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Tactile Elements: Their Role in Fire Investigation Virtual Training

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Abstract. The delivery of training for early career fire investigators is recognized as increasingly problematic due in part to the availability of uncontaminated real time fire scenes for training purposes. In response to this challenge Charles Sturt University has developed a fire investigation subject (JST415 Fire Investigation Cause and Origin determination) which utilizes virtual reality technology for simulated investigation skill development. With the implementation of this innovative approach to fire investigation studies, a study has been completed on the impact of this mode of training on learning outcomes and competence rankings of students. Whilst the study identified a number of key findings in relation to the use of online training for developing professional practice this paper presents a discussion of the relationship of the absence of tactile elements in the virtual environment and the implications for the design of training delivery which utilizes virtual worlds. The results suggest that the absence of tactile elements in the virtual environment does not inhibit the students' ability to successfully investigate the virtual burn scene and determine the cause and origin of a structural fire and can have advantages for the initial learning phase for fire investigators.

1. INTRODUCTION

The delivery of subjects focussing on the investigation of the cause and origin of structural fires has historically been complex. Traditionally, students undertaking fire investigation studies through Charles Sturt University could elect to study by distance education mode utilising text based learning materials or attend a 5 day short course residential school which included investigating a real time fire scene for assessment purposes. Here lies one of the problematic elements of teaching fire investigation, guaranteeing the availability of an uncontaminated fire scene for residential students to investigate, demonstrating the knowledge and skills acquired during the course of their study and providing the opportunity for aligned learning experiences which are time independent or asynchronous.

Prior to 2007, an uncontaminated real time fire scene for students to investigate had been provided through combining the timing of the residential course with the training needs and cooperation of the New South Wales Rural Fire Service. In brief, a building is identified (within reasonable proximity of the residential course) in need of demolition, a permit sought for destruction by fire, a NSW Rural Fire Volunteer training day programmed to coincide with igniting the building and extinguishing the resultant fire and students notified of the date for attendance at the residential school. With students travelling from interstate and overseas to attend the residential course it is neither practical nor desirable to rely on a structural fire occurring naturally that fits the above logistical criteria. A further obstacle which has emerged since 2005 with increasing impact is new restrictions imposed by the NSW Protection of the Environment Operation Act 1997.

To address this challenge the fire investigation course, JST415 Fire Investigation Cause and Origin Determination (JST415) embraced the use of virtual environments. Here a virtual environment made up of navigable photorealistic imagery developed from previously filmed fire scenes was provided for assessment of the student's investigation knowledge and skills. This virtual environment was developed using the Interactive Scene Recording and Presentation System (ISRAPS), based on Apple's *QuickTime VR* technology, which involves the 'stitching' together of a series of photographs making up one or more 360 degree panoramic images (Chen, 1995). The student investigator is then able to explore the images by zooming, panning or tilting the view direction around the scene and upwards and downwards. Providing a mechanism which allows for jumping from one view position to another creates a photorealistic virtual environment which is an alternative to 3D model virtual environments. The greater visual fidelity in photorealistic VR environments is an advantage; however the inability to provide smooth movement between viewpoints is a limitation when compared with 3D virtual environments.

This paper reports on the results of an evaluation of the effectiveness of the learning resources developed for this subject with a particular focus on how the absence of sensory and tactile elements in the virtual environment affected the successful achievement of learning outcomes.

Four student cohorts who undertook the study of JST415 were included in the research as shown in Table 1.

Table 1: Student Cohorts in the Study

Cohort	Learning Context
Group 1 (to be referred to as the *Short Course Real Time Fire Burn group* or SCRTB)	Residential face to face course - investigated real time burn scene Text based learning materials
Group 2 (to be referred to as Short Course Virtual Assessment 1 or SCVA1)	Residential face to face course - investigated version 1 virtual fire scene on CD CD based learning materials
Group 3 (to be referred to as Short Course Virtual Assessment 2 or SCVA2)	Residential face to face course - investigated version 2 virtual fire scene on CD CD based learning materials
Group 4 (to be referred to as Distance Education Virtual Assessment 2 or DEVA2)	Distance Education study - investigated version 2 virtual fire scene on CD CD based learning materials

2. VIRTUAL ENVIRONMENTS AND LEARNING

The term *virtual environment* has widely differing definitions. For example, for some (see for example Wann & Mon-Williams, 1996) the term encompasses environments containing a 3D model allowing for user-controlled navigation and dynamic view generation. However, for others (see for example, Dillenbourg, Schneider & Synteta, 2002), the term *virtual learning environment* may refer to any Web-based learning resources even those that do not include any form of visual simulation. In this paper the term virtual environment is used to refer to environments that include some sort of visual simulation that can be explored and navigated but does not necessarily imply the use of a 3D model.

A number of researchers have suggested that the use of virtual environments as learning resources is compatible with constructivist learning principles (see for example Bricken, 1990; Jonassen et. al., 2003), due to the ability for learners to actively explore the simulated domain and construct their own individual knowledge representation. Winn (1993) asserted that educational virtual environments align very closely with constructivist theories of learning because rather than consisting of the prescribed instructional transactions of traditional computer-assisted learning resources, they are open ended and allow for knowledge construction through first-person experience.

Dalgarno, Hedberg and Harper (2002) identified eight potential contributions of virtual environments to student learning, three of which were seen as potentially applicable to the virtual fire scene environment. Firstly, it was thought that the virtual fire scene would be helpful in "facilitating familiarisation with inaccessible environments" (Dalgarno et al., 2002, p.4) similar to the exploration of microscopic environments to help students to understand quantum atoms as described by Kontogeorgiou, Bellou and Mikropoulos (2008), and the exploration of an environment modelled on a historic theatre in Italy as described by Alberti, Marini and Trapani (1998). Secondly it was thought that the virtual fire scene would be helpful in "facilitating task mastery through practice of dangerous or expensive tasks" (Dalgarno et al., 2002, p.4), in a similar way to the way the environment described by Mikropoulos, Chalkidis, Koutsikos, Strouboulis and Vrellis (2005) was able to be helpful for earthquake preparedness training and the environment described by Psotka (1995 was helpful for training astronauts in how to repair a space telescope. And lastly it was thought that the virtual fire scene would be helpful for "improving transfer by situating learning in a realistic context" (Dalgarno et al., 2002, p.4).

3. THE JST415 CDROM

The design rationale for the JST415 CD was to address the factors impacting on the availability of real time fire scenes as mentioned previously and produce an engaging authentic learning experience for distance education students which closely replicates that received in the residential face to face environment. To this end the JST415 CD evaluated in this project contained in addition to the virtual fire scene for assessment purposes, the following: voiced lecture presentations aligned to those delivered in the residential course, hyperlinks to photographic and text based reference materials, assessment instructions, marking criteria and hyperlinks to communication channels with subject lecturers and university based assistance i.e. essay writing guidelines. The key concept is the progressive building of skills and knowledge so as to undertake a holistic assessment of the learnt skills and knowledge as outlined by Biggs (1991). Figure 1 depicts a screen shot from the JST415 Virtual Fire Scene Environment.

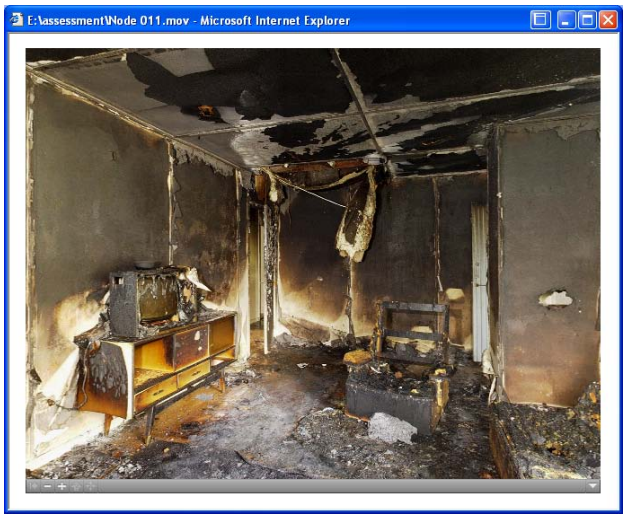

Figure 1: Screen Shot from the JST415 Virtual Fire Scene Environment

4. RESEARCH PARTICIPANTS AND DATA COLLECTION

All students within the four student cohorts (Groups 1 – 4) were invited to participate in the research project to evaluate the impact of the JST415 Virtual Fire Scene Environment on learning outcomes. Table 2 indicates the number of students who completed the study of JST415 and participated through submission of the research survey and the number of students from each cohort who were interviewed. It is important to note here, that more than 90% of participants were active NSW Fire Service employees and at the time of conducting the research interviews were on 24 hour on-call roster for the annual NSW summer fire fighting season.

Table 2: Summary of Student and Research Participant Numbers

Group	No. of students who completed all course assessment requirements	No of students who completed the evaluation of the JST415CDROM & submitted the research survey	No of students interviewed
1	14	5	1
2	8	6	1
3	4	6	2
4	1	2	1

Irrespective of their learning pathway, Groups 1, 2 3 and 4 were all provided with identical copies of the JST415CD for evaluation purposes. The data collection process for this research then included students completing a questionnaire which contained a mixture of Likert scale questions and open ended questions. The questionnaires differed slightly across the four groups because of differences in learning conditions of each group, but in each were divided into three sections. The first section, Section A, contained general questions relating to the participants' level of experience with fire investigation studies and the use of online vs. print based learning materials. The second section, Section B related to the experience of undertaking the course assessment via the Virtual Fire Scene or real time burn. The third section, Section C related to the evaluation of the JST415 CDROM in terms of accessibility, quality of materials, adequacy of the materials to prepare the student for undertaking an investigation either real time or through the virtual environment. Additionally, a selection of participants were interviewed and to provide triangulation of data the project participants' course assessment results and competency rankings were also used as part of the analysis.

5. RESULTS

To more clearly interpret the value of the participants' perspectives in relation to the impact of the absence of sensory and tactile elements in the virtual environment it is first necessary to explain the overall results of the participants in their study of JST415. The average result for Assessment 2, the investigation of the fire scene (real time for Group 1 (SCRTB) and virtual for Group 2 (SCVA1), 3 (SCVA2) and 4 (DEVA2)) indicates 61.5 % for Group 1 (SCRTB) with an ascent to a Group 3 (SCVA2) average of 73%. Group 2 (SCVA1) weighs in with an average of 76.9% and Group 4 (DEVA2) at 81%. The identified difference between the Group 1 average percentage and those of the remaining Groups may to an extent be accounted for by the assessment experience, i.e. the time constraints, the inability to revisit an uncontaminated scene, and inability to record completely the details of the scene. This issue has been discussed in more depth in earlier work (see Davies & Dalgarno, 2008).

In recognition of other factors which may impact on the final mark awarded for Assessment 2, such as previous report writing experience, lack of familiarity with academic writing requirements, the markers assigned a competency ranking[1] to each participant based on the contents of their Assessment 2 submissions. This reflected a similar relationship between the average competency ranking achievements of the four groups, with the mean competency achieved for Group 1 (SCRTB) below that of each of the other groups (see Figure 2).

[1] The criteria for determining competency included demonstration of competency in the following areas: Theory of Chemistry Combustion – Safety of Investigator – Fire Spread Mechanisms – Ignition sources – Determine Cause Origin – Document Scene – Evidence Importance – Evaluate Scene – Arson - Reporting

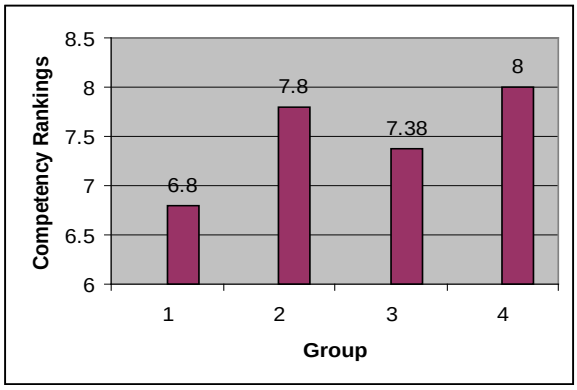

Figure 2: Group Mean Competency Ratings

In the exploration of the role of virtual fire scene investigation activities in developing professional practice the value attributed to the sensory and tactile nature of fire investigation emerged through responses in interviews. Here lies the inherent value of unstructured interviews which offer the opportunity for the participant to provide rich and meaningful articulation of their learning experiences which may not be revealed through survey responses (see Douglas 1985; Fontana & Frey 1994; Punch, 2000, Creswell 1994; Neuman, 1994).

The environment of real time fire scenes intrinsically produces elements which engage the sensory receptors of fire investigators; a myriad of burn smells, smoke, vapours, sodden ash, dampness and water dripping from where flames have been extinguished, at times heat or warmth from smouldering objects and potentially an overwhelming sense of destruction. In exploring the impact of the absence of these elements in the virtual environment it is appropriate here to firstly consider the following comments where this absence was noted. Participant 1B[2] who at the time of interview had completed the short course with the real time fire scenario to assess and had subsequently investigated several real time fire scenes in the work place commented:

> *"I don't think anything prepares you for the tactile things, for the smell the feeling of loss some people have, not going to be able to capture some of the tactile things on CD… "*

Participant 3C suggested in response to the question: What significant differences would you identify between using a VLE for assessment and using a real burn scene? responded with:

> *"Ah well the smell!, the physical aspects of lifting stuff and I guess that is where you don't get that opportunity to do that with your virtual environment.."*

Further, participants suggested that the sensory/tactile elements can be distracting when conducting investigations:

> *…I believe that the atmosphere at the real fire contributes to some confusion when you enter the scene…*
>
> *And*
>
> *…that 'noise' that gets in the way of your clear thinking. Nothing prepares you for the damage; peoples damage….going to the wreck of someone's house. The smell of the fire is in the back of your head all of the time and you have to try and ignore it cut it out, it interferes "*

Additional benefits provided by the virtual fire scenes for training and assessment purposes which participants identified as the key to their development of foundational skills and knowledge were: unrestricted access to an uncontaminated scene and the ability to revisit the scene as often as necessary to confirm their understanding. As Participant 2E commented in response to the open questioning:

> *"The ability to view the scene numerous times and to go over many details again and again helped me to fully comprehend all aspects of the scene"*
>
> *And*
>
> *"…with the virtual I found I had time to think clearly, to look, to search"*

It is apparent that these features of the Virtual Fire Scenes were the major reason for the better assessment performance and competency ratings of the groups who undertook their assessment task using the Virtual Scenes rather than the Real Time Burn Scene.

The questionnaire response shown in Table 3 further illustrates this point. Students in Group 1 clearly indicated that they had insufficient time in the fire scene and students in all groups indicated that the ability to revisit the fire scene as often as needed was desirable.

[2] Participant 1B achieved a final competency ranking of 7 and a mark of 63.2% for Assessment 2

Table 3: Comparison of responses to questions relating to the elements which assist the investigation of the fire scene?

Question	Group 1 (SCRTB)			Group 2 (SCVA1)			Group 3 (SCVA2)			Group 4 (DEVA2)		
	n	mean	sd	n	mean	sd	n	mean	sd	n	Mean	sd
1.There was sufficient time allowed to undertake the investigation of the fire scene	4	2.75	2.09									
2.It would have enhanced the quality of my final report if I had the opportunity to revisit the fire scene	4	6.25	.43									
3.I found it assisted my study of the fire scene to have the facility to revisit the detail in the scenes as often as I needed	5	6.2	.75	5	6.4	.73	6	5.67	.94	2	5	0

Where no number recorded for a Group indicates this question not applied to the Group
n= number of responses per Group
7 = very strongly agree, 6 = strongly agree, 5 = agree, 4 = unsure, 3 = disagree, 2 = strongly disagree, 1 = very strongly disagree

Participant 3B[3] (who was out in the field 48 hours after completely the residential short course) proffered insightful comments in relation to the advantage of learning the foundational skills of fire investigation through the use of virtual environments:

> *I think that the way it is presented the distance education learning [CD with the virtual scenario] would give students the skills it is vital in terms of learning and then to actually go and match it against the smell, smoke etc at a scene, I really think you are going down the right learning pathway with the CD"*

Similarly, Participant 4B remarked:

> *..it has prepared me in that I have a good foundation, but it does not make me an instant expert, that comes with experience of attending actual fire scenes.*

6. DISCUSSION AND CONCLUSION

The JST415 CD-ROM was developed initially to address logistical problems with the provision of real fire scenes for students to investigate as part of their assessment. It was thought that the provision of a Photorealistic Virtual Reality environment would provide a fire scene with visual fidelity approaching that of the real scene. However, it was acknowledged that such an environment would not include many of the tactile elements of a real fire scene, including the smell, the feel of the ashes and water underfoot and the heat. Students with experience investigating real fires also made the point that the overwhelming sense of loss that one feels when visiting a real fire scene cannot be replicated when looking at a virtual scene on the computer.

Interestingly, however, survey responses and comments during interviews suggested that the virtual fire scenes had some unanticipated advantages over the real fire scenes. The ability to spend as long as they wanted exploring the virtual scene and to revisit it as many times as they wanted without risk of contamination were seen as very important during learning. Student assessment results suggested, in fact, that this advantage of the virtual scenes outweighed any disadvantages associated with the lack of tactile and other sensory information.

The comment from one participant that they found the additional tactile elements of the real fire scene along with the smell of the smouldering fire, to be 'noise' that they had to get out of their head in order to complete their investigation task effectively suggests that the lack of tactile and other sensory elements in the virtual fire scenes may in fact have been an advantage.

The important conclusion from this study that is likely to be of relevance to others involved in the development of simulated virtual environments for training purposes is that maximising the fidelity or realism of the simulated environment may not in fact be desirable. Sometimes an environment without all of the elements of the simulated real environment can be more effective for learning purposes. Obviously sooner or later learners need to be provided with the opportunity to practice their skills in an authentic context but during learning there are strong arguments for the provision of scaffolded learning environments that include the most important elements of the real environment but not so many of the characteristics as to be overwhelming during learning.

[3] Participant 3B is a 20 year experienced trainer utilizing computer technology and is currently a trainer with the NSW Fire Service

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