicated that using STAD in managing learning activity was able to help students in collaborative learning such as learning together, sharing idea, communicating inner team, and helping each other. It was able in improving students learning achievement and developing students' knowledge.

In order to overcome the lack of instructional media and to present an alternative learning network topology method, we propose an AR-based learning package for learning computer network topology via STAD method to encourage effective instruction and promote collaborative skills of learner accorded learning in 21st century education. While using AR technology to stimulate student's learning motivation, simultaneously, this learning package uses the manipulative tool to assist in deepening student's understanding of concepts in technology and in increasing student's achieving. The concrete manipulative was proved to be helpful for enhancing students to engage natural interaction in the physical world (Jamhari, 2016). There are three objectives in this study including (1) to develop an AR-based learning package for learning network topology, (2) to investigate students' learning achievement regarding network topology using the AR-based learning package, and (3) to investigate students' satisfaction toward the AR-based learning package.

2. Methodology

This research contributes based on quantitative research: one group pretest-posttest design. The flowchart of this study is shown in Figure 1. Before intervention, students begin with taking the pretest on the learning management system called STADLMS (detail in section 2.4). Students are divided into small group with different levels of pretest score, then they are assigned into 4 or 5 member learning group which each groups consist of students with different levels of pre-test score. Whereas, the learning activity, students will be taught by using AR-based learning package according to STAD process. After conducting learning activity, students will be receiving the individual posttest to investigate post-understanding in network topology concept. Moreover, students will be given the questionnaire to assess satisfaction toward the learning by using AR-based learning package.

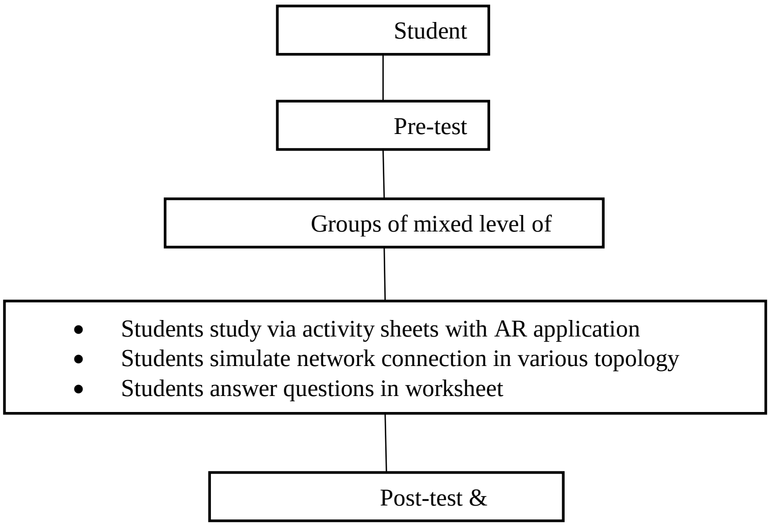


Figure 1. The research flowchart of this study

2.1 Participants

The participants of this research were 10th grade students in the high school at Ubon Ratchathani, Thailand. They were 27 students studying on science classroom program in the first semester of academic year 2019. The experiment was conducted at Ubon Ratchathani University, Ubon Ratchathani, Thailand.

2.2 Development of AR-based Learning Package for Learning Network Topology

Since the AR-based learning package was designed for 10th grade students which was based on the occupations and technology standard curriculum of Thailand core curriculum, there were two main parts of contents consisting of learning basic devices that used in network connection, and learning network topology. The learning package included AR application running on Android and the designed concrete manipulative board. We designed the AR-based learning package according to the pedagogical theory of John Dewey's philosophy –learning by doing, students are able to observe new knowledge or various contents by themselves through real or virtual environment (Krupatom, 2019).

2.2.1 Concrete Manipulative Board Kit for Learning Topology

A concrete manipulative is defined as an object that can be handled and moved. The concrete manipulative board kit was designed and developed to assist students in translating abstract concepts into concrete, practical concepts. This kit was aimed to enable students to deepen their understanding of concepts of the network connection. The kit was consisted of a quadrilateral board, rubber bands, AR markers, and pins, as shown in Figure 2. The quadrilateral board was used as a foundation, which was made from crate boxes. The rubber bands were used in place of the communication mediums. AR markers were used to connect pins and rubber bands, which simulated the network connection in various topology.

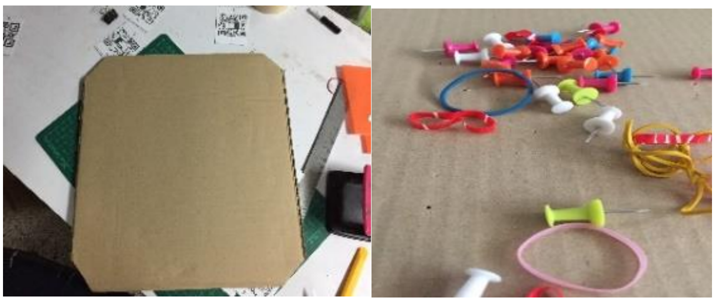


Figure 2. The concrete manipulative board kit

2.2.2 *3D Topology: AR Application*

The AR application called 3D Topology was developed to run on an android device. It was developed by using Maya and Unity in form of 3D animations, which was divided into two main parts –devices learning and topology learning. Students can learn the basic network devices through 3D animation models in the device learning section while they are able to study the shape of topology connection and data transfer among nodes in each topology in the topology section. Moreover, students are able to interact with models by sending data from one device to another, and by setting which device is broken.

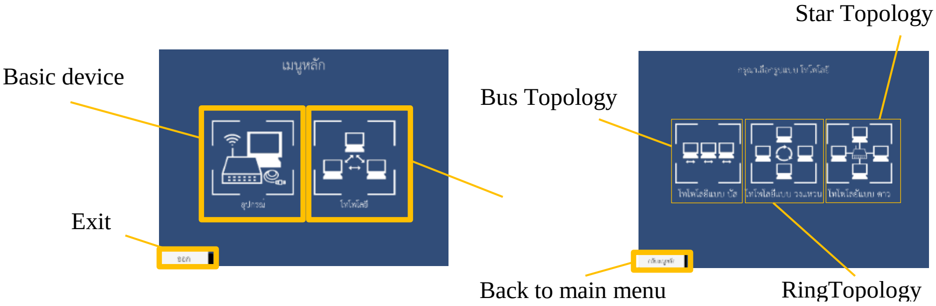
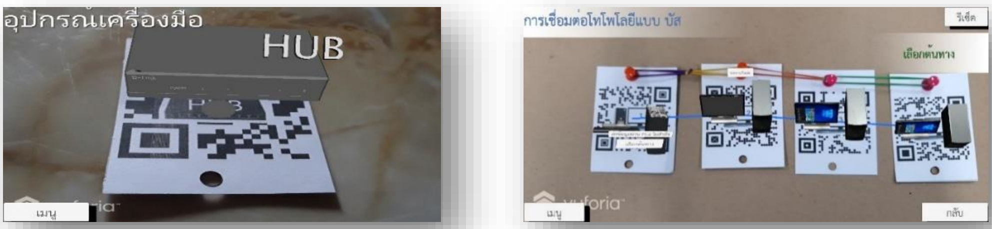


Figure 3. Main menu (left) and topology menu (right)

As shown in the Figure 3, when the AR application was started, the main menu (Figure 3 (left)) will be shown. There are two sub menus including basic devices and network topology. If the basic device menu is selected, the built-in camera will be activated (AR mode). The student can learn the network device through 3D models by using AR markers (example illustrated in Figure 4 (a)). If the student select the topology menu (Figure 3 (left)), there will be three sub menus appeared on the screen consisting of Bus topology menu, Ring topology menu, and Star topology menu (Figure 3 (right)). Once the student selects the sub menu, the AR mode will be activated. The student will use markers with the board to create the topology and interact with them as shown in Figure 4 (b).



(a) (b)

Figure 4. The examples of AR application screenshot

2.3 Data collection tools

The pre-achievement test, post-achievement test, and satisfaction questionnaires were used for collecting both quantitative and qualitative data. Pre- and post- tests were designed in terms of an objective test and multiple-choice items. There are 10 questions which were divided into 2 different sets (pre- and post- tests). There were 10 items in questionnaires used for examine students' attitude toward the AR-based learning package. It was developed according to 5-point Likert scale including strongly disagree = 1, disagree = 2, neither agree nor disagree = 3, agree = 4, strongly agree = 5.

2.4 Implementation

The preliminary study was conducted to investigate the possibilities on the use of the developed AR-based learning package in conjunction with STAD learning process to enhance students' understanding on network topology. We used STAD learning management system (STADLMS), proposed by Kumseang (2016), to facilitate teacher to manage examination and learning activity.

STADLMS is an online learning management system in form of web application to support student teams' achievement division learning process. The system provides teachers to create courses and to manage their lessons so that students are able to learn via the system. Students were also able to do group activities and pretest-posttest created by the teacher. The tests were simultaneously checked and graded, then the system automatically generates student groups based on their pretest scores. Figure 5 shows the screenshot of STADLMS for learning network topology which includes 5 sections: teaching plan, overall testing score, pre-post tests, group assignment, and team recognition and rewards.

Figure 5. Example of STADLMS screenshot

As illustrated in Figure 1, once the pretest and group division have been done via STADLMS, students were assigned the group assignment. It consisted of worksheet, knowledge sheet, AR application, and concrete manipulative board kit. They worked in group as shown in Figure 6.

(a) (b) (c)

Figure 6. Learning activity (a) study of network devices (b) simulate network connection with the board kit (c) use 3D topology app and interact with the model

3. Results

3.1 Learning Achievement

Students' learning achievement after conducting the learning activity was investigated by the test consisted of 10 items of 4 multiple-choice. The pass criteria was 5 scores. We analyzed the data by mean and percentage. The results showed that (illustrated in Figure 7):

- All posttest scores were higher than pretest scores.
- The average of posttest was 85.19% while that of pretest was 52.22%.
- The average of posttest of low-achieving group was increased from 34.55% to 83.64%.
- The average of posttest of medium-achieving group was increased from 52.50% to 82.50%.
- The average of posttest of high-achieving group was increased from 76.25% to 90.00%.

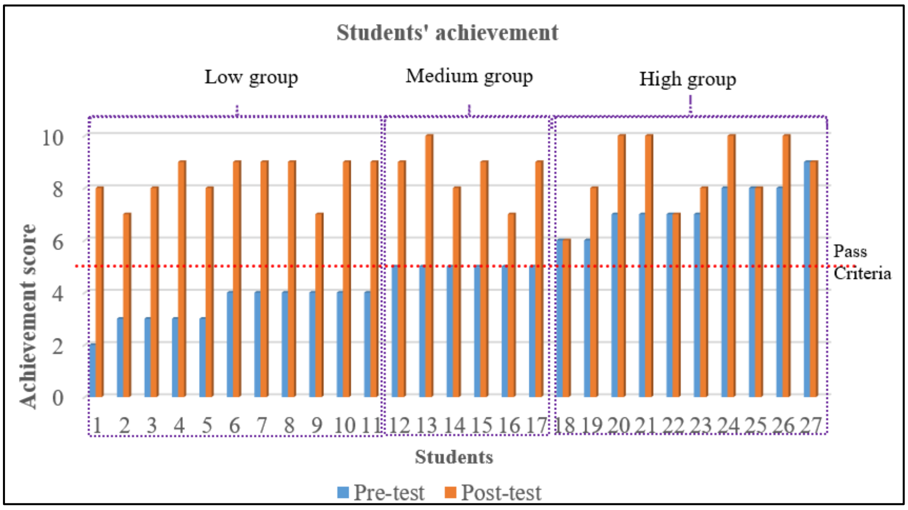


Figure 7. Learning achievement

3.2 Students' Learning Gain

The normalized gain <g>, introduced by Hake (Bao, 2006), was used to analyze pre- and post- tests in order to investigate students learning progress after learning through our developed learning package. The average <g> can be calculated using either the average scores of the class or individual student's scores detailed as follows.

3.2.1 Individuals' Learning Gain

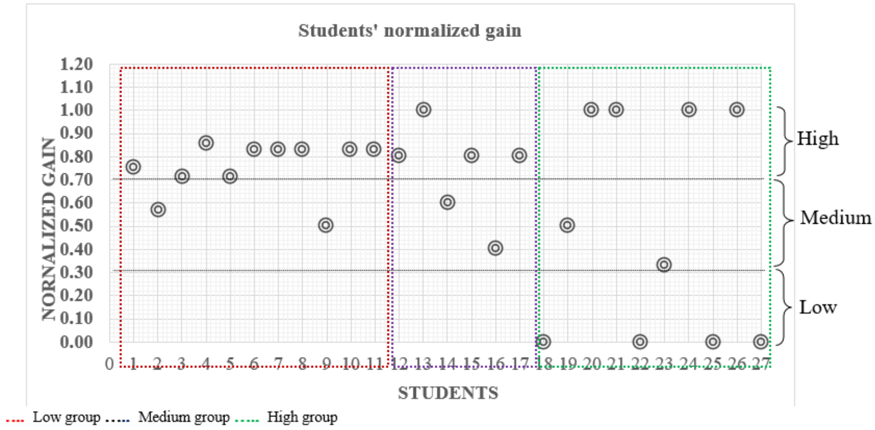


Figure 8. Individual students' normalized gain

The learning progress of students after they learned through this learning activity was analyzed by normalized gain shown in Figure 8. The results showed that 17 students have increasable learning progress that <g> value was between 0.70 and 1.00 which were classified into the high group (high gain) that was 62.97 percent all of students. There were 6 students having <g> value between 0.30 and 0.69 which were classified into medium gain group that was 22.22 percent all of students. Moreover, 4 students were classified into low gain group having <g> values lower than 0.30 that was 14.81 percent. From our analysis, we found that the low gain group was in the high group. They had their pre-achievement score as high as post-achievement score, thus the normalized gain was 0.

3.2.2 Learning Gain Classified by Achievement Group (Low, Medium, and High)

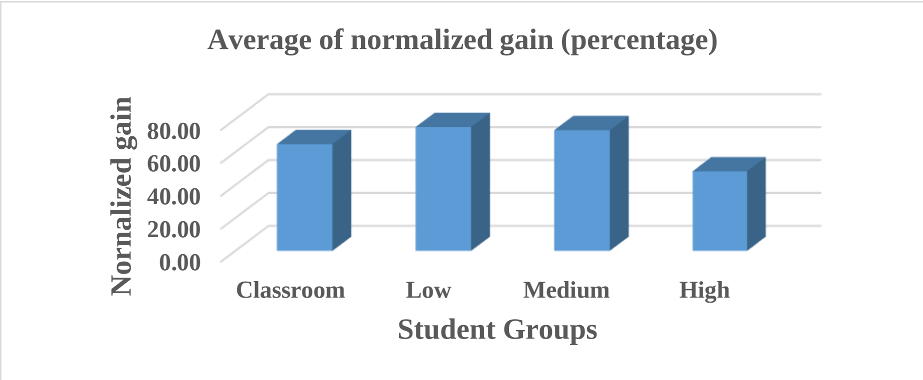


Figure 9. The percentage of achievement group normalized gain

The students' learning gain was calculated among group and classroom. The results were shown in Figure 9. It found that the highest of normalized gain was in the low group. This might be concluded that our developed AR learning package can promote students' understanding.

3.3 Students' Satisfaction

Table 1
Results of Students' Satisfaction toward AR-based Learning Package

Questions	Mean	S.D.	Level
Learning activities encourage students to exchange knowledge and ideas.	4.52	0.70	Highest
Learning activities help students helping each other.	4.56	0.57	Highest
Learning activity allows students to freely do activities.	4.48	0.75	High
The environment of the learning set makes students responsible for themselves and the group.	4.52	0.70	Highest
Learning activities give students the opportunity to express opinions.	4.44	0.75	High
The environment of learning activity gets fun and enjoy.	4.56	0.75	Highest
Learning activities make students want to learn more.	4.44	0.80	High
Learning activity makes content easy to understand.	4.40	0.75	High
Learning activity makes students able to remember the content longer.	4.48	0.81	High
The level of satisfaction toward the learning activities.	4.60	0.57	Highest
Overall	4.50	0.62	Highest

Table 1 shows that the average of students' satisfaction was at the highest level (Mean = 4.50, S.D. = 0.62). From the results, we found that the highest satisfaction were *learning activities help students helping each other* and *the environment of learning activity gets fun and enjoy* which were the same mean of 4.56 but different standard deviation.

4. Discussion and Conclusion

The AR-based learning package was well-received among the students. With the combination of the AR application and the concrete manipulative kit, students were able to understand not only the concepts of topology themselves, but also their application to the practical settings. As a result, students were much more engaged in the activities and motivated to learn.

The experimental results revealed that this AR-based learning package was able to increase students' learning achievement. From the results of normalized gain, we found that the learning activity had more effectiveness with students who were in low-achieving group and medium-achieving group than students who were in high-achieving group.

Moreover, the leaning management based on STAD learning approach helps enhance student to develop their communication skills and teamwork skills, which is one of needed in 21st century skills. STAD is good interaction among students and helps them to improve their positive attitude through subjects which consistent with Tuncharoen et al (2018) stated that the STAD learning method promoted many aspects of students' performance, and also made students had better achievement, and interaction in themselves and working together.

In conclusion, this study discussed the development of the AR-based learning package for topology for the secondary-level students in Ubon Ratchathani, Thailand. Students learned not only the subject, its concepts, and its practicality, but also skills of necessity in life to advance their lives. In the future, this study may be expanded to different levels of schools in Thailand and compared with students in control group who learn by using other learning methods.

Acknowledgements

This research is supported by the Project for the Promotion of Science and Mathematics Talented Teachers (PSMT) under supervision of the Institute for the Promotion of Teaching Science and Technology (IPST). We would like to express our gratitude to Mr.Tosporn Ngamtuan in helping development of AR application.

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