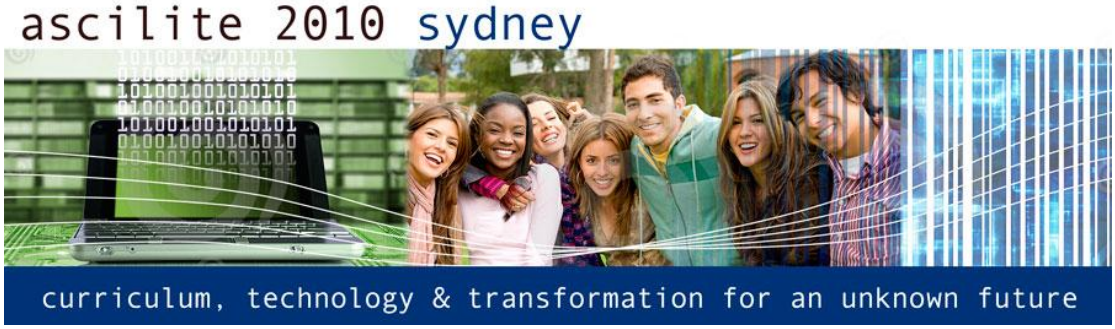


# Pre-service teachers' perspectives on using scenario-based MUVEs in science education

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This paper presents the findings of a study on the understanding and attitudes of pre-service teachers in the use of scenario-based multi-user virtual environments in science education. The participants in the study used *Virtual Singapura*, a virtual world, and completed an open-ended questionnaire. Data from the questionnaire indicated that gender and current computer game use were likely to affect the perceived benefits of using virtual worlds in a classroom setting. Behavior management was seen as being a constraining factor on a pre-service teacher's willingness to use a virtual world in the future. Overall, the results of the study indicate that teachers are both aware of virtual worlds and have an understanding of both their potential advantages and disadvantages within a classroom setting.

Keywords: Virtual worlds, problem-based learning, science education, pre-service teachers, ICT

## Introduction

There is a growing body of research surrounding the use of scenario-based multi-user virtual environments (MUVEs) in inquiry learning in secondary school science education. Scenario-based MUVEs such as *Quest Atlantis*, *River City* and *Virtual Singapura* have all shown the value of these tools in engaging and maintaining student motivation (Bailenson et al., 2008; Barab, Dodge, Thomas, Jackson, & Tuzun, 2007; Barnett, Barab, & Hay, 2001; Beylefeld & Struwig, 2007; Dede, Clarke, Ketelhut, Nelson, & Bowman, 2005; Dickey, 2003; Gee, 2005; Jacobson, June Lee, Hong Lim, & Hua Low, 2008; Shaffer & Gee, 2007; Squire, Barnett, Grant, & Higginbottom, 2004). Apart from the motivational aspects of the environment, MUVEs such as *Virtual Singapura* and *Quest Atlantis* have been planned to meet the needs of teachers. *Quest Atlantis* has been designed so that teachers can modify and adapt materials to suit the needs of their students allowing for flexibility in the classroom. *Virtual Singapura* was developed in consultation with teaching staff and has undergone several iterations to suit the science curriculum. Furthermore, educational MUVEs such as *Wolf Quest*, *Quest Atlantis* and *Virtual Singapura* are free to download and are contained environments meaning that teachers do not have to be concerned with the expense of software or the issue of privacy and child safety. Yet, despite these benefits the use of virtual environments in schools is rare.

The role of teachers in facilitating the use of integrated classroom technology (ICT) is pivotal in the successful implementation of the technology in a classroom. Yet many teachers are resistant to using technologies such as MUVES for many reasons that include the additional time pressure to learn new skills, lack of technological support within the school and concern over the value of the pedagogical value of the technology (Barab, Hay, & Duffy, 1998; Dede, 1997; Henriques, 2002). These organizational and time constraints place technologies such as MUVEs not in the 'too hard' basket, but in

'if only' basket; if only there was more time, if only there were more computers, and if only we could download the software on the school's computers. *Quest Atlantis*, the most widely used scientific inquiry MUVE, was also designed to be accessed by students at home removing many of the barriers, such as bandwidth, that teachers face when using ICT in a classroom. However, not all virtual learning should be undertaken at home and there needs to be greater accessibility of the technology at a school level. Teachers also need to have a more detailed awareness of how MUVEs can be used to facilitate learning at school. It is this awareness of the potential of MUVEs that re-directs the attention to teacher training programs. New teachers heading into the schools should be equipped with a well-rounded understanding of education including the diverse range of technologies that are available and that extends beyond interactive white boards, wikis and blogs.

The purpose of this paper is to present the findings of a study with pre-service science teachers on the use of a scenario-based MUVE to teach inquiry skills in secondary schools. The study investigates pre-service teachers' current knowledge of virtual worlds; their attitudes towards using a virtual world in a classroom; their understanding of a virtual world designed to develop inquiry skills and their perceived technical limitations of the world. The purpose of this study is to see how pre-service teachers' attitudes towards MUVEs and computer games influence their view of MUVEs as teaching tools. The results of the study were used in the re-design of materials that were used to train teachers in the use of *Virtual Singapura.*

## Background to scenario-based Multi-User Virtual Environments

A MUVE is a virtual environment derived from game technology. One of the main features of a MUVE environment that makes it distinct from other virtual environments is the ability for a number of users to be present in the environment at one time and to be able to communicate with each other. Another feature is that users are represented by an avatar or virtual character. This avatar can interact with objects or intelligent agents within the world as well as other avatars. The use of the term 'game' is often used in this context as the technology used in virtual environments is often drawn from gaming technology, and 'game' is also a user friendly term in that member of the general public can identify with the concepts of online gaming. This research will avoid the use of the term game to describe *Virtual Singapura* as *Virtual Singapura* does not engage the use of features such as scores, which are identifying markers of a "game". MUVEs can afford enhanced visualizations, multiple perspectives and can bring together a large group of students together for a collaborative experience, a situation that may be difficult to replicate in a normal classroom environment, but one which can result in a learner being more psychologically present (Bailenson et al., 2008).

As with most computer games, a scenario-based MUVE is underpinned by a narrative that forms the basis of the learning experience. The benefit of using a scenario-based MUVE in an educational space is that learners can interact with an environment that they may not be able to access in real life. This study uses *Virtual Singapura*[1]. Due to the element of fantasy, students have, for the most part, a positive view of the use of MUVEs in the classroom, and the more interest a learner has in a topic the more they are motivated or willing to commit to learning and gathering knowledge in that area (Burigat & Chittaro, 2007; Gee, 2003; Gros, 2003). This motivation inspired by the game experience can contribute to learning outside of the learning space. As Squire and Steinkhuler (2005) explain, games can contribute to life long learning – players are often motivated to visit library and check out books related to games such as *Civilisation III* or *Rome Total War*, showing a cross over from the game environment to the real world.

The story or scenario for *Virtual Singapura* lends itself to scientific inquiry learning – the scenario is complex and the environment is rich with information. *Virtual Singapura* is an open-ended problem-based learning (PBL) environment. Open-ended PBL, in this instance, is used to describe the scenario as students are able to develop and test their own hypothesis thus being in control of where and how they collect and analyze data (Veletsianos & Doering, 2010). The problem is considered to be open-ended for two reasons. Firstly, students can arrive at an answer via a number of routes; hence, there is not a guided approach to the activity and students are not directed through a sequence of levels. Secondly, there is not a 'correct' answer, students need to develop and test their own hypothesis and their answer is formed on the basis of their evidence and analysis. Consequently, the open nature of the

[1] *Virtual Singapura* was developed in Singapore as part of a collaborative project between researchers at Singapore Learning Sciences Laboratory and Nanyang Technological University http://155.69.101.53/wiki/index.php/Main_Page

environment may mean that every group of students arrives at a different outcome and may make different recommendations. The rationale for this approach is that in science, there is not an answer, as such; rather scientists need to test and explore their hypothesis. The development of inquiry skills comes not through presenting a 'correct' answer but through engaging in the process of exploring and addressing the problem. The 'real world' context and rich immersive environment are cited as being motivating factors for learners – the intense visual, aural and textual stimulation support the learning of material in context (Rieber, 1996; Shaffer & Gee, 2007).

As with role-playing MUVES such as *Quest Atlantis*, *River City* and *Wolf Quest*, *Virtual Singapura* has a narrative that is designed to engage students in a similar manner to role-playing games (RPG) such as *RuneScape* and *World of Warcraft*. *Virtual Singapura* is set in 19th century Singapore and is based on historical information about malaria, cholera and tuberculosis epidemics. The students are transported back in time to help the Governor of Singapore, Sir Andrew Clarke, and the citizens of the city try and solve the problem of what is causing the illnesses and to make recommendations about the Governor's proposed health initiatives. Students can visit several worlds to see if initiatives such as changing the night-soil coolies' practices or draining the swamp will reduce the number of people becoming ill. In order to create an authentic learning experience, 19th century artefacts from Singapore have been included in the environment. These artefacts include historical 3D buildings and agents that represent different ethnic groups in Singapore at the time such as Chinese, Malay, Indian, westerners, and historic period photographs (see figure 1).

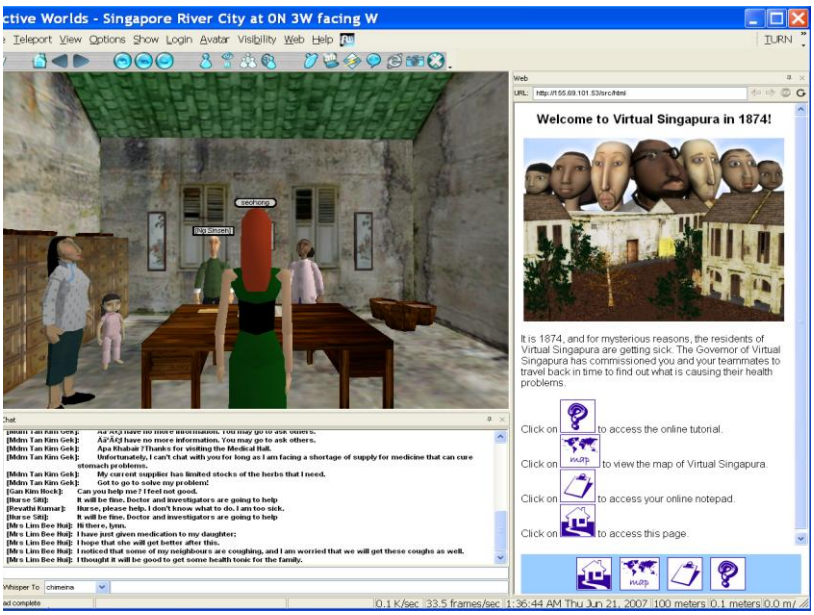


**Figure 1: Screen shot of *Virtual Singapura* showing chat functions, intelligent agents and an avatar**

Much of the research on scenario-based MUVEs has focused on how learners respond to the virtual environment, purported learning benefits and technological developments. The bulk of the research has focused on the analysis of data gathered from questionnaires, focus groups and pre-and post-tests (Bailenson et al., 2008; Barab et al., 2007; de Freitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulovassilis, 2010; Ketelhut, Nelson, Clarke, & Dede, 2010). However, despite all of the purported benefits of using MUVEs as learning platforms, there is a significant lack of substantial evidence of transfer of learning goals outside of the MUVE (Jacobson et al., 2008). Thus, the learning experience may be engaging and fun, but real transfer of skills is still the main objective of any learning.

In terms of pre-service teachers and teacher training, worlds such as *River City* and *Quest Atlantis* provide training for teacher users. *Quest Atlantis* provides online training that teachers can join. There is, however, a paucity of literature on how teachers and pre-service teachers use scenario-based MUVES in a classroom setting. The focus of this paper will be on how pre-service teachers perceive scenario-based MUVEs after participating in a virtual activity.

## Research design

### Participants

This research study involved 28 participants from a pre-service science education course at Sydney University. There were 13 female participants, 13 male participants and two participants who did not identify their gender. The participants had all completed at least one in school practicum and were from either Bachelor of Education (18 participants) or Master of Teaching (10 participants). None of the participants had ever undertaken work as a teacher within a secondary school.

In terms of current computer game use it is evident that the male participants played computer games more frequently than the females and that males are more inclined to play first person style games such as first person shooters (FPS) and RPG. Female participants tend to play arcade games such as Tetris and Solitaire or to be involved in virtual worlds such as SIMs. This needs to be taken into consideration when analyzing the data as the increased familiarity with game spaces may impact upon a participant's virtual experiences and understanding of how to interact with the interface. Tables 1 and 2 provide an overview of current computer game use and the preferred games.

### Data collection

The data collection took place during the normal lecture time for the group. The participants were divided into two groups and participants were randomly assigned to teams of three. One group accessed the virtual world for the first hour of the three hour lecture while the other group learnt about PBL. After one hour the groups swapped. The final hour was spent discussing PBL and virtual worlds.

Participants were provided with an overview of the virtual environment and were then allowed 40 minutes to explore the problem space. They were provided with the handout that secondary school students participating in the trial in June will receive. After the participants finished their in-world explorations they were asked to complete a fifteen-question open ended questionnaire. The questionnaire was divided into two sections. Questions 1 – 8 addressed the participants' current knowledge of virtual worlds and their attitudes towards using virtual worlds in education. Questions 9 – 15 addressed the scenario and technical issues.

## Results

The results of the data analysis will be presented in the four contextual areas. Area 1 presents the current knowledge of virtual worlds, game use and understanding of the technology. Area 2 addresses the use of virtual worlds in education from the perspective of a teacher. Area 3 addresses the clarity of the problem. Area 4 discusses the technical limitations of the world and additional comments.

### Area 1: Current knowledge of virtual worlds and games use

The participants were asked to respond to four questions in this area: what is a virtual world? What are some virtual worlds that you know? What sort of computer games do you play? How often do you play? These questions were design to elicit current knowledge of virtual spaces as well as current game usage. The more a participant plays computer games and interacts with virtual worlds the more familiar they are with different interfaces and the greater the likelihood that they will have the appropriate level of technical literacy needed to interact with *Virtual Singapura* without the need of additional technical support.

Question 1 related to the participants current understanding of what a virtual world was. During the introduction phases of the data collection process, students were given a brief two minute overview of the scenario, but were not provided with an overview or definition of the technology. The responses to the first question indicate that the participants all had a basic understanding of what a virtual world was when compared with Bainbridge's (2007, p. 472) definition of a virtual world, which is described as 'an electronic environment that visually mimics complex physical spaces, where people an interact with each other and with virtual objects, and where people are represented by a virtual character'. This definition was selected as a comparison as it most concisely drew together the elements of virtual environments raised in the body of literature available on virtual worlds. Participant responses included:

- A made-up computer game based on the real world
- A world that exists with a technology – it is not real, but simulates a real world
- A world designed and accessible by computer technology
- A simulation which allows interaction between a played character and the elements of the world.

The most commonly occurring words/themes were computer generated (15), simulation (8), real world (4), imaginary (4) and non-physical (3). These words/themes were not included in the introduction to *Virtual Singapura* indicating that the participants' understanding of a virtual world was either pre-existing or developed as a result of their activities in-world. The level of understanding of a virtual world was not linked to current computer game use – people who used computer games more frequently did not show a more in-depth or detailed understanding of the technology.

Question 2 was designed to elicit an understanding of the types of virtual worlds that participants were familiar with. The results of this question indicated that almost all of the participants, regardless of their level of use, knew of at least one virtual space – two participants did not respond. The results included computer games (15), World of Warcraft (8), SIMs (8), Second Life (7), Facebook/Twitter/Social sites (3) and *Virtual Singapura* (3). The participants that wrote *Virtual Singapura*, Facebook, twitter or social networking sites were all infrequent or non users of computer games indicating that their actual knowledge of virtual worlds was less than that of their peers. The two respondents that did not answer this question were non users of computer games.

Questions 3 and 4 were designed to find out the types and frequency of game use (see Table 1 and Table 2). Males were more likely to be frequent/weekly game users (7) while females were more likely to be occasional/monthly users (8). It was also evident that there was difference between the genders on the preferred game choice with FPS being more popular with males (8) to females (0); similarly males played more RPG (8) to females (1). Females (4) were more likely to play arcade games than males (0), and females were also more likely to play SIMs (2) than males (1). This indicates that males will be more likely to be familiar with *Virtual Singapura* and other scenario-based MUVEs which are derived from first person RPGs.

**Table 1: Pre-service teachers' current game use and preferred games**

| Gender | Frequent/Weekly game use | Occasional/monthly game use | Never | Preferred games |
|---|---|---|---|---|
| Female* | 1 | 8 | 3 | SIMs, RPG, arcade style |
| Male** | 7 | 3 | 1 | RPG, FPS, Sports |
| N/A[+] | 1 | 0 | 1 | RPG, FPS |

* One female participant did not respond to this question
** Two male participants did not respond to this question
[+] Two participants did not identify their gender

**Table 2: Comparison of gender and game play and the use of virtual worlds in a classroom**

| | | Gender | | | | |
|---|---|---|---|---|---|---|
| | | **Female** | **Male** | | **Female** | **Male** |
| Computer game use | Infrequent or non user | 91.6% | 36.4% | Use virtual worlds in class | 84.6% | 100% |
| | Frequent user | 8.4% | 63.6% | Not use virtual worlds in class | 15.4% | 0% |
| | *n* | 12 | 11 | *n* | 13 | 13 |

### Area 2: Virtual worlds in education

Participants were asked to respond to four questions in this area – How can virtual worlds be used in education? What are some advantages/benefits of using virtual worlds in education? What are some problems and issues? Would you, as a teacher, use virtual worlds in your classroom?

Question 5 was used to identify how pre-service teachers though that virtual worlds could be used in education. The majority of respondents did not answer the question properly. Rather than indicating 'how' they would use the technology they responded to 'why' they would use the technology. Overwhelmingly, the participants indicated that engaging and motivating students (16) would be a reason to use a virtual world and that visualizing and modeling (6) were also seen as beneficial, while developing literacy skills (3) and inquiry skills (3) were also seen as reasons to use virtual worlds in a classroom. One participant indicated that virtual worlds would be useful in science, history and math's education.

The perceived advantages and the problems of using a virtual world in a classroom setting were addressed in questions 6 and 7 and this information is presented in table 3.

**Table 3: Pre-service teachers views on the potential advantages, benefits, problems and issues of using virtual worlds in a classroom setting**

| **Perceived Benefits** | | **Perceived Problems** | |
|---|---|---|---|
| **Characteristic** | **%** | **Characteristic** | **%** |
| Visualization | 41.7% | Off-task | 53.3% |
| Motivating | 20.8% | Lack of resources | 20% |
| Interactive, | | Not liking computers | 10% |
| learner centered | 16.7% | Too complicated | 6.7% |
| Engaging | 8.3% | Too expensive | 6.7% |
| Risk free | 8.3% | Repetitive | 3.3% |
| Team work | 4.2% | | |
| *n* | 24 | *n* | 30 |

The results of these questions indicated that there are clearly perceived advantages and disadvantages of using a virtual world in a classroom setting. The most significant advantage was seen as the ability visualize information (41.7%) that would not be possible from a text or normal classroom setting. The motivating (20.8%) and interactive (16.7%) elements of the environment were also seen as being advantageous to learners. The most significant disadvantage was that students would be off-task (53.3%) and that it would be difficult to make sure that students were completing the activities when the teacher could not monitor student progress:

- Kids not saving work.
- Using the game as a chat room instead of a learning environment.
- If working in groups some students may hog the computer
- Can't control the activities so students can waste time chatting or chasing each other through the environment
- Students going off-task, especially in a large group
- Keeping all students on-task – need a master computer or guidelines or strict assessment to keep them focused.

A lack of resources (20%) was also seen as being a potential problem of using virtual worlds in a classroom.

Question 8 related to whether or not a pre-service teacher would consider using a virtual world in the classroom. A significant proportion of the participants (71.4%) indicated that they would use the technology. All of the frequent computer game users indicated that they would use the technology in their classrooms, and 21.4% of the respondents indicated that would possibly use the technology, but it

depended on several conditions, such as smaller, groups, technical support, sufficient time and class behavior.

> Yes. If it can fill my class time whilst teaching and engaging then I'll definitely use it! Provided that it has good feedback from others
>
> Yes, because students will be engaged as it'll be a game also to provide them with problem based learning experience about real-world situations which cannot be done through reading a text
>
> Not really - as I have no experience with such games I would have trouble finding time to weight (sic) up academic benefit… I also have little personal interest i.e. I would have difficulty being the teacher of such an activity
>
> Maybe: if I thought that students would benefit from the experience by gaining knowledge or skills in order for this to happen students must be engage in the activity
>
> Absolutely. From just its engagement factor AND potential for learning.

Only 7.1% participants indicated that they would not use the technology in their classrooms. The two participants that indicated that they would not use the technology were infrequent or non users of game technology.

> Not really as I have no experience with such games I would have trouble finding time to weigh up the academic benefit… I also have little to no personal interest i.e. I would have difficulty in being the teacher of such an activity.

It is evident from the responses of the pre-service teachers that making sure that the students are on-task is the major concern of using a virtual world, while the main benefits are the motivation and engagement of students and the increased visualization.

### Area 3: Problem clarity

Questions 9, 10 and 11 were designed to ascertain if the introduction, scenario and problem were clear. This information will be used to modify worksheets and information that will be presented to students during the trial of *Virtual Singapura* in June with year 9 students. The results are presented in Table 3.

**Table 3: Pre-service teachers' understanding of the introduction, scenario and problem**

| | Clear | Not/clear | Suggested improvements |
|---|---|---|---|
| Clarity of introduction to *Virtual Singapura* | 20 (71.4%) | 8 (28.6%) | Audio introduction, shorter, explanation of tools, and tool bars, improved navigation |
| Clarity of virtual scenario | 23 (82.1%) | 5 (17.9%) | More detail, explanation of control and experimental conditions, more understanding of navigation |
| Clarity of problem to be solved | 17 (60.7%) | 11 (39.3%) | More detail of problem needed, more time to see how to navigate, better understanding of functions like bug catchers, hard to move between worlds |

The results indicate that while the introduction and the scenario were clear that the actual problem that students will need to solve needs to be made more transparent in the trial in June. The pre-service teachers struggled with the fact that there were five experimental conditions and one comparison condition. The limited time spent in-world is reflected in the responses that more information on how to actually navigate and use the tools was needed. Students participating in the trial will have a forty-minute introduction to the tools and capabilities of *Virtual Singapura,* which should overcome these issues. The feedback from the participants and the suggested improvements were used to re-design the introduction to the problem and scenario. Information on how to navigate between the worlds was added. The introductions to the three interventions were also modified, so that the problem that needed to be addressed in each of the interventions is explicit – participants are now directed to water-testing devices this places the focus of the interventions on the control of Cholera rather than Tuberculosis and Malaria. This reduces the number of variables to be tested and should improve clarity.

### Area 4: Technical limitations, group work and additional comments

Questions 12, 13, 14 and 15 were designed to identify problems that pre-service teachers had with the Active Worlds interface and additional comments. The information is provided in Table 4.

**Table 4: Pre-service teachers' perceptions of virtual world interface and additional comments**

| | **Technical Problems** | **Suggested improvements additional comments** |
|---|---|---|
| Interface issues | Sinking under the water (10)<br>Problems moving avatar (6)<br>Chat function (4) | Sound,<br>Better graphics,<br>More thrill |
| User issues | Clunky graphics (2)<br>Navigation of menu (3) | Less users per computer,<br>More scaffolding for activities,<br>Online introduction like an online tour |

The main problems that participants had with the interface were that they were teleported under the water and they had trouble teleporting in general. This is a design issue with Active Worlds and is a result of the time taken to download *Virtual Singapura.* Problems with the chat function were actually a design restriction – teams could only talk to one other team to avoid the whole class getting off task. Many issues raised were related to the Active Worlds interface and were not related to *Virtual Singapura.*

## Discussion

The use of virtual worlds in science education affords teachers with opportunities to enhance students' ability to visualize and engage with complex problems. Science education is often presented as a body of facts that needs to be remembered it is linked to exams, curriculum content, text books, and paper-based representations of science (Siorenta & Jimoyiannis, 2008). There is a division between what scientists do in real life and how science education is presented in the classroom and many educators are aware of this divide, which results in a division between the practice of science and science education (la Velle, Wishart, McFarlane, Brawn, & John, 2007). Technology, such as virtual worlds, can result in better teaching outcomes as students can visualize a situation or concept that may be difficult without additional support (Brack, Elliott, & Stapleton, 2004; la Velle et al., 2007; Lowe, 2004; Webb, 2005; Zacharia, 2003). The pre-service teachers in this study were aware of the potential learning affordances of a virtual space such as *Virtual Singapura*; yet, their main concern was in regards to behavior management and keeping the students on task.

The results of this study suggest that pre-service teachers perceive the issues relating to behavior as more influential on their chosen method of delivery than the technical or potential learning benefits of the virtual world. This shows that while pre-service teachers may be willing to use a tool such as *Virtual Singapura*, they would weigh this up against factors such as class size, class temperament, access to technology and skill requirements. These findings were consistent with several research studies that found that the limited and inadequate amount of training that pre-service teachers often receive before entering a classroom means that pre-service teachers, in many cases, do not feel that they have the technical support, the skills, or a pedagogical rationale for implementing ICT in the classroom (Angeli, 2004; Lee, 1997).

The focus on behavior management is perhaps a result of their inexperience as classroom teachers. Experienced classroom teachers may present a different set of attitudes to ICT, as they are more likely to be aware of both the technical capacity and the behavior of the student cohorts at the school in which they work. One issue that is evident in school based trails of *Virtual Singapura*, is that the technical limitations of the schools are often prohibitive. Firewalls that are designed to protect students often mean that teachers cannot download the client software that is run off a browser due to the private IP address. For many teachers, circumnavigating obstacles such as a firewall without ongoing technical support will render defunct most well-planned virtual activities as it may take several months to rectify the problem. A current trial of *Virtual Singapura* has been delayed by several months due to such an issue.

This study also indicates that the greater familiarity that a pre-service teacher has with computer games and virtual worlds the more likely they are to consider using this technology in their classroom. Correspondingly, as a greater proportion of male pre-service teachers in this study use computer games more frequently than females, more male pre-service teachers would be likely to use virtual worlds in their science classes. This issue needs to be considered in greater detail in pre-teacher training. This is consistent with the findings of BECTA (2004) who also indicate that females are less likely to use technology in the classroom. Although, this study was limited to 28 participants and is, therefore, not conclusive in terms of the impact of gender on pre-service teachers' use of ICT, the results were consistent with the findings of game use in recent studies. Several research studies do indicate that that boys and girls play games differently (Dickey, 2006; Squire et al., 2004; Taylor, 2003; Upitis, 2001). One of the findings of this study that is consistent with the research is that females will play a game if there is not much else to do, while males will play games as the first choice of entertainment.

The results of this study indicate that there is a potential divide in the use of ICT in science education depending on both gender and technical literacy. One limitation of this study was that there were only 28 participants. A second study has been planned in order to gain a deeper understanding of the potential divide and the impact of gender on attitudes towards virtual worlds. This study will build on the results of this trial and will follow pre-service teachers once they are in the classroom over a period of several years in order to ascertain if classroom experience changes a teacher's perceptions to using virtual worlds in the classroom. This will involve a more prolonged exposure to *Virtual Singapura* as well as more in-depth questions about computer game use and virtual worlds. This longitudinal study will follow the participants once they have commenced teaching to see if their attitudes towards ICT and virtual worlds change after they have become more familiar with classroom teaching.

## Conclusions

This study sought to gain an understanding of how pre-service teacher attitudes to the use of virtual worlds in science education was related to their current understanding of virtual worlds and their experience using *Virtual Singapura*. The results of the study indicate that while the majority of pre-service teachers were positive about the use of virtual worlds in the classroom they were aware of constraints such as expense, access to the technology and differences in students abilities as well as issues with behavior management.

The pre-service teachers in this study saw the main value of scenario-based virtual worlds in terms of their ability to engage and motivate students and their ability to present learners with an opportunity to visualize a problem might be too complex to visualize in a classroom setting without the aid of a three dimensional virtual space. Pre-service teachers need explicit training in the use of technologies such as scenario-based MUVEs as the greater the familiarity a teacher has with a technology, in terms of benefits and potential issues, the better the integration of the MUVE technology in a classroom setting.

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