

Immersive Virtual Reality in a University Setting: Creating an Authentic Learning Environment Through the Virtual Golden Foods Corporation

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ABSTRACT

An authentic learning environment is learning that involves real world problems that are relevant to the learners and relate to their real life experience. Research indicates that Information and Communication Technology (ICT) tools can facilitate in creating authentic learning environment, thus improving student learning, interaction and satisfaction. Previous research has focused on using various forms of ICT such as online learning and web-based learning into the classroom. However, little attempt has been made to investigate the effectiveness of incorporating immersive Virtual Reality (VR) technology into the university classroom.

Virtual Golden Foods Corporation (VGFC) is a simulated Virtual Reality (VR) organization being developed for use in teaching and learning at a large technology based university in Australia. This study focuses on authentic learning environment where students learn about decision making in complex business contexts

ISSN 1823-7797

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throughout the semester which culminates in immersive VR exposure. The findings report that immersive VR environment helps to increase students' understanding of decision making concepts.

Keywords: *learning environment, virtual reality, information technology*

Introduction

Technology offers great advantages for authentic learning environments that were not available before. Technology can provide scaffolds for the students and can allow students access to tools not normally encountered in schools. The use of Information Communication Technology (ICT) tools in learning has become part of normal classroom learning especially in higher education. One of the most widely applied approaches is the use of ICT to support learners who are not necessarily physically present. This approach, generally referred to as online learning allows learners to access resources, support and undertakes assessment from virtually anywhere a computer can be connected at any time.

In this study, we explore how an authentic learning environment is constructed with five different instructional modes of delivery, where immersive Virtual Reality (VR) technology is the main focus. Other modes include lectures and tutorials, group work, online learning, VR intervention and industry panel presentation.

A central characteristic of any VR environment is the ability of the user to interact with the environment by direct manipulation (Riva et al., 2007). Therefore, VR has the potential to provide a powerful interactive simulation of three-dimensional structures in a virtual world. They also argue that VR environments support natural aspects of human perception by extending virtual information in three spatial dimensions. Thus, the simulation provided by VR can be adapted to enhance learning.

This paper attempts to find out how effective is immersive VR technology, as part of an authentic learning environment, in enhancing learning in Marketing Decision Making. By way of background research, two issues will be explored, namely authentic learning environments and immersive Virtual Reality environments. These issues provide a framework for exploring the implementation of an authentic learning in Marketing Decision Making.

Authentic Learning Environments

Authentic learning environment is a pedagogical approach that allows learners to explore, discover and discuss ideas to come up with meaningful information. Learning in such environment enable learners to construct concepts and relationships in contexts that involve real world problems and projects that are relevant to the learners and relate to their real life experience (Brown, 1989; Turner, 2007). These meaningful contexts are key to promoting the acquisition and application of skills based on real-life situations, problems and tasks.

Immersing students in an authentic setting have the capability to motivate and encourage learner participation through students' willing suspension of disbelief. In this way, students become immersed in the setting and such immersion can provide the motivation that is needed for the initial perseverance. Once students have persevered with what can initially be quite discomfoting and unfamiliar settings, they are able to develop the forms of familiarity and the skill sets required so that the authentic setting no longer provides a distraction from the cognitive engagement that higher order learning requires (Herrington, 2000). Different competencies developed through authentic learning environment that represents real life problems are vital in ensuring learning that lasts.

VR technology has the potential to provide real world simulations with real world complexity and limitations that are present in real life (Herrington, 2000). Given situations or circumstances where exploration of real environments is impractical, dangerous or inaccessible, VR technology provides an alternative experience. Bailenson et al. (2008) argue that students learning in such environments should be able to demonstrate the knowledge learned to face their future professional life.

Virtual Reality Environment

A VR environment is defined as an environment where participants become part of the environment (Spicer, 2001). According to Dalgarno (2001), VR environments have four main characteristics:

- The physical or complex situation is modelled using three-dimensional vector geometry, meaning that objects are represented using x, y

and z coordinates describing their shape and position in three-dimensional space,

- The user's view of the environment is rendered dynamically according to their current position in three-dimensional space; that is, the user has the ability to move freely through the environment and his or her view is updated as they move,
- At least some of the objects within the environment respond to user action; for example, doors might open when approached and information may be displayed when an object is selected with a mouse,
- Some environments include three-dimensional audio, that is, audio that appears to be emitted from a source at a particular location within the environment. The volume of sound played from each speaker depends on the position and orientation of the user within the environment.

Recent developments in three spatial dimensions of high end virtual reality allow immersive, multisensory interface environments to be exploited in a learning environment. Users are immersed in three-dimensional worlds using the visual, auditory and haptic (touch and pressure) senses. For example, in Bailenson et al. (2008), the participants were able to explore science learning activities in a Virtual Reality environment that incorporated taste, smell, sound and touch.

The concept of "immersion" in VR environment means that users feel the sense of being a part of the computer-generated world. Developments in three spatial dimensions of high end virtual reality allow immersive, multisensory interface environments to be exploited in a learning environment. Users are immersed in three-dimensional worlds using the visual, auditory and haptic (touch and pressure) senses.

Issues in the Application of VR in Education

A review of the research literature indicates that VR environments have been utilised in diverse fields such as medicine, engineering, military training, medical training, telecommunications, arcade and home entertainment, production and assembly management, health care, digital design, product sales and marketing, and education and training. Within these fields, VR environments have been used in situations:

- Where “real-world” access would be dangerous (Bailenson et al., 2008),
- Where observation of internal workings/structure is important to aid understanding (Shim et al., 2003),
- Where interaction is important to aid understanding (Ng et al., 2009),
- Where applications are so complex that conventional teaching methods are inadequate,
- Where there are difficulties with certain real-world experiences (e.g., time-based or economically-based), and
- That cannot be experienced in real life at all (e.g., nuclear fission).

One of the important characteristics of VR simulations in learning is the creation of structured environments that focus students’ attention on specific learning objectives. Sykes and Reid (1999) argue that desired learning outcomes can be targeted easily through VR simulations because the subject matter makes immediate sense to students. They also argue that combined with traditional teaching and guidance, virtual reality can make a subject crystal clear. According to Bricken (1991), there are four characteristics in a VR environment:

1. *VR is experiential.* Students experience the environment as if it is real while still fully aware that it is computer-generated. They feel the sense of presence within a virtual world. They experience the environment as if it is real and they also feel the sense of being in the VR world.
2. *The VR learning environment allows intuitive human-computer interaction.* The technology is designed to fit human architecture. A virtual world empowers students to move, talk, gesture, and manipulate objects and systems in a natural way. The skills needed to function within a virtual world are the same skills used in everyday life.
3. *The VR learning environment is a shared experience.* A personal computer is designed for solitary operation; there is one keyboard, one mouse, and one display. Virtual worlds can be both individual and social contexts. Networked VR allows multiple participants to interact simultaneously in the same audio-visual environment, sharing control naturally while conversing with augmented capability.
4. *The VR learning environment allows entirely new capabilities and experiences.* This is a powerful context, in which you can control time, scale, and observe the environment from many perspectives. The ability to understand multiple perspectives is both a conceptual

and a social skill; enabling students to practice this skill in ways that cannot be achieved in the physical world may be an especially valuable attribute of VR.

Many research have found that VR environments effectively facilitate learning. For example, Lloyd, Persaud & Powell (2008) compared route-learning performance in a desktop virtual town with performance around a real-world route. Participants completed strategy checklists after learning each route. Results indicated simple desktop virtual environments may be useful in increasing route learning.

Limniou, Roberts, and Papadopoulos (2008) compared learning in two-dimensional (2D) chemical animations designed for computer's desktop with three-dimensional (3D) chemical animations designed for the full immersive virtual reality environment CAVE™. Findings for the study reveal that students understand better learning in the 3D environment compared to the 2D environment.

Yahaya, Euler & Godat (2004) studied decision making and negotiation skills within an immersive virtual reality environment. They studied two groups of university students where one group was exposed to the VR environment-only treatment while the other was exposed to the lecture and VR environment treatment. The result showed increased learning occurred to the group exposed to lecture and VR.

Other studies have found that VR environments enhanced the learning achievement levels of students (Yahaya, 2005), enhanced the problem solving skills of students, and fostered peer interaction. Based on an extensive review of the research literature and his experience as a developer of virtual reality learning environments, Dalgarno (2001) argued that VR simulations can provide contexts for endogenous construction of knowledge. Jackson and Fagan (2000) confirm that immersive VR learning environment can be successfully integrated into school curricula.

Although a review of the research literature generally supports the use of VR environment, it is much less clear about the most effective ways it can be used to enhance learning. A review of the literature on VR and learning indicates that minimal research has been done to investigate whether VR is more effective if used alone or if used with other learning activities such as lectures, group discussions, case studies and other resources.

One of the few studies that investigated this issue was Bowman et al. (1999). They studied learning in a virtual zoo exhibit. The 24 students in this study were divided into three groups: the control group, the

information group and the habitat group. The control group had normal class lectures, the information group attended class lectures and were exposed to the VR environment while the habitat group attended class lectures and used the VR system but they could not access any embedded information. The outcome of this study suggested that VR environment can increase learning when combined with normal classroom teaching.

Due to the dearth of research that has investigated the issue about how VR environments can be used most effectively to enhance learning, this research investigated learning in an immersive VR environment.

The Study

This study was preceded by a pilot study done in 2003. In the pilot, three different subject groups with a cohort of 20 students from each group were observed in an immersive VR environment. Students take on the roles of supervisors, managers and marketing decision makers in a crisis-rich environment. Decisions and actions are made in real time allowing for a two-phased process of decision making, negotiation, risk-taking, problem solving and conceptual learning to take place during the crisis (individual and collaborative action) and after exposure to the crisis (reflection and review). The outcome of the pilot indicated the effectiveness of immersive VR in providing a real-life, crisis-rich environment. Discussion from the pilot study recommended future research to focus on a selection of different delivery modes in the classroom to maximize the authentic learning environment.

This study, therefore, attempts to address the recommendations from the pilot study. It focuses on incorporating other modes of instructions with immersive VR learning environment to maximize learning.

Context

This study is a semester long study where students were observed in the classroom setting and the VR lab setting. The lectures and the tutorials were taught by the same lecturer. However, another lecturer acted as a facilitator for the VR lab exposure. Participants of this study were a cohort of 18 final year students studying for an undergraduate degree in Business.

The university has developed its own Courseware Management System which is referred to as Open Learning and Teaching (OLT). Using the existing format of the OLT website available to all units, the instruction was delivered in an objective based self paced manner using the principles of objective, theory and example to illustrate the new elements. This background is followed by an example such as an Excel or Access database that can be worked on to complete exercises. The notice board (another feature of the OLT interface) is an important tool. The delivery of the lecture and regular messages were posted and sent to students to remind, inform and direct their learning.

Instructions were delivered using PowerPoint software and tutorials were done in a lab setting using online materials. Students were expected to attend lectures where they learned decision making theories and tutorials where they actually put theory into practice. They were given different case study scenarios to solve using different decision making models every week. They worked in groups of four or five in solving the problems. Two weeks before the end of the semester, VR intervention and industry panel presentation were held respectively. Students applied their knowledge in decision making theory to their chosen case study for the presentation. Students were also expected to join online discussions held twice over the semester.

The discussion forum was used in two ways. Firstly, as an assessable item where the discussion forum points to arguable areas in the use of technology and decision making as well as the use of decision making tools such as qualitative and quantitative methods and VR intervention. This means students were required to research and argue various points of view about the topics.

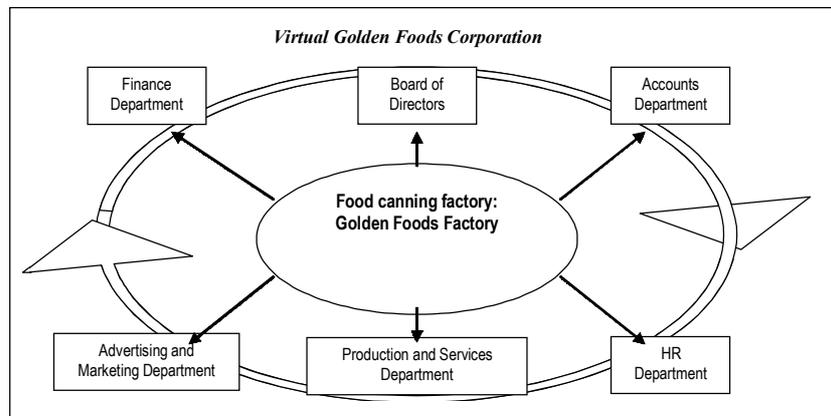
Secondly, the non assessable method of use of the discussion forum is as a dialogue to help students. Students can talk on the discussion forum to assess help in completing exercises and clarifying lecture materials. Helpful web sites were also provided to students for assistance in completing and presenting the exercises and assessments. This uses the helpful web site section of the OLT site.

Finally, the unit has a definite 'culture' which is a combination of theory and practice. No student is incorrect in their views and the buddy system of learning is promoted. Students were encouraged to speak their views, provide input into all lectures and exercises and make suggestions to the cohort. Certain discursive practices were adopted which encouraged students to voice opinions, debate issues and reach

consensus on issues through discussion. The discussion forums helped to refine this cultural element as does the major assessment item of a group presentation and report to an industry panel.

The VGFC Model

VGFC was first developed online in 2004 and was later published online in October 2005. The website: <https://olt.qut.edu.au/udf/VGFC/> (this website is not accessible to the general public) was developed to look like a real company with real divisions. Each division represents different departments of the Faculty of Business, Accounts, Finance Department, Advertising, Marketing and Public Relations, Production and Services Department and Human Resource Department (refer to diagram). The VR scenario simulates a food canning factory, the Golden Foods Factory. Lecturers and students are able to access their respective departments from the website where they are able to follow the directions when completing the VR experience.



Method

Participants in this study have been described above. Permission was obtained for their participation and appropriate ethical approval of the research was obtained through the University Ethics Committee.

Data sources included focus groups, classroom and VR lab observations and interviews. Two focus group sessions involving all students were held at the end of the semester after exposure to the VR lab. The discussions were tape recorded and transcribed. The researcher was present in all lectures and tutorials, in the VR intervention and the final industry presentation. Classroom interactions between group members and with the lecturer were coded. Informal, short interviews were conducted from time to time to interpret students' interactions. Students were observed and discussions were video taped. During the VR simulations, three video cameras were placed strategically in the lab to capture students' interactions with each other and with the facilitator.

Delivery Mode

Several modes of delivery that were considered suitable to the subject taught were selected. They were lectures and tutorials, group work, online learning, VR intervention and an industry panel presentation.

Lectures and tutorials. Students attended a 1-hour lecture and 2-hour tutorial for 9 out of 13 weeks. Two weeks were reduced in place of online discussions while the other two weeks were for VR lab simulation and final group presentations. The 2-hour tutorial was a laboratory workshop type of delivery where students were given case studies to work on. Students had access to online computers and they were allowed to access the internet to search for information. Students were asked to work on the case and adopted a marketing decision model to their problems. During these sessions, students were encouraged to get involved in class discussions at the end of the tutorial.

Group work. Students were divided into groups of 4 or 5 during the first week of the semester. They were given the task to choose different marketing decision making models to evaluate and use as part of their project. At the end of the semester, they presented their findings in front of six industry panel.

Online learning. Some aspects of the OLT website include online discussions, online notice board and email access. Students contacted the lecturer through email at any time for answers to questions or problems. For the online discussion, there were two separate sessions where the lecturer posed a situation and students were expected to give feedback based on their understanding of decision making theories. Their contributions were graded and feedback was discussed in class. Online

notice board was used to transmit messages to students relating to class activities.

VR intervention. The type of VR environment in this study is the group immersive VR, using a spherical screen in a commercial VR theatre that can fit groups of up to 20 people for maximum immersion. VR simulation was introduced during the first week of lecture using desktop computer in the normal computer lab. The VR technology was a simulation of the factory situation where different personnel were available for communication in case of a factory accident. Students were shown different aspects of the VR simulation. Subsequently, students were reminded of the VR simulation at alternate weeks. During the first week, they were given a case study to solve which later became the simulation for the VR exposure at the end of the semester.

Industry panel presentation. At the end of the semester, one week after the VR exposure, students presented their findings about decision-making models and theories to a line of industry experts. The industry experts gave live feedback to each group's presentation.

Results

The outcome of the study revealed that the incorporation of immersive VR technology is effective in increasing students' learning in Marketing Decision Making. The use of VR technology in this study supports the idea that VR technology has the ability to enhance students' learning. This is demonstrated in the industry presentation where students compared the VR environment with the case study they were doing.

Students made similar assumptions in their case studies to the VR case. This supports the idea that the VR intervention had some positive impact on their learning about decision making:

Last week we visited QMI and we did a virtual reality exercise and in that we had to continually look at the cost increases as there are errors in the plant like cleanups and everything in there, the variable cost per unit rises in regards to that, so you can see in that one that the breakeven almost triple (referring to the screen).

Results for the focus groups showed that students who never had any work experience before were enthusiastic with the VR intervention. They thought it represented real life scenario and it gave them a sense of direction in the scenario as opposed to just doing it on paper and trying

to imagine every aspect of the factory. Students felt that the exposure helped them to understand the case being studied. They also mentioned that they can really apply what was taught during the semester to the VR scenario. For example, the following exchanges were indicative of the student's attitudes.

This course, this subject has been very good in really putting the nuts and bolts behind decision making processes and I came across some decision trees and the VR just took me off into a completely different area that I've never even thought about. I thought it was something really basic.

It (the VR exposure) makes you think more in depth.

The VR exposure is the closest to the actual experience of what I expected being a marketing manager, not sitting there constantly reading books and reading and writing marketing plans but actually making the smaller decisions. This one's the one that's got me closer to where I imagined I would be in marketing.

Perceptions of the VR scenario were positive. Students who were new to the VR concept found it very interesting and amazing. They were able to visualize the scenario for the case study.

That was the greatest visual experience I have ever had.

As far as what you can possibly see, the furthest your eyes can go type thing, it was my favourite thing I could ever see, type thing. It was the most amazing thing I have ever seen. It could be applied to other situations.

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When asked about the role VR contributes in learning about decision making, students felt that VR completes the "big picture" of the whole course. Many commented on how the VR experience made them realized what would happen in the real world. Some related their experience with the lesson learned during the semester and applied the theory of decision making models to the case study in the VR scenario. Some general comments from students are as follows:

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You've got something like a decision tree or a flow chart in the notes. You have like internal procedures (in the VR environment) so in the case of an emergency this person would be the first person you contact or this person or this person.

You could use the model to take that and say, O.K., that's a flow chart to this person to this person to this person to this person in the VR lab.

If you want to find out how much stock you have waiting to be dispatched, you contact the delivery, you don't go to the packing area, you go to dispatch. If they don't know, you go back to the packing area. So the model to do that, you can do it that way. You can apply the model to the VR lab.

The simulation provided by the VR scenario was beneficial to students, especially those who were fresh from high school. This opinion which reflects real life experience is very crucial in understanding the case.

I think as an undergraduate subject, it's important because most people in this degree, have just been looking at the flow charts or reading through text saying this is how the factory works. I guess it just depends on the level of experience. Some students may have never walked through a factory and so it's critical and really helps people orientate themselves. Some people have and they know what it's all about, so it's probably less of a help to them.

If you've come straight from school to uni and you haven't been anywhere and experienced decisions like that before, it's really good.

The industry panel presentation held at the end of the semester indicated positive responses showing knowledge being applied correctly to the cases being presented. Students used the knowledge gained throughout the semester including the VR exposure and applied them to their case study. The industry panel gave interesting insights to each group's presentation. They noticed that students had a good understanding of decision making theories and knowledge of applying the models to their case study.

Panel 1:

You didn't waste time telling us all about how the models work, you give very high level of introduction to each model, this is what it does for you, being the strengths and weaknesses.

Panel 2:

That was good and that would apply to that area so, each of the levels you presented, to me you gave good examples and where they came from in different areas, so the decision tree is probably the best decision for that example.

This outcome supports the idea that learning through different modes of instruction has helped students better understand the concept of marketing decision making. Theories learned through lectures, online discussions and in the VR environment were effectively applied in the presentation.

Some Limitations

Some limitations of the VR simulation of VGFC were noted. The animation and graphics effects of VGFC were not as the same standard as the video games available out there, however, the imagery can be improved. Some comments on the graphics:

I've seen it before so compared to the other ones this was pretty basic. The other ones you were much highly involved so if you've seen those ones and then coming back to this, it's pretty basic.

Despite this, realistic environment was successfully achieved. Upgrading of the software was not possible due to time and budget constraint.

The next issue is the availability of the VR theatre. This study was conducted in a commercial VR theatre where the capacity for maximum immersion is up to 20 people. In a normal university setting, the availability of a VR lab is always a concern. Even if there is one, the recommended capacity for maximum immersion in such labs are around 4-5 people. Furthermore, with current situation where class size is of utmost importance at practically all universities around the world, the use of VR technology for a large group of students requires a lot of funding and research.

Discussion

These results provide an insight to how students responded to an authentic learning environment incorporating VR technology with lectures and

tutorials, group work, online learning, and industry panel presentations. The study in particular revealed a number of key issues as follows:

1. Generally, students were more informed of the case study scenario after the immersive VR exposure. Many of them felt the learning experience helped them to be involved in the case problem. However, the VR environment was conducted by a different lecturer which made students felt that they had to adjust to him before they could concentrate on the tasks at hand.
2. Feedback from the industry panel indicated that students had an excellent grasp of the different decision-making models. The VR intervention actually helped them realized that things could go out of hand and could adversely affect normal day-to-day operations. As Marketing Executives, they had the responsibility to make crucial decision that could affect the company's relationship with its clients.
3. The online learning played an important part in supporting student learning. Every aspect of the OLT was utilised to deliver information to students. Discussion forums allowed students to apply their knowledge learned in class and gave feedback, discussed or critiqued each other's responses. Some students who were fresh from high school and had never experienced online learning before were able to cope after getting lessons in class.

Results of this study also support the idea that using VR technology as part of authentic learning is an effective method of delivering knowledge in the classroom. The integration of VR technology not only enhances learning, but it also provides participants with real life experience that they can relate to. While it remains to be proven conclusively that learning is significantly enhanced in this setting, the positive reactions of students provide at a minimum, a platform to continue to explore the potential of VR. It is recommended that future research focus on delivering high quality graphics in a VR simulation to match students' expectations. Advances in technology will make it cheaper and easier to provide such environment in the university setting. Researchers are also urged to expand the application of VR into other areas of study.

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This paper was presented at the 3rd International Conference on University Learning and Teaching, 14-15 March 2006, ACRULeT, Faculty of Education, UiTM.