The Study of Using Different VR Coursework to Enhance Student Learning in the Mathematic Volume Curriculum

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Abstract-The purpose of the research is to explore the effect of using different virtual courseware (Augmented Reality and Virtual Reality, AR and VR) in the mathematic volume instruction of elementary school curriculum. The quasi-experimental study was used in the study and measured by pretest, posttest and one month later posttest to understand the learning effect of the research. Several suggestions were offered for the future research.

Keywords-Augmented Reality (AR); Virtual Reality (VR); Information Technology Integrated Instruction; Volume Concept Teaching

I. INTRODUCTION

In November 2003, the Nine-Year Curriculum Committee of Taiwan Ministry of Education mentioned that the Mathematics’ courses have the following parts: “Number and Quantity”, “Geometry”, “Algebra”, “Statistics and Probability” and “Link”. In “Number and Quantity” part, the volume topic belongs to the section of Number and Measurement. When students learn the volume concept, they often considered the volume topic which is just a series of formula (Tan, 1998). They lost the true understanding of the Volume concept. This lack of the learning process has also resulted them in a loss situation when applying the basic Volume concept (Shen, 2003).

For this problem, use of the virtual three-dimensional objects could produce some benefits for students who learn the Volume concept. As a result, it may be one of the strategies which help students solve problems by using virtual reality (VR) technology and combine the application of three-dimensional objects. Kuo (2008) found that the VR technology very attract to the audiences’ attention when using the web browser to explore some information about the museum. Therefore, if the more the attention of students we could attract, the more initiative learning we could bring about.

The purposes of this study mainly focused on the concept of Volume curriculum of the elementary school. By designing different Virtual courseware to understand the elementary school students’ learning effect.

II. LITERATURE REVIEW

A. The Volume Concept of Courses

According to the study of Volume curriculum misconception, Hsu (2003) found that the six-grade elementary students’ learning existed the following problem: (a) the initial concept. (b) The retention concept. (c) The measurement concept. That is when students learned the Volume concept, they often regard the object’s volume as its weight, and the same area objects are equal to the same volume. In other words, students couldn’t estimate the remaining volume after we put two different objects into one box. Besides, when compared the two different volume size, they would consider the higher or the wider one often as the larger one. From the above description shows that students do not understand the Volume concept, and they were easy to be limited or to be confused when calculated the object’s volume by numerical formula. They couldn't have a correct understanding of the Volume concept.

From this view, students could have some cognitive problems about the Volume concept. For example, they could have difficulties observing the object’s volume through the pattern, the formula to answer their question. Also, they could have difficulties separating or synthesizing the three-dimensional objects. Therefore, if we could more likely to meet the needs of students by designing the corresponding teaching aids and then using in volume teaching process, and then doing visual decomposition and synthesis. It would have a better learning result of developing students’ Volume concept. As a result, for how to enhance students’ understanding of the Volume concept in fifth-grade teaching and allow students to create a complete concept in their mind, through the visual mode, it would be more easily to synthesize or decompose three-dimensional objects. That’s the important key factors that we selected for using a virtual multimedia teaching material in this study.

B. Augmented Reality (AR) and Virtual Reality (VR) Technology

In order to establish a teaching material that we can facilitate students through the visual mode to synthesize or decompose three-dimensional objects, it may be a suitable technology and one of the strategies for applying the VR technology. VR is an impressive world which constructed by the computer. This virtual world, including a variety of senses, and can be interacted with users in a real-time (Auksztalaknis & Blatner, 1992). We can through the sensory stimulation then let users as an impressive situation by using the VR technology. Eventually, the VR system would give some responses and would have let users imagined the world according to theirs’ operation. Besides, it occurred the process of imaging by creating an interactive; otherwise, it would lose the reality sense (Grigore C. Burdea & Philippe Coiffet, 2003).
In other words, users would have the Volume concept more easily by operating the visual synthesis and decomposed the three-dimensional objects when established the virtual objects in VR environments. Those were the advantages of the multimedia power.

But the learning of the Volume concept was a process that you understand the real world. Therefore, in addition to add in the VR technology, even it was a good choice that we should consider how to integrate the AR and VR technology in our curriculum design. AR is a technology that would extend the virtual objects to the real environments, and it was a real-time interactive technology. Azuma defined AR as the following: (a). AR combined the real and the virtual. (b). AR was in a Real-time interaction. (c). AR objects defined in 3D space. Maybe it would be helpful to students' Volume concept learning that occurred between the virtual reality and real world.

C. The Learning Application of VR Courseware

Cheng (2009) has designed a CAI courseware that suitable with fifth-grade elementary students. He integrated the VR use into the teaching of the volume's surface area, and then tests the effectveness for student learning. The quasi-experimental study was used, Traditional teaching strategy was the experimental group and another one (AR in use) was the control group. He also conducted the group analysis in accordance with the students’ mathematical academic achievement, teaching mode (traditional teaching and AR in use), and the gender.

![Fig. 1-2. Integrating the AR Technology into the Teaching (Cheng, 2009)](image)

After the experimental treatment, Cheng considered the effectveness of VR group was superior to traditional teaching group. Besides, among the medium and low learning achievement of the experimental group, it has significant effectveness in volume, surface area aspect and also their performance was better than the AR group. Otherwise, there was no significant difference in high learning achievement one.

From the above discussion, there was a potential benefit that applies the VR technology in elementary volume concept courses. Therefore, the main purpose of this study was designed the different VR course wares and explored the effect that the multimedia AR courseware to the students’ Volume concept.

III. METHOD AND DESIGN

This study mainly focused on the learning effect of Volume concept in elementary school curriculum. By designing the different VR course wares, we want to explore the learning benefits. The research method is shown as the following:

A. The Content of the Volume Concept (Experimental Group)

<table>
<thead>
<tr>
<th>The mathematical field, suitable for the first semester of fifth-grade: Chapter V: Cuboid and Cube</th>
<th>Published by the Nan-in bookstore</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The teaching key points</strong></td>
<td><strong>The chapter name</strong></td>
</tr>
<tr>
<td>To understand the elements of the cubed and cube; and its' relationship.</td>
<td>The definition of the cuboid and cube</td>
</tr>
<tr>
<td>To understand the perspective and expansion figure of the cuboid and cube.</td>
<td>The perspective of the cuboid and cube</td>
</tr>
<tr>
<td>Calculate the surface area of the cuboid and cube.</td>
<td>The expansion figure of the cuboid and cube</td>
</tr>
<tr>
<td>To understand the relationship of the plane which is the vertical, parallel of the cuboid and the cube</td>
<td>The relationship of the vertical plane, parallel</td>
</tr>
</tbody>
</table>

According to the above design of teaching description which we used as our sample design, and we show it as the different multimedia materials. That is, we can sure the same learning goals that all of the students should be reached.

B. The Tool of the Different VR Course Wares for Experimental Group

![Table II. The Interface of Different Virtual Reality Course Wares](image)

![Table III. The Teaching Chapter of Different Multimedia Materials](image)

In order to confirm the curriculum of Volume concept, this study designed different course wares as the Table 1 and Table 2 shows:
C. The Pre-test and Post-test of Learning Achievement

The pre-test and post-test design mainly focus on the content of the Volume concept, the two-way specification table and item analysis as the following table 4 and table 5 shows:

<table>
<thead>
<tr>
<th>Cognitive level Chapter name</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Volume Concept</td>
<td>18</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Congruent relationship</td>
<td>0</td>
<td>18</td>
<td>9</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Surface Area Calculation</td>
<td>0</td>
<td>26</td>
<td>10</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>50</td>
<td>19</td>
<td>13</td>
<td>100</td>
</tr>
</tbody>
</table>

D. The Later Post-test

One month after the treatment finished, we implemented the later post-test in the first achievement test of school. In this test, we collected some result data which be used as the study’s later post-test. This achievement test is performed by 4 teachers, who have worked more than 5 years. At the following Table 6 shows:

<table>
<thead>
<tr>
<th>Cognitive level Chapter name</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>The relationship between surface</td>
<td>48</td>
<td>0</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>Surface Area Calculation</td>
<td>34</td>
<td>9</td>
<td>9</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>9</td>
<td>9</td>
<td>100</td>
</tr>
</tbody>
</table>

E. The process of the Treatment

We selected 2 classes which have 58 fifth-grade elementary students which be considered as our sample size. After using the analysis of homogeneity, we sured 58 samples have the homogeneity in Volume concept (pre-test) and the ability of mathematic. So we named the 2 classes that we selected as the AR group and VR group.

In the process of the treatment, we used the same teaching content but using the different virtual reality course wares. Then we adopted the group learning strategy in order to promote the efficiency of discussion and enhance students’ learning.

IV. CONCLUSIONS AND SUGGESTIONS

This study mainly focused on the learning effect of Volume concept in elementary school curriculum. According to the key point of learning difficulties, we developed a series of AR and VR course wares. The quasi-experimental study was used in the study and measured by pre-test, post-test and one month later post-test to understand the learning effect of the research. The conclusions and suggestions as the following:

A. Conclusions

1) Using the AR Courseware Could Establish a Long-Term and the Whole Volume Concept More Easily than Using the VR Courseware.

The VR group has a better performance than the AR group in the later post-test which belong this item: the relationship between surface and the surface area calculation. That is because of using the AR courseware to define the true world, it needed an anchor. Researcher has used which is named as “marker”. In other words, we used one side as a location. So when we established the basic volume concept, it could lack for one side (as the following figure shows).

Fig. 3. AR Can’t Show the Whole Virtual Object Due to Its Position

The AR technology can’t show the whole virtual object due to its position; however VR has no problem at this point. Using the VR technology, it can be presented all of the whole and different sides and directions.

2) Using the AR Courseware Could Be More Interested in Learning Volume Concept than Using the VR Courseware.

From the feedback of the students, we found that all of the students could be interested in learning by using the AR or VR course wares. However, the AR group was more interested in learning than the VR group. (As the following table shows:)

<table>
<thead>
<tr>
<th>Cognitive level Chapter name</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Volume Concept</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>The relationship between surface</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Surface Area Calculation</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>4</td>
<td>21</td>
</tr>
</tbody>
</table>
Table 8 shows that using the AR technology could establish the virtual objects in the true world. We have the virtual objects and the true world connected with each other. It would be raised the learning motivation with this kind of connection while VR technology has a limited use in the true world (only presented on the monitor). Beside, it couldn’t as funny as the AR technology.

3) Students Could Acquire a Strong Impression When Learned the Volume Perspective Concept by Using the AR or VR Course Wares.

From the feedback of the students, we found that whether the AR or the VR course wares, which could help learning. Perspective conception included some difficult parts which weren’t easy to express. If we showed this conception with a skeleton presentation, that is, lost the meaning of perspective. On the other hand, it could have been more ineffective if we made it with transparent paper as an object’s surface. So we taught the chapter “perspective” by using the virtual objects which could be shown the advantage. (By adjusting the opacity of the virtual objects, which can be shown a translucent side, as the following shows:)

Fig. 4. The Effect of the Different Course Wares

B. Suggestions

What a successful multimedia learning materials, in addition to focus on how to show the efficiency of the object, is in line with the purpose of teaching and play its' advantages more efficiently. No matter what course wares we selected, which be suited to the virtual multimedia learning materials. Nevertheless, this study suggested that we should stay focused on how to use of the two different cursors (AR or VR courseware).

1) The Suggestions on How to Use the AR Courseware in an Educational Environment.

Such as the AR object which merged into the true world, it provided the virtual and the physical world for some interactive opportunities. For example, we could show the size of insects by using the AR technology so as to be known to the students. Or we could establish a relative virtual tennis object with “marker” when estimated and measured the height of objects. Then we could provide students a self-control function to perform an observing activity by copying several virtual objects. (As the following figure shows)

Fig. 5. The AR Courseware Was Applied to the Height Measurement (Simulation)

2) The Suggestions on How to Use the VR Courseware in an Educational Environment.

Because the virtual reality be established in a virtual world, it could suitable for the learning materials which needed a high degree of freedom. For example, in the curriculum of natural science, we could easy to observe the arrangement of plants’ vascular bundles by adjusting the transparency in the VR courseware. Besides, we could observe the longitudinal section and the cross-section arrangement of the plants’ vascular bundles directly by adjusting the angle of objects.

Therefore, it could be a thinking direction that how to use both of the two course wares (AR or VR course wares) properly and demonstrate its advantages for our educational career.

REFERENCES