Analysis on the Effects of the Augmented Reality-Based STEAM Program on Education

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Abstract. The purpose of this study is to develop an education program that can increase the learning effect of students, and suggest a more systematic and practical problem solving procedure for inquiry learning. Through effectiveness verification, this paper demonstrates the significance of the augmented reality-based STEAM education program founded on the inquiry learning model. It also verified the effectiveness of the augmented reality-based STEAM education program on the cultivation of active inquiry learning ability.

Keywords: STEAM Education, Augmented Reality, Inquiry Learning Model

1 Introduction

Augmented reality, which presents information of the virtual world to the real world, maximizes learning interest and immersion (concentration) by providing experiences of experimental learning to learners, allowing them to use experimental tools, presented as virtual objects, directly with their hands.

STEAM is a new tendency, a driving force for the innovation of future education systems, and a new form of smart education that converged science, technology, engineering, arts and mathematics. It is an educational approach that not only enhances individual knowledge transfer ability and creativity but also allows practical connection with the cutting edge science and technology world.

On the other hand, inquiry learning allows learners to understand the experiment results through the inquiry process of 'problem understanding – setting up hypothesis – experimental design and implementation – hypothesis verification – drawing conclusion.' However, as a systematic teaching method, it is inadequate in suggesting valid grounds for the processing of experimental results and hypothesis verification. Therefore, based on this perspective, it is necessary to have a new systematic education program that can enhance the capacities of learners and successfully verify causes and results. In this context, the purpose of this research is to develop a meaningful STEAM education program that goes beyond the conventional learning
methods that mainly depended on experimental activities. The education program developed in this research enhances context awareness using augmented reality technology, and allows learners to experience a systematic and practical problem solving process in inquiry activity.

2 Theoretical Background

STEAM education is an educational policy that awakens the creativity and emotions of students by adding Arts to STEM (Science, Technology, Engineering, and Mathematics) education, which was implemented since the 1990s in the United States with the purpose of strengthening the education on mathematics, science, engineering and technology in order to nurture future human resources for the science and technology sector. The purpose of STEAM education is to nurture creative human resources in the science and technology sector by increasing students’ interests on mathematics, science, engineering technology.

Meanwhile, it has become easier to utilize augmented reality display devices in school education field with the recent increase in supply of smart phone devices. Moreover, as it is easy to produce the marker through printouts, there are various attempts to create educational contents based on augmented reality as supplementary teaching materials. Borrero and Márquez (2011) compared the remote lab educational effect of augmented reality environment lab, virtual environment lab, and real classroom environment lab and found that the augmented reality lab had the highest educational effect. Thus they argued that augmented reality can become a new method for e-learning. Ko and Kim (2012) analyzed the learners learning activities using learning contents, which combined augmented reality objects, in classrooms. The results implied that the contents had significant impact on knowledge and practice, which are the main factors that determine the level of academic achievement.

In this sense, as educational contents based on augmented reality technology have the advantages of providing practical tasks and enhancing self-directed learning and problem solving ability, there is a need to develop augmented reality-based contents and learning programs not only for a certain field but also for STEAM convergence education.

3 Education Program and Validity Test

The education program is for grade 5 and 6 of elementary school level. There are two programs: 1) Darwin’s Galapagos expedition and 2) designing public service posters for the protection of the ecosystem. The course is divided into seven classes. It is structured to help students acquire basic knowledge and to gradually expand their knowledge. The learning contents as in the chapter of ecosystem, environment and environmental protection, includes various fields such science, social science, and arts. This provides a convergence class approach on one theme with an integrated perspective. Moreover, the program not only allows learners to observe the virtual ecosystem and analyze the ecosystem structure using the augmented reality
technology, but also provides experiences of cooperative problem-solving as a group in the stage of producing results.

This program was structured into 5 stages of inquiry process: ① Learners collect information and confirm, ② identify concepts, ③ set up hypotheses, ④ verify, and ⑤ solve the problem. To verify the validity of the program, the education program and learning contents were shown to three STEAM experts. The validity was verified based on the question of whether the augmented reality of each stage were appropriately developed based on the inquiry learning model or not.

Table 1. Education program 1,2. Expert Validity Test Methods and Results

|► Composition of Experts | 1 expert with five years of STEAM development experience / 1 expert with four years career / 1 middle school teacher |
|► Investigation Method | 5-point Likert Scale method / email survey method and face-to-face interview method |

<table>
<thead>
<tr>
<th>Application of Suchmans’ Inquiry Learning Model</th>
<th>Program 1</th>
<th>Program 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Confronting the problem situation</td>
<td>3.66</td>
<td>3.66</td>
</tr>
<tr>
<td>2. Confirming the problem and data</td>
<td>4.33</td>
<td>5</td>
</tr>
<tr>
<td>3. Collecting data and experimenting</td>
<td>5</td>
<td>4.66</td>
</tr>
<tr>
<td>4. Explaining the inquiry results</td>
<td>3.66</td>
<td>4</td>
</tr>
<tr>
<td>5. Analyzing the inquiry process</td>
<td>4</td>
<td>4.33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4.13</strong></td>
<td><strong>4.33</strong></td>
</tr>
</tbody>
</table>

The expert opinions on the STEAM education program are as follows. First, in the stage of ‘confronting the problem situation’, experts commented that there is a need to suggest a more detailed situation in order to encourage self-thinking. Second, one class is not enough for ‘collecting data and experimenting’ and it should be given more time. Based on these comments, in order to suggest a more detailed situation a video clip on various living things and various examples of public service posters were added. Also the time allocated for producing the public service advertisements was expanded adding one more class.

4 Application of Program and Analysis

4.1 Subject of Field Application of Program and Application Method

|► Subject | Grade 6 Students of ‘K’ Elementary School, Gwangjin-gu, Seoul |
The research experimented the utilization of augmented reality on the 2009 curriculum of grade 6 1st semester of science 4. The course was divided into seven times. First, in the ‘confronting the problem situation’ stage, the program ① suggested video clip on various living things → ② increased curiosity → ③ made the students individually think about the characteristics of the various living things suggested in the video clip regarding to how they adapted to the environment. Next, after explaining the introduction of the inquiry process; in the ‘confirming the problem and data’ stage and ‘collecting data and experimenting’ stage, ④ make the students personally control (place and arrange each markers on the designated places) the augmented reality contents developed →⑤ learn through experience of observing the changes in the birds depending on different conditions. The experiment was made as a pair activity. Each person was to decide a role, conduct the experiment and produce a study paper. For the study contents based on the experiment, learners go through the stages of ‘explaining inquiry results’ and ‘analyzing inquiry process. At the end, a survey was conducted to examine learners’ response.

### 4.2 Analyzed Results

The survey results on learners regarding the class experience are as follows.

**Table 3. General Tendency of Class Satisfaction (N=50 *The higher the score, the higher the satisfaction*)**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science class has become more amusing than before</td>
<td>1</td>
<td>5</td>
<td>3.74</td>
<td>.853</td>
</tr>
<tr>
<td>My understanding of science and maths increased</td>
<td>1</td>
<td>5</td>
<td>3.90</td>
<td>.707</td>
</tr>
<tr>
<td>I have become more interested in science and maths than before</td>
<td>1</td>
<td>5</td>
<td>3.84</td>
<td>.889</td>
</tr>
<tr>
<td>I have become more interested in science technology than before</td>
<td>1</td>
<td>5</td>
<td>3.96</td>
<td>.880</td>
</tr>
<tr>
<td>I like reading science books and writings more than before</td>
<td>1</td>
<td>5</td>
<td>3.30</td>
<td>.909</td>
</tr>
<tr>
<td>I can think of my own to solve a problem</td>
<td>1</td>
<td>5</td>
<td>3.90</td>
<td>.814</td>
</tr>
<tr>
<td>I can finish various learning activities not giving up on the way</td>
<td>1</td>
<td>5</td>
<td>4.00</td>
<td>.782</td>
</tr>
<tr>
<td>I encounter a problem from various perspectives</td>
<td>1</td>
<td>5</td>
<td>3.88</td>
<td>.659</td>
</tr>
<tr>
<td>I try to associate what I have learned with real life</td>
<td>1</td>
<td>5</td>
<td>3.74</td>
<td>.899</td>
</tr>
</tbody>
</table>
I try to apply what I have learned about problem solving in life 1 5 4.16 .650
I participate in class more actively than before 1 5 4.34 .823
I discuss with my friends more rationally 1 5 4.22 .840
I express my ideas to friends 1 5 4.44 .675
I listen and respect the opinions of others 1 5 4.08 .752
I understand the importance of cooperating with others 1 5 4.26 .694
I have become more considerate to others than before 1 5 4.18 .661
I do not fear failure and accept challenges 1 5 4.12 .659
I am more interested in jobs related to science and technology than before 1 5 3.46 1.014
Total class satisfaction 1 5 3.97 .431

Compared to about 4% of the students who have answered that ‘the class was not amusing at all’ or ‘the class was not amusing most of the time’, about 78% of the students answered positively that ‘the class was very amusing’ or ‘the class was amusing most of the time’. For the question asking whether they want to consistently take STEAM classes, about 62% positively answered ‘strongly agree’ or ‘agree’ while about 2% answered ‘strongly disagree’ or ‘disagree’. The weaknesses pointed out were: shortage of time (52.0%), conflict during discussions (34.0%), high difficulty of the problem (6.0%), and difficulty in understanding the contents (4.0%).

5 Conclusion

This research utilized augmented reality technology, a cutting edge technology, so applying to direct experiences, and made practical applications in field education. Unlike the conventional subject of education, it approached with an integrated perspective of various fields. Also, this research developed a STEAM education program analyzing science, social science, and arts as convergence education. Moreover, Suchman’s inquiry learning model was applied to the program and through validity verification by experts the program was modified. By demonstrating the class in the educational field, the program was further improved.

As a result of field application, the significance of the STEAM education program applying the inquiry learning model based on augmented reality was proven. Also the analyzed results showed that the program significantly improved learners’ active inquiry learning capacities. Also, it was able to increase motivations and interests of students as the program makes the students cooperate, experiment and experience in groups. Through this process, students easily acquired various knowledge related to the educational principles included in the curriculum. Although the expert validity test modified the program (adding class time), there were additional comments that there was a lack of time for research, practice, and making. Therefore there is a need to take complementary measures regarding the time allocation.
Although the STEAM education program suggested in this research has been structured to increase the interests of elementary school students, the period of education is very short and there are concerns that the increase in interest will be a temporary phenomenon. Therefore, it requires further research to complement the weakness and modify the program.

References