The Use of Virtual Reality in Education

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Abstract

Recent research in the area of multimedia conducted by the author in Australia, the United States and Latin America has re-confirmed the importance and effectiveness of visual features in teaching and learning materials. It has been demonstrated that multimedia can provide a very effective teaching and learning environment in such a way that the learning style preferences (visual, aural, text and kinaesthetic) of the learners are taken into consideration.

According to the findings, the visual aspects and interaction with the multimedia system are the most preferred features amongst the surveyed students. In all of these studies, the surveyed students have also indicated that the visual features play a very important role in understanding the concepts.

Based on these findings, further research was carried out to investigate the possibilities of creating even richer visual learning environments. The objective was to explore the learning effectiveness of virtual reality educational multimedia systems.

Using the virtual reality multimedia, students from two different backgrounds (Nursing and Business) were given a tutorial on topics related to basic human anatomy. After the completion of this tutorial, each student was interviewed and invited to provide comments and feedback. It was concluded that virtual reality multimedia could enhance learning by providing much more realistic images and visual features. Both groups of students found the virtual reality multimedia teaching to be very effective in terms of ease of learning and its very close relationship with the real world. This paper reports the research findings of using virtual reality in teaching and learning. It also investigates the possibilities of incorporating virtual reality technology into the tertiary education courses.

Key words: virtual reality, immersive, multimedia, nursing, education

Introduction

Although the term Virtual Reality (VR) is used for different purposes, the original concept refers to immersive virtual reality. The general concept of immersive virtual reality was developed back in the late 80s. In immersive virtual reality, participants interact with a world completely generated by computer which is a virtual replica of the actual subject.

As suggested by Beier (2004), one of the main characteristics of immersive virtual reality is that the environment is a full scale replica of the real world and it relates to human size. Hence, the participants get the feeling as if they are interacting with the real environment or subject.

Immersive virtual reality applications include either real or abstract worlds. The human body and mathematical concepts are examples of real and abstract situations respectively. Examples of these situations include:

- Medical students can operate on virtual patients and practise various surgical procedures in an interactive manner;
- An architect can take his/her clients on a virtual tour of the dream home designed, see Easypano (n.d.); or
- Different people at different locations can become part of a team, interact with common objects and environments. They can see each other as avatars (virtual humans), and communicate with each other from their perspectives.

Using virtual reality, we can enter and interact with a world that either does not exist or it is difficult to access due to costs or safety reasons. A virtual environment or object is created by computer and humans can interact with this environment for the purposes of training or experimentation. 3-dimensional virtual reality images are more dynamic compared with the physical models. Virtual reality will be ideal in situations where:

1. Access to the real object or environment is hard or impossible.
2. Using the actual objects is unsafe or poses a health hazard for the user.
3. Obtaining and experimenting with the real object is too expensive.
Imagine the practical applications of virtual reality models in situations where using animal organs can be unsafe and restricted. For instance, Bovine Spongiform Encephalopathy (commonly known as the Mad Cow disease) poses a problem with the use of animal brain for dissection experiments. This paper examines the effectiveness of virtual reality in teaching and learning. Two groups of students from Nursing and Business were studied and their preferences were compared.

**Research Background**

According to a recent survey by the author in 2002, it was discovered that most (about 58%) of High School students in the Darling Downs region of Queensland, Australia have a preference for visual learning with regard to the topic of Statistics. See Figure 1.

![Figure 1 – High School Students’ Preferences for Different Types of Media](http://www.usq.edu.au/course/material/MGT2102/)

Recent research and studies in the area of multimedia by the author and his colleagues constitute the foundation of this project. The findings have re-confirmed the importance and effectiveness of visual features in teaching and learning materials (Nooriafshar and Todhunter, 2004). Figure 2 illustrates the students’ learning modal preferences with regard to Web Enhanced Multimedia Learning Environment (WEMLE). This learning environment is a visually rich multimedia system which was used as an instrument in the study. As Figure 2 shows the visual features and interaction with WEMLE appear to be most popular amongst the 100 surveyed undergraduate and postgraduate students. For details on WEMLE, see (http://www.usq.edu.au/course/material/MGT2102/).
In December 2003, the author conducted another formal survey on 34 students at the Instituto Tecnologico Autonomo de Mexico (ITAM) in Mexico City. WEMLE was used as an instrument in this study. After receiving a seminar on introductory project management, students were interviewed on their experience with the visually rich multimedia system. As illustrated in Figure 3 a vast majority (97%) of them indicated that the visual features played a very important role in understanding the concepts.

**Figure 3** – The importance of Visual Features

The Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) scientists have developed a virtual reality system for teaching medical
students. This system allows the medical students to interact with virtual organs as if they were touching and manipulating the real ones. Some of the advantages of this digital model as reported by team include:

- greater depth and more dynamic features compared with textbook illustrations; and
- reusability of the models.

See CSIRO Mathematical and Information Sciences (n.d.)

As suggested by RTI International (2004), a combination of the leading edge technology and educational theory will produce an advanced learning environment which aims to achieve a cost-effective education. It should be noted that the medical applications of virtual reality are not only limited to education. The technology can also be adopted in diagnosing diseases. For instance, colon cancer detection is an area which has been investigated. As reported in the March issue of Nursing 2004 Magazine (2004), research findings have demonstrated that the virtual colonoscopy approach is much more accurate in detecting malignant cases (Pickhardt et al., 2003). Virtual colonoscopy uses special X-ray images to assemble and construct a virtual image which is almost a true representation of the colon under investigation.

**Proposed Research**

The above-mentioned research projects and their findings have inspired the authors to undertake further research into the visual component of multimedia. It is envisaged that the visually rich multimedia ideas will be taken a step further by enhancing them so that the learner can interact with the subject in a more realistic manner.

The main objective is to explore the possibilities of utilising the leading edge technology of virtual reality with the aim of applying it to Business related topics. Due to the complexities and costs involved with development of virtual reality products, it was necessary to conduct an initial study. The main purpose of this study was to investigate the effectiveness of virtual reality in tertiary education. A suitable package of hardware and software on human anatomy was selected for this purpose. In order to test the medium and the technology involved, it was decided to include both Nursing and Business students. A comparison of the preferences and perceptions of these two groups would make it possible to assess the teaching effectiveness of the technology on students with different backgrounds.

A virtual reality multimedia on human anatomy was selected for the purpose of this research project. The product is called Human Lab (http://www.3dworld.com/).
The Human Anatomy Lab has a lecture mode, which allows the teacher to guide the student. It also incorporates tutorial and quiz modes.

24 University of Southern Queensland (USQ) undergraduate students were chosen randomly to participate in testing the virtual reality multimedia system on human anatomy. These students were from the following two backgrounds:

- Group 1: 12 Nursing students with formal exposure to human Anatomy; and
- Group 2: 12 Business students with no formal exposure to Human Anatomy.

The purpose was to test the technology and the media rather than the content. This is one of the reasons why a basic human anatomy application was selected.

These learners were provided with Crystal Glasses so that the presentation of photographic quality and truly three dimensional (3 D) images would be possible. In other words an almost real (virtual) presentation of the real objects was presented to these learners. Hence, the learners were able to interact both mentally and physically with the learning materials. The effectiveness of this visual enhancement was measured via a survey instrument. The students were invited to rank their perceptions on a 5 point (Likert) scale for the following 6 different factors:

1. How much did you enjoy your VR learning experience?
2. How do you rate the speed of your learning experience?
3. How do you rate the ease of your learning experience?
4. How do you rate the relationship between the learning materials and the real world?
5. How do you rate the way VR method helped with your understanding of the concepts?
6. Would you like to have VR multimedia incorporated into your learning materials?

The research instrument consisted of:

- an organised VR tutorial;
- a structured Questionnaire; and
- interview for comments.

(a) Calculation of Weighted Average Index (WAI)
The frequencies of responses of students were recoded in SPSS program by giving the highest weight of one \((5/5 = 1)\) to the ‘strongly agree’ and 0.8 \((4/5 = 0.8)\) weight to the ‘agree’ and so on. And then, the Weighted Average Index (WAI) was calculated as follows:

\[
WAI = \frac{f_1 \times 1 + f_4 \times 0.8 + f_3 \times 0.6 + f_2 \times 0.4 + f_1 \times 0.2}{F_{total}}
\]

Where, \(WAI\) = Weighted Average Index,

\(f_1\) to \(f_5\) = Frequencies of the ‘Factor’ (one to five)

\(F_{total}\) = Total Frequency

(b) Test of Significance

The combined and separate WAI values of two groups of students were analyzed. And then, Independent Student’s t-test was applied to determine whether or not the perception of two groups of students on different factors is significantly different.

Research Outcomes – Students’ Feedback

The virtual multimedia system provided striking views of human anatomy. It was interesting to observe some of the students who were fascinated by these images and were trying to grasp parts in front of the monitor which was really an empty space to the observer. These virtual images were produced by combining two slightly offset actual images through the special goggles which alternated (switched on and off) at 30 frames per second.

The following statements are some of the comments made by the Nursing and Business students with regard to the virtual reality way of teaching:

- VR explains deeper into each concept. I would love to see it introduced in human anatomy because most people need visual expression to understand reality.
- I found the VR learning experience was excellent as I was able to put theory of learning into a practical application, which is very beneficial in a profession such as nursing which requires a hands-on approach. Also it is often difficult to see particular organs in a two dimensional scenario.
- I found the experience very positive, also in terms of eliminating completely the hazards of possible infection potentially found in real tissue samples.
• The 3 D visual experiences definitely make far better absorption of the material. Also the enjoyment of learning in this fashion far outweighs other methods. This should become available for students; the sooner the better.
• The VR experience was great. It has definitely made it easier to retain information. It is easier to learn by visible examples rather than textbook. The availability of this would improve peoples' learning capabilities.
• Puts things in perspective—where things are better. You can see where they are in relation to other parts depth, how close etc. Really good.
• Catch and maintain attention and interest. Would contribute greatly for learning process, ease understanding, and improve association with complex and difficult topics.
• Very good, excellent visualisation to reinforce concepts. Makes the outcome easier to comprehend.
• Excellent learning aid. I would pay extra to have this sort of learning.

Statistical analysis has revealed that an overwhelming number of students do strongly agree with the following factors. See Figure 4 and Table 1 for details:

1. I enjoyed my VR learning experience.
2. My learning experience speed was very fast.
3. My learning experience was very easy.
4. The learning materials were related strongly to the real world.
5. The VR method helped me greatly with my understanding of the concepts.
6. I would very much like to have VR multimedia incorporated into my learning materials.
Figure 4 - Frequency Distribution of Factors (1 to 6) as Provided by Students

Table 1: Frequency Distribution of Factors (1 to 6) as Provided by Students

<table>
<thead>
<tr>
<th>Perception</th>
<th>Enjoyment</th>
<th>Speediness</th>
<th>Easiness</th>
<th>Real World View</th>
<th>Concept Building</th>
<th>Inclusion in Learning Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>21 (87.5)</td>
<td>6 (25)</td>
<td>12 (50)</td>
<td>20 (83.3)</td>
<td>15 (62.5)</td>
<td>21 (87.5)</td>
</tr>
<tr>
<td>Agree</td>
<td>3 (12.5)</td>
<td>16 (66.7)</td>
<td>11 (45.8)</td>
<td>3 (12.5)</td>
<td>9 (37.5)</td>
<td>3 (12.5)</td>
</tr>
<tr>
<td>Neutral</td>
<td>0</td>
<td>2 (8.3)</td>
<td>1 (4.2)</td>
<td>1 (4.2)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No. of students</td>
<td>24 (100)</td>
<td>24 (100)</td>
<td>24 (100)</td>
<td>24 (100)</td>
<td>24 (100)</td>
<td>24 (100)</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses are in percentages
Research Outcomes – Statistical Analysis

The combined and separate Weighted Average Index (WAI) values of two group of students on all factors are greater than 0.8. This indicates that on average, students, are in between the agree and strongly agree choices on all learning factors. In fact, the Overall weighted Average Index value is 0.9264 which is very close to one. Hence, it can be claimed that the overall importance of this method is very high in terms of students’ learning preferences.

The WAI values of the two factors, Enjoyment and Inclusion into Learning Materials are highest among the others and are equal (0.975 for both factors) too. This shows that the VR Multimedia Method is more important for those two factors. However, the WAI values of Nursing students for all factors are higher than Business students. Especially, the WAI values for Enjoyment, Real World View and Inclusion in Learning Materials of Nursing students are much higher than Business students. The Overall WAI value (average of WAI) of Nursing students is very much closer to one than Business students (Table, 2). This may be due to the background of the Nursing students.

We applied the Independent Student’s t-test to determine whether or not the WAI values of two groups of students on different factors were statistically significant. We found that for each factor, the calculated t-values were less than tabulated t-values (Table 3). This shows that the null hypothesis is true, that is, the population WAI values of Nursing and Business Students are not different from each other. For that reason, we conclude that the VR Multimedia method is equally preferred by both groups of students.

Table 2 - Weighted Average Index Values of Different Factors

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Enjoyment</th>
<th>Speediness</th>
<th>Easiness</th>
<th>Real world view</th>
<th>Concept Building</th>
<th>Inclusion In Learning Materials</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing Students (Number of Students/Responses = 12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAI</td>
<td>1.0000</td>
<td>0.8667</td>
<td>0.9167</td>
<td>0.9833</td>
<td>0.9333</td>
<td>0.9833</td>
<td>0.9472</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.0000</td>
<td>0.0984</td>
<td>0.1029</td>
<td>0.0577</td>
<td>0.0984</td>
<td>0.0577</td>
<td>0.0437</td>
</tr>
</tbody>
</table>
### Table 3 - Independent Samples t-test Between Two Groups of Students (Nursing (Group 1, sample size of 12) and Business (Group 2, sample size of 12))

<table>
<thead>
<tr>
<th>Test Factors</th>
<th>t-calculated</th>
<th>Degrees of freedom</th>
<th>t-tabulated at 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment</td>
<td>1.915</td>
<td>22</td>
<td>±2.07</td>
</tr>
<tr>
<td>Speediness</td>
<td>1.483</td>
<td>22</td>
<td>±2.07</td>
</tr>
<tr>
<td>Easiness</td>
<td>1.043</td>
<td>22</td>
<td>±2.07</td>
</tr>
<tr>
<td>Real World View</td>
<td>1.216</td>
<td>22</td>
<td>±2.07</td>
</tr>
<tr>
<td>Concept Building</td>
<td>0.405</td>
<td>22</td>
<td>±2.07</td>
</tr>
<tr>
<td>Inclusion in Course Material</td>
<td>0.596</td>
<td>22</td>
<td>±2.07</td>
</tr>
</tbody>
</table>

### Conclusions

It was reported that visually rich multimedia can provide a very effective teaching and learning environment. A virtual reality multimedia can even further enhance learning by incorporating more realistic images and visual features. This would lead to a situation where the learners could immerse themselves in the environment and interact with objects and scenarios in a dynamic manner. Very high Weighted Average Indices, t-tests and interview comments in this study support that:

- the virtual reality multimedia is a highly preferred way of teaching and learning;
- there is not a significant difference between the two groups’ preferences; and
- the benefit is transferable between different fields.

Future projects will include exploring ways of designing educational virtual reality multimedia for other topics. For instance, *Factory Layout* in a typical Production and Operations Management course would be ideal application in terms of user interaction.
References

Australian Academy of Science (2002), *Virtual reality bytes – military uses of VR*


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