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Using game-based inquiry learning to meet the changing directions of science education

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This paper presents the results of a study designed to develop pre-service teachers' skills and pedagogical understanding of how game-based learning can be used in a classroom. The study used a technological pedagogical content knowledge (TPACK) conceptual model. 18 pre-service science teachers participated in the study that used *Death in Rome*, a point and click inquiry-based game to learn how to teach scientific inquiry. In the workshop the participants were required to complete several activities using game-based learning that included the evaluation of a range of online games and virtual worlds. Participants were required to complete pre-and post-tests. The results of the pre-and post-tests indicate that there was a significant shift in pre-service teachers' attitudes towards game-based learning as a result of the workshop. Overall, this study showed a positive change in attitudes towards game-based learning in science education.

Keywords: Pre-service teachers, inquiry, game-based learning, TPACK, pedagogy

Introduction

There is a growing body of research on the integration of information and communication technologies (ICTs) into pre-service teacher training programs and the varying degrees of success of these initiatives (Hu & Fyfe, 2010). Numerous studies, such as Phelps et al. (2011) and BECTA's (2004) literature review, have confirmed that a teacher's attitude towards technology has a significant impact upon a teacher's decision to use ICT. The importance of pre-service teacher training that focuses on the development of novice teachers' skills in using ICTs is garnering increasing attention mainly due to the apparent limitations of graduate skills in using ICTs appropriately (Galstaun, Kennedy-Clark, & Hu, 2011; Lee, 1997; Markauskaite, Goodwin, Reid, & Reimann, 2006) It is often assumed that during pre-service training that students will develop ICT literacy skills, yet, many novice teachers enter the classroom not having developed systematic and sufficient ICT skills

(Markauskaite, et al., 2006). In terms of teacher training programs, there are numerous recommendations aimed at developing long-lasting skills and positive attitudes towards technology enhanced learning. Firstly, teachers need well-designed, hands on tutorials and discussion in order to develop their skills (Lee, 1997). These sessions need to be developed with the specific needs of the teachers in mind rather than generic skills development. Lawless and Pellegrino (2007) indicate that discipline based training is more effective, so having training for science teachers separate from English teachers may result in more customised and, consequently, more usable skills. Webb and Cox (2004), support this premise stating that by blending ICT with subject area expertise teachers can plan to maximise and explain the affordances of a technology to students more readily. In response, students are more likely to be motivated and engaged in the learning activities and are able to make the most of the use of ICT. While these studies have all focused on classroom teachers, pre-service teachers also need the same exposure to ICTs during the duration of their degrees. This study was designed to develop both skills in using game-based learning and in the evaluation of resources within the context of a secondary science education degree program.

This paper presents the findings of a study that integrated game-based learning into a pre-service teacher unit of study. The study was set in the context of an inquiry unit of work and used a technological pedagogical content knowledge (TPACK) conceptual model. TPACK is aimed at moving teachers beyond "technocentric" strategies that focus on the technology rather than the learning (Harris, Mishra, & Koehler, 2009). TPACK emphasises the importance of developing both integrated and interdependent understanding of the four core elements of TPACK: technology, pedagogy, content and context. Since Mishra and Koehler (2006) articulated the concept of technological pedagogical content knowledge, also known as technology, pedagogy and content knowledge, there has been an emerging body of literature reiterating the importance of TPACK in pre-service teacher training. TPACK was deemed an appropriate framework to adopt in this study due to the flexibility of the framework. According to Harris et al. (2009), the parsimonious nature of TPACK is a result of the diverse range of content areas, ICTs and teaching contexts. They explain that professional development using a TPACK framework needs to be flexible and inclusive enough to account for a range of contexts, teaching philosophies and styles. As acknowledged by Mishra and Koehler (2006), some simple learning-technology-by-design experiences would not fully prepare teachers to use ICT effectively. It is perhaps more appropriate to regard the pre-service teachers' experiences with the workshop as building a foundation of a beginning repertoire of ICT skills. The research questions to be answered in this study are: What are a pre-service teacher's attitudes to the use of game-based learning in scientific inquiry? And What is the impact of TPACK on a pre-service teacher's self-reported confidence and competence in using ICT in a classroom?

Technological Pedagogical Content Knowledge (TPACK)

There is a substantial amount of literature regarding the need for teachers to use a combination of different knowledge types when in the classroom. These knowledge types are presented as falling under the broad headings of Content, Pedagogy and Technology (Graham, 2011). These individual knowledge types have been combined to form a string of acronyms representing new knowledge, such as PCK (pedagogical content knowledge), TPK (technical pedagogical knowledge) and TPCK (technical pedagogical content knowledge) (Graham, 2011). The TPACK framework combines the four core components, technology, pedagogy and content knowledge and context. The result being seven combinations of these components, such as pedagogical knowledge, content knowledge and technical knowledge. TPACK emphasizes a teacher's understanding of how technologies can be used effectively as a pedagogical tool (Koehler & Mishra, 2009). Koehler and Mishra (2009) explain that technologies have their own characteristics, affordances and limitations, which may make them more suitable to certain tasks. Moreover, Markauskaite (2007) found in her research with pre-service teachers and ICT literacy that being able to plan to use and evaluate different forms of ICT is as important as having the capabilities to implement the ICT. TPACK is a complex interplay of three bodies of knowledge: (1) pedagogical content knowledge (Shulman, 1986), (2) technological content knowledge (knowing what kind of technology tools are available for teaching what), and (3) technology pedagogical knowledge (able to choose an ICT tool based on its affordances to address a particular teaching/learning need) (Schmidt et al., 2009). To develop TPACK, teachers not only need to know how to use a computer and its associated software applications, but also be aware of the strategies to incorporate ICT tools to enhance student understanding of a particular subject's content. Using a TPACK approach has, in preliminary studies, been shown to improve a pre-service teacher's confidence and skills in the productive use of ICT (Galstaun, et al., 2011; Hu & Fyfe, 2010).

Game-based learning

The term game-based learning is often used simultaneously with terms such as "serious" games, educational games and virtual learning environments. However, before moving into more detail it is worthwhile to clarify exactly what these terms means so as to distinguish between the point and click games and the virtual worlds that the pre-service teachers accessed in this study. Game-based learning is the use of a computer-based game, also called a video game, in an educational context (Watson, Mong, & Harris, 2011). Game-based learning can incorporate commercial off-the-shelf (COTS) games that are used in education such as *Civilization III®* (Squire, 2004). Game-based learning can also be the use of single player point and click games or the use of mobile device applications, such as iPhone "apps" that are developed for learning contexts. Game-based learning also incorporates the use of multi-user virtual environments (MUVEs) such as *Quest Atlantis* (Barab et al., 2009; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). The main distinction between a virtual world and a scenario-based virtual world is that a virtual world often mimics "real" life in that lectures, meetings, classrooms are all held within the virtual space - virtual worlds are popular in distance education and are often hosted in places, such as *Second Life* (Gregory et al., 2010). A scenario or narrative-based virtual world is based on a story or narrative and information is built into the environment, where students take on the role of a character and interact with elements of the story using game-based elements such as point scores (Barab, et al., 2009). As they are proving to be an effective means of attracting and gaining students' attention, games, virtual worlds and virtual realities have been touted to be one of the technologies to watch over the next five years by the Australia–New Zealand Horizon Report (2009). This changing direction and changing demand combined with teachers' interest in ICT and increased access to ICT as a result of the Digital Education Revolution in Australia were motivating factors in this study into the use of game-based learning.

Research Design

The study was set in the context of a core science curriculum unit. In this unit of study, students were either completing a Master of Teaching or a Bachelor of Secondary Education combined degree majoring in science. The two-hour workshop focused on the integration of game-based learning into inquiry learning. The workshop applied the following TPACK principles (1) learning tasks are problem-centred, (2) skills are developed via learning-technology-by-design approach, (3) design tasks are accomplished collaboratively, and (4) learners are encouraged to engage in reflective practice. Table 1 provides an explanation of these principles.

Table 1: TPACK and Related Activities

TPACK Three Bodies of Knowledge	Activities
Pedagogical content knowledge	Design activities that support how they would use *Death in Rome* in a science inquiry lesson. Identification of year group syllabus area and context.
Technological content knowledge	Evaluation of a range of online game and virtual environments. Evaluate for usability and effectiveness of software.
Technology pedagogical knowledge	In groups explore the affordances of the allocated online games and how they address a particular teaching/learning need.

The development of TPACK aims at equipping pre-service teachers with the knowledge and skills that will enable them to utilize ICT tools to mitigate some of the problems that students face when learning complex or difficult topics that are often challenging for teachers to teach and for students learn. This study presents the findings of this two-hour workshop. However, as the participants were self-reporting it is difficult to gain a full or more detailed understanding of the full impact of TPACK as a framework or whether the pre-service teachers would, in fact, use ICT in a classroom.

Participants

18 students participated in the workshop (11 females and seven males) with an average age of 24.4 yrs and a standard deviation of 5.52. These students were all majoring in science education and 10 were post-graduates and 8 were undergraduates. None of the participants had worked as a paid classroom teacher and they had all completed at least one in-school practicum.

Materials

The materials for this study included *Death in Rome*. *Death in Rome*, is a point and click adventure game hosted by the BBC website (http://www.bbc.co.uk/history/ancient/romans/launch_gms_deathrome.shtml). The game is set in 80AD in Ostia river port, Rome. In this game, students have to find and evaluate evidence in order to support a hypothesis on how Tiberius Claudius Eutychus died. They were also provided with workshop handouts that provided information on the background of game-based learning and virtual worlds and the TPACK conceptual model.

Procedure

The workshop on game-based learning was arranged for week 4 of Semester 1, 2011. In week 3, students were emailed both the workshop materials and the pre-test. They were asked via email to complete the pre-test and to print out the materials for the workshop. This study used both pre- and posts-test surveys, hereafter referred to as pre- and post- tests. The pre- and post-test had 14 questions. The first five questions were five-point Likert style questions and were adapted from an instrument used by Hu and Fyfe (2010) in their study using a cohort of pre-service teachers. Questions six to 14 were open-ended questions that were used to assess attitudes and were based on an instrument used in a previous study by Kennedy-Clark (2011).

As students arrived at the workshop they were asked to submit the pre-test, 17 pre-tests were collected. The pre-service teachers participated in a discussion on computer games and virtual worlds; identified who played games; discussed what types of ICTs they had used in their in-school professional experience; and identified problems that the pre-service teachers had encountered during their professional experience. The class discussed inquiry learning and what inquiry learning meant in science. The pre-service teachers were introduced to TPACK and how pedagogy, technology and content could be integrated in classroom situations.

The students, in groups of two or three, completed the online BBC UK historical inquiry activity *Death in Rome.* The lesson was modelled for the pre-service teachers in that they were given the role of the student. In this game, students have to find and evaluate evidence in order to support a hypothesis on how Tiberius Claudius Eutychus died (Figure 1). This game gave the pre-service teachers access to artefacts in Tiberius's house, on his body, modern scientific views, the views of historians and the accounts of historical sources, such as a slave and a Roman trader. The pre-service teachers could not put forward a cause of death until they had accessed several pieces of evidence or consulted with sources. Moreover, they could not confirm a hypothesis unless they selected three pieces of evidence. Ultimately, Tiberius died from malaria, but the pre-service teachers could not confirm this without investigating the evidence thoroughly. They accessed the game twice, swapping groups between games so that the pre-service teachers were paired up with new group members.

Figure 1: Screen shot from Death in Rome

The purpose of swapping the groups was to draw on the expertise of the groups that successfully completed the activity, and was based on expert novice differences and communities of learners (Lave & Wenger, 1991). Using a think, pair, share strategy the group discussed issues such as where, how, why they would use this activity; the strengths and weaknesses of the tool; and connections to the NSW state high school science syllabus for Years 7-10. The influence and importance of modelling in pre-service teacher preparedness has been demonstrated in similar studies. For example, Gill and Dalgarno (2008) in their investigation into pre-service teacher preparedness to use ITC found that the pre-service teachers saw modelling of the use of ICTs in lectures as a good way to learn how to use the ICT.

Students were then allocated three websites to critically analyze from a list of 20 websites that the group self-identified as science education resources. These were all 'educational' science websites and were either games or virtual worlds, for example, *NASA*, *The Jason Project, Whyville*, and *Quest Atlantis*. The pre-service teachers were provided with scaffolding for the critical analysis and as a group discussed and reflected upon the sites. They ranked them for their potential usefulness and usability in the class and whether they, as teachers, would use that site. This critical analysis was based on the TPACK framework. In the critical analysis pre-service teachers reflected on and discussed the scenarios and types of technology; the skills needed to masterfully use the technology; how they would use the technology in a classroom; and the relevance to a Syllabus curriculum area. They were also asked to advise their peers as to whether or not their sites would be useful to visit. A list of the three best sites was created for the group. Students were then asked to complete the post-tests, and 18 post-tests were received.

Data Analysis

Content analysis was used for the analysis of the data to make replicable and valid inferences from the data to their context of using game-based inquiry learning in the teaching of science (Krippendorff, 1980). Four contextual areas emerged allowing for a single category construction. Area 1 centered on TPACK, Area 2 on current game use and preferred games, Area 3 covered knowledge of education games and Area 4 addressed the use of educational games in a classroom context. The data were then coded using five themes that emerged from the data. These themes were gender, game use, current understanding of games and virtual worlds, potential use of games and virtual worlds used for education, and the educational challenges of using games and virtual worlds in teaching science education. Many of the participants supplied multiple responses to a question, and these responses were taken into consideration, and, consequently, *n* is not always 18.

Results

The results of this study showed that there were significant shifts in the negative responses in the pre-test towards positive responses in the post-tests. Students' responses showed shifts from the contextual areas listed, namely, knowledge pre-service teachers' current use of games and their choice of preferred games, current knowledge of educational games for classroom use, and the use of educational games in education.

Area 1 – TPACK

The first contextual area of TPACK contained the first five questions in the pre-and post-tests used a five-point Likert scale to rate the pre-service teachers' confidence or belief in their ability to integrate ICT into a classroom using the TPACK framework. The tests measured prospective teachers' technological knowledge (TK), technological pedagogical knowledge (TPK), Technology Pedagogy and Content Knowledge (TPACK) and pre-service teachers' evaluation of the workshop. The effect size was measured using Cohen's *d* and used a pooled standard deviation. The most significant effect was the change in strong disagreement with a *d* of -0.9, the negative effect indicates that these students' that had previously shown strong disagreement in the pre-test shifted towards agreement. Moreover, a medium effect size of 0.5 was recorded for agreement, meaning that more students were showing agreement. There was no effect in the strong agreement category and only small effect sizes were recorded for neutral (-0.3) and disagree (-0.2) respectively. Overall, the results of the pre- and post-tests do signify a positive change and this is consistent with the findings of Hu and Fyfe (2010)

There is a clear indication that the pre-service teachers involved in this study showed increased confidence in selecting, evaluating and using ICT (Table 3). For example, in question 3 that asked students on their ability to use strategies that combine curriculum content, ICT tools and teaching approaches, in the pre-test 52.9% agreed while in the post-test 83.3% agreed that they had this capability, showing that more students felt that they had strategies for using ICT in the post-test than in the pre-test. However, in question 4, which related to leadership, the post-test showed a decrease in confidence. This is not surprising as the pre-service teachers have only had one or two in-school professional experiences; it is unlikely that they will feel confident in providing leadership on ICTs. The responses to the first five questions showed an increased confidence in pre-service teachers' knowledge to select appropriate resources and use of resources. That is, through using a TPACK framework the pre-service teachers believe that they can use the technology effectively as a teaching tool and that their selected resource will work in a classroom.

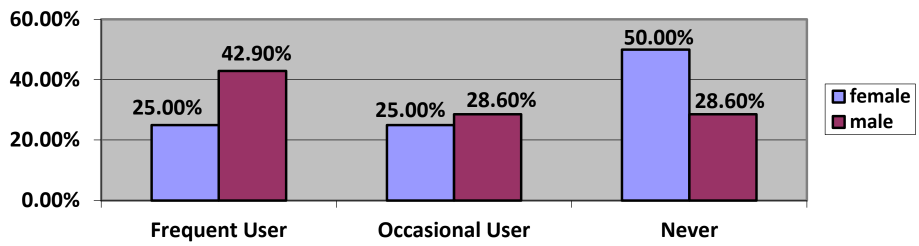

Figure 2: Pre-service teachers' current game use and gender

Area 2 - Current game use and preferred games

In the pre- and post-tests, questions 6 and 7 asked students about their current game use and what types of games they played. As with studies 1 and 2, the participants' use of computer games was analyzed and the results of this study indicate that the males (42.9%, n=3) were more likely to be frequent computer game players than the females (25%, n=10) (Figure 2). The study also showed that females were more likely to never play games (50%) in comparison to males (28.6%). This is consistent with the findings of similar studies on gender and game use (Upitis, 2001). The most common games played by males were first person shooters (FPS,) role playing games (RPG) and sports games and females played phone apps, such as *Bejewelled, Angry Birds* and *Tetris*. A Chi-square test showed that there is no statistically significant association between gender and game play frequency (χ^2=7.744, p=.021). Nearly all of the frequent and occasional game players indicated that they played more during university holidays and on the weekends. The findings of gender, game use and types of games played are consistent with other studies using a similar cohort in that males play more RPGs and FPS (Kennedy-Clark, 2011). However, the most noticeable difference in comparison to similar studies was the increase in females and males playing iPhone game "apps". Although there were still more frequent male players, the difference was no longer significant. This is perhaps a reflection of the increase of phones with game applications as females were still more likely to play games on their mobile phones. However, there is a marked difference between phone applications and online role-playing games in terms of the nature of play. Consequently, the term "game" in this sense needs to differentiate between single and short instance games, such as *Angry Birds* and ongoing role-playing games such as *Warcraft.*

Area 3 – Current knowledge of educational games

Questions 8, 9 and 10 centred on the participants current knowledge of educational games and virtual worlds. In question 8, the participants were asked to define the term educational computer game. Students were asked to choose the best characteristic of the game from a list provided. The most frequent response in both the pre- and post-tests characterized educational computer games as games designed or used for learning and content (47.1%, *n*=8; 42.9%, *n*=9). Other responses included games to teach concepts (11.7%, *n*=2; 4.8%, *n*=1) and skills (5.9%, *n*=1; 9.5%, *n*=2). There were no significant changes between the pre- and post-tests (Table 3) Note that in the table, multiple answers were given by the participants. Consequently, *n* is calculated as the number of responses and not the number of participants.

Table 3: Educational Game Characteristics

Educational Games Characteristics			
Pre-Test	**%**	**Post Test**	**%**
Learning and content	47.1%	Learning and content	42.9%
Concepts	11.7%	Skills	9.5%
Brain training	5.9%	Interactive	9.5%
Engaging	5.9%	Fun	9.5%
Mathletics	11.7%	Concepts	4.8%
Skills	5.9%	TPACK	4.8%
Curriculum area	5.9%	Activities	4 .8%
Not relevant	5.6%	NASA/BBC	4.8%
		Mathletics	4.8%
n=17		*n*=21	

Table 4: Pre-service teachers understanding of a virtual world

Virtual World Characteristics			
Pre-Test	**%**	**Post Test**	**%**

Computer-generated world	27.8%	Simulates real life	35%
Simulates real life	27.8%	Immersive	20%
ICT resource	16.7%	Interactive	15%
Avatar, character representation	11.1%	Online, multiplayer	15%
Limited	11.1%	Avatar, character representation	5%
Fantasy	5.6%	Computer-generated world	5%
		Useless	5%
n=18		*n*=20	

In question 9, participants were asked to define a virtual world. Again, students were given a list of characteristics to choose from. The results of the pre- and post-test are shown in Table 4. The most frequent responses in the pre-test included a computer-generated world (27.8%, *n*=5) and simulates real life (27.8%, *n*=5) in the post test this shifted to simulates real life (35%, *n*=7) and immersive (20%, *n*=5). When compared to Bainbridge's (2007, p. 472) definition that a virtual world is "an electronic environment that visually mimics complex physical spaces, where people can interact with each other and with virtual objects, and where people are represented by a virtual character". The post-test responses indicate that the participants had a better understanding of the characteristics of a virtual world, such as interaction, multiplayer and immersive. The response of "useless" was explained as nothing beats real life.

In question 10, participants were asked to provide examples of virtual worlds that they were familiar with, and the results show that of the 14 participants that responded to the question in the pre-test that 71.4% (n=10) of participants knew of or were familiar with *World or Warcraft* and 35.7% (n=5) *The Sims.* Other virtual worlds that were mentioned included *Virtual Singapura* and *Second Life.* In the post-test, participants added virtual worlds that they had evaluated, such as *Quest Atlantis* and *Whyville.* Knowledge of these two virtual worlds was consistent with previous studies indicating that in terms of game play and knowledge of educational computer games and virtual worlds, that the participants in the studies were fairly consistent (Kennedy-Clark, 2011).

Area 4 - Use of educational games

The open-ended questions 11 to 14 focused on the use of educational games in education. The analysis of the pre- and post-tests indicated that students' perceptions of educational games changed as a result of the workshop and showed a positive shift towards using technology in the classroom. In question 11, students were asked how they might use games in an educational setting. The student responses are presented as characteristics in Table 5. As with other results, *n* is representative of the number of characteristics and not the number of participants.

In question 12, pre–service teachers were asked what they perceived to be the benefits of using educational games in the science classroom, and question 13 asked students what they felt were the possible problems or issues that may arise. The results have been presented together in Table 5. It is evident from the results that the pre-service teachers in both the pre- and post-tests saw the value of using educational games in their ability to teach concepts (18.2%, *n*=4; 17.2%, *n*=5) and to engage learners (18.2%, *n*=4; 27.6%, *n*=8). Other benefits included visualization (13.6%; *n*=3; 6.9%, *n*=2) and interactivity (9.1%, *n*=2; 6.9%, *n*=3). The main shift in the concerns about the use of game-based learning in education is evident in the results of question 13. In the pre-test, fun, but no learning (18%, *n*=4) was the main concern, but in the post-test this had shifted to technical issues (37.1%, *n*=13). This may actually be a beneficial change. Many of the pre-service teachers were naïve in regards to the integration of ICTs into a classroom. This heightened concern about the technical issues is in alignment with classroom teachers concerns about ICTs raised in studies, such as BECTA's Review of *The Research on Barriers to the Uptake of ICT by Teachers* (2004), and shows a more realistic appraisal of using ICT.

Table 5: Pre-service teachers views on the potential advantages, benefits, problems and issues of using educational games in a classroom setting

Perceived Benefits			
Pre-Test	**%**	**Post test**	**%**
Concepts application	18.2%	Engagement	27.6%
Engagement	18.2%	Concepts application	17.2%
Visualization	13.6%	Motivating	10.3%
Context	9.1%	Modern relevance	10.3%
Safety/simulation	9.1%	Visualization	6.9%
Interactivity	9.1%	Interactivity	6.9%
Problem solving	4.5%	Complex systems	6.9%
Revision	4.5%	Collaboration	3.4%
Enjoyment	4.5%	Inquiry	3.4%
Learning styles	4.5%	Problem solving	3.4%
Literacy	4.5%	Revision	3.4%
		Safety/simulation	3.4%
		Literacy	3.4%
n	22	*n*	29
Perceived Problems			
Pre-Test	**%**	**Post test**	**%**
Fun, but no learning	18%	Technical issues	37.1%
Lack of ICT skills	18%	Off-task/distracted	25.7%
Off-task/distracted	18%	Fun, but no learning	8.6%
Technical issues	16%	Un-reliable/not specific content	8.6%
Un-reliable/not specific content	16%	Time consuming	5.7%
Perpetuate misconceptions	8%	Cyber safety	5.7%
Time consuming	8%	Perpetuate misconceptions	2.9%
Cyber safety	8%	Lack of ICT skills	2.9%
Parental concern	4%	Plagiarism	2.9%
Plagiarism	4%		
n	25	*n*	35

In regards to question 14 the pre-service teachers were asked if they, as teachers, would use educational games and virtual worlds in their classrooms. In the pre-test, of the 13 students that responded to the question, 61.5% (*n*=8) indicated that they would use games in the class for reasons that included:

> *Yes, I see the benefit in teaching through educational games. The advantages outweigh the disadvantages but mostly as a tool for revision.*
>
> *Yes, games make the learning experience more enjoyable and interactive for the students, they can relate and engage greater due to the technology being a prominent aspect in most students' everyday lives.*

The remaining five students (38.5%) were uncertain of whether they would use games in the classroom.

In the post-test, of the 15 students that responded to the question 86.7% (*n*=13) indicated that they would use computer games in the classroom. Their explanations indicated that they are critical of the ICT resources and that the resource would need to deliver content and be reliable, for example:

> *Yes, but I would have to ensure that all the educational goals are met and they can be easily accessed by all students.*
>
> *Yes, given proper scaffolding and relevance to classroom material.*

Yes, only appropriate games which tie in closely to curriculum content and pedagogical orientation.

Yes, I find games very useful. I have used puzzles, wheel of fortune and I have made chemistry bingo. They combine skills such as teamwork, communication etc. with content knowledge

Yes, I would use it as an alternative way to cover content, but not the only way.

The students' responses to this question and their intention to use the games is based on the educational value and learning affordance of the tool. This suggests that by allowing students to evaluate and report to the class on their group's ICT resources was developing essential skills in critically evaluating a source on the basis of criteria such as content, ease of use, time constraints and technical limitations. These responses indicate that the pre-service teachers were considering how ICT can be used in context. This may also show a move away from teaching the tool to teaching with the tool to using ICT meaningfully (Figg & McCartney, 2010).Of the remaining two students, one was unsure of whether they would use games depending on the quality of the resource and the other indicated that they would not use games as they were too distracting and time consuming. This student in the pre-test would have used computer games in class. When questioned as to what changed their views, one student's response indicated that several of the examples given in the introduction to the workshop had made her cautious of using ICT in the future.

Discussion

The study showed that a pre-service teacher's attitudes to the use of game-based learning in scientific inquiry were mainly positive as a result of a one-off workshop. The pre-service teachers indicated in the post-test that engagement and visualisation were the main learning affordances of using game-based learning in classrooms, which is consistent with other studies on these technologies (Barab, et al., 2005; Ketelhut, Clarke, & Nelson, 2010). There was a significant difference between the pre-and post-tests in the barriers that might be faced by a teacher using game-based learning in a classroom. In the post-test, the pre-service teachers were more concerned about technical problems rather than the learning outcomes, which is consistent with several studies on teachers attitudes towards using ICT in classrooms (Urhahne, Schanze, Bell, Mansfield, & Holmes, 2010; Webb & Cox, 2004). When designing this study several key points raised in the literature were considered. The session was designed to encourage hands on involvement and discussion in order to develop pre-service teachers' skills in using game-based learning. The focus of the session was on the skills needed for pre-service teachers rather than developing generic computer skills. Furthermore, the workshop was discipline-based and focused on inquiry learning, which is considered to be more effective than a generic skills workshop (Lawless & Pellegrino, 2007). As stated by Webb and Cox (2004) blending ICT with subject area expertise can make students more engaged in the learning activities while making the most of the use of a technology. In this study, the pre-service teachers were motivated by the array of possibilities for bringing game-based learning into the classroom. These considerations are aligned with the TPACK concept model that focuses on technology, pedagogy and content knowledge within a particular learning context (Figg & McCartney, 2010; Mishra & Koehler, 2006). The TPACK conceptual model seemed to be an effective framework. Koehler and Mishra (2009) explain that TPACK emphasizes a teacher's understanding of how technologies can be used effectively as a pedagogical tool, and in this study students had the opportunity to evaluate a range of games and virtual worlds and generate a list of resources that they believed could be used to provide a content rich experience in a pedagogically sound manner. The pre-service teachers identified the characteristics, affordances, and limitations, which may make them more suitable to certain tasks. This is consistent with the research of Koehler and Mishra (2009).

Conclusions

This study showed that there was overall positive change in attitudes of pre-service teachers towards games-based learning in science education. Though there was significant shifts in pre-service teachers' negative responses in the pre-test to positive responses in the post-test responses, the study has some limitations that need to be taken into consideration. The first significant limitation is that this was a one-off study. A longitudinal study that follows pre-service teachers into the classroom once they have graduated will provide a more realistic understanding of the use of ICT in the classroom. Factors such as school efficacy and pre-service teacher attitudes have a more resounding impact on a novice teacher than a brief interlude with a game-based learning workshop (Choy, Wong, & Gao, 2008; Phelps, et al., 2011; Webb & Cox, 2004). Furthermore, the school environment will have a greater influence over pre-service teachers than their university training. A second limitation is that although as a TPACK conceptual model was used to design course materials, it needs to be considered that at what level the TPACK framework influenced the results. This has not been addressed in this paper. There was a significant change between the pre-and the post-tests in favour of game-based learning, but the pre-and post-tests did not demonstrate how TPACK may have influenced the outcome of this study. Moreover, this study did not consider all of the permutations of the TPACK elements. Another limitation was that although the workshop was a one-off, the pre-service teachers would not have had the opportunity to develop sufficient competence to use computer-games in education effectively. Further studies need to be undertaken to gain a better understanding of how novice teachers use ICTs, such as computer games and virtual worlds, when they are in the classroom. Research also needs to be undertaken to provide a better understanding not only of the TPACK conceptual model, but also of how TPACK may influence a pre-service teacher's design of activities and approaches to embedding ICT into a classroom.

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