The notion of presence in virtual learning environments: what makes the environment “real”

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Abstract
To know where they are in the environment, humans rely on their senses for information. If the environment is artificially generated then it raises the question as to what information is needed to allow humans to know their location in the environment and have a more tacit feeling of presence within it. This paper looks at the role of Virtual Environments as conceptual learning tools in Science and the notion of “Presence” within these types of environments. Presence in this context is based on the stream of sensory input, organized by our perceiving systems, and out of which emerges our sense of being in and of the world. This feeling is also engendered by our ability to affect the world through touch, gesture, voice etc. These are very private actions and to research this we conducted interviews with competent computer users about their feelings of “presence” when using virtual environments. One of the main findings has been that audio feedback is perceived to be one of the most important features that engender a sense of presence. We have also found that ease of navigation around the environment affects perceptions of presence and this is reflected to some extent with users’ personal experience.

Introduction
Virtual Environments (VE) were first developed from 3D cinema in the 1950s and 1960s (see Rheingold (1991) for a detailed description of the history). It is only with the recent growth in technology and the emphasis that the aerospace industry has placed on its value, that has seen the growth in this technology for educational purposes. Although the environments used within the aerospace industry are either fully immersive systems or flight simulations, it is the success of virtual environments in pilot training which has led to their development for other educational settings (Kruegar, 1982).
Immersive virtual environments (ie those environments which use data gloves and headsets), are not available to the home user due to the cost and necessary space, hence immersive environments have primarily been used in training areas such as the aerospace industry or for major corporations to promote awareness of their goods and services (Watts et al., 1998). However, more convincing desktop non-immersive systems have been developed and as Bruce Jenkins, vice president of Daratech, a market research firm for the CAD/CAM industry says:

“Nonimmersive VR in high-performance visualisations is taking the market by storm. Though these visualizations don’t have the sex and sizzle of immersive VR, they’re enjoying very rapid and widespread market adoption” (quote taken from Hodges, 1998).

Although full immersive systems are not a practical method of tuition for the United Kingdom Open University (UKOU), it does not preclude the use of desktop environments as learning environments. In fact Watts et al. (1998) point out that it is only in the past couple of years that there has been a large enough number of powerful PCs on the market to allow the technology to be available to a significant number of users.

Previously the computer market was not in a position which would have enabled UKOU to make the use of VE a viable proposition, but now with the growth in computer ownership and the increased specification of many home computers the situation has changed.

Recently the UKOU produced a number of science virtual field trips. These were designed to enable students to explore areas not normally available to them, such as the bottom of the ocean ie, the North Atlantic Ridge, or to collect data within an Oak Wood to understand food webs and take part in virtual geological field trips (Whitelock, 1999a).

In confirmation with the UKOU’s development of VE there has been more interest in virtual reality for educational purposes. Kalawsky (1996) says one of the reasons for the growth in virtual reality techniques for education and training is the ability to provide cost effective access to high fidelity computer simulations. Virtual Environments offer students the opportunity for “hands on” learning. It offers the opportunity for simulations and for concept visualizations. Kalawsky sees virtual reality as allowing a participant to:

• become immersed in a computer generated environment,
• achieve a sense of presence in the environment,
• become uninhibited where conventional laws of physics can be controlled in a way that assists greater understanding,
• achieve a sense of non-real time, where situations can be presented in slow or fast time,
• achieve a degree of interaction that can exceed the real world,
• perform in a safe environment with the ability to repeat the task until the desired level of proficiency is achieved.

How does this development affect science teaching? Virtual Environments open new possibilities for instructional designers to create more interactive worlds for learners. In
fact a great emphasis is placed on interactivity by a number of educational theorists. Piaget (1930) stresses the role of action upon objects, whereas Bruner (1996) takes a more conceptual view and emphasises the importance of the categorisation of actions. While Vygotsky (1962) recognises the social aspects of learning, particularly highlighting action upon others. As with all these theoretical positions it is often difficult to translate the theoretical notions into real classroom experiences and raises the question of whether the ability to interact and manipulate in a new software environment is going to be enough to promote conceptual learning.

Hence, what are the parameters of a Virtual Environment that will afford interaction for conceptual learning? (In this instance conceptual learning is defined as a conceptually-oriented method of learning, where specific scientific content is understood and later manipulated by the subject, as opposed to the subject gaining procedural skills from working with a training environment.) The parameters could be different from those needed to produce a training environment, such as pilot training (Kruegar, 1982), which may have merited commercial success. Virtual Environments allow students the opportunity to meet situations where it is too expensive or dangerous to allow them to try out the roles they want to learn and has the advantage in that it gives the student time to reflect on their course of action (Schank and Cleary, 1995). It allows students to return to a previous position and see their current result, which in turn allows the student the opportunity to approach the situation differently a second time. At the UKOU the Science faculty developed two desktop virtual environments for its Level One (foundation level) Science course. The Faculty developed a CD ROM which contained two environments called Oak Wood and The North Atlantic Ridge. Oak Wood required the student to investigate a wooded habitat with a complex eco-system. The North Atlantic Ridge environment required the student to explore, via a submarine, the bottom of the ocean. Students could explore the terrain for geological structures and biological life in seven major locations along the Ridge. Only this latter environment met the criteria outlined by Schank and Cleary since it allowed students to enter situations that otherwise would have been prohibitive.

Open University students are adults, and relatively new to information and communication technology, with little or no prior experience of manipulating computer environments, particularly game environments. Entering a virtual environment or using a computer interface for the first time can be a problematic experience. But past experience (which is often neglected by interface designers) has a role to play which cannot be ignored. As Grove and Williams (1998) point out, students’ past experience is, more likely than not, based on games and they question whether it is beneficial to encourage children to see the experience of VR as a game:

“... especially where the ostensible aim of the VR encounter is for the learners to ‘experience’ a ‘reality’.”

There is however, the alternative point of view put forward by Schank and Cleary (1995), that when a student is doing something that is fun, s/he can be learning a great deal without having to notice it.
“The problem is to change the skills to be learned from hand-eye co-ordination tasks to content-based tasks, where one needs to know real information to accomplish one’s goal on the computer.”

Schank and Cleary further suggest that the simulation does not need to be realistic. Its role is to help the student become interested in knowing the facts that we are trying to convey. They suggest that student goals should be the driving force and offer a list of principles of quality software:

- learn by doing: learning should centre on task
- problems then instruction
- tell good stories
- power to the students
- provide a safe place to fail
- navigation to answers (student able to ask questions)
- the software is the test
- find the fun.

This is further substantiated by Regian et al. (1992), who say that if learning can be made more interesting and fun, students may remain engaged for longer periods of time. They also say that in addition to staying longer in the learning environment, students are engaged experientially in the learning context. Virtual environments have the potential to engage learners in creative interactive tasks that could not be achieved through any other medium. Hence, past experiences with virtual environments need to be considered in this context.

**Presence**

The notion of “Presence” is considered to be an important conceptual component of any Virtual Environment, whether it is immersive or desktop. So what is Presence? Presence is where we are immersed in a very high bandwidth stream of sensory input, organized by our perceiving systems, and out of this “bath” of sensation emerges our sense of being in and of the world. This feeling is also engendered by our ability to affect the world through touch, gesture, voice etc.

According to Kalawsky (1993) both teleoperation and virtual environment systems convey a level of personal presence within the synthetic or remote environment. People feel immersed or present in the environments and seeing one’s own body reinforces the feeling of presence. However, Edgar and Salem (1998) found that the interface can seem more of a hindrance than a help. They found that common problems focused on the speed at which the interface reacts to the movement of ones avatar (the representation of yourself) and objects.

Presence does not refer to one’s surroundings as they exist in the physical world, but to the perception of those surroundings (Steuer, 1992). Steuer refers to telepresence as the extent to which one feels present in the mediated environment, rather than the immediate physical environment. This means that the dependent measures of virtual reality must all be measures of individual experience providing an obvious means of applying knowledge about perceptual processes and individual differences in
determining the nature of virtual reality (Steuer, 1992). The more an individual is aware of the interface then the harder it will be to achieve a high level of telepresence. To lessen the awareness of the interface, there needs to be increased level of presence.

One way which apparently evokes a greater level of presence appears to be through the use of sound. Sound gives feedback to the user and offers greater levels of reality, and Laurel (1993, 160) refers to the use of sound to evoke emotional responses. Rheingold (1991, 151) also refers to sound as valuable for feedback, particularly 3D acoustics. As he says: “there’s nothing like the sound of footsteps behind you to help convince you that you are in a dark alley late at night in a bad part of town—sounds have the ability to raise the hairs on the back of our neck.”

One of the important components of presence stressed by a number of researchers appears to be good sound feedback. However, will the sound emphasis be important for conceptual learning?

At the UKOU the expert designers had rated the Oak Wood system with higher representational fidelity than the North Atlantic Ridge. It was felt that the North Atlantic Ridge would be unfamiliar terrain to students and therefore on the scale of representational fidelity it received a lower rating by the designers. Experiments with Virtual Learning Environments (VLEs) at the UKOU (Whitelock, 1999b) found that when students used the two desk top virtual environments, they learnt more in the Oak Wood environment than with the North Atlantic Ridge. This might be attributed to the tighter task structure and more elaborate feedback, but students’ perceptions of engagement and learning were higher in the North Atlantic Ridge environment. Students’ perceptions of the degree of presence afforded by these two environments were different. There was a higher notion of presence in the North Atlantic Ridge experience rather than in the Oak Wood software. Why should this occur? One suggestion is that higher immediacy of control also contributes to the notion of presence (this was the case with the North Atlantic Ridge) and that the parameters of immediacy of control is a confounded variable within a cluster of attributes that define presence in virtual environments. In order to probe this latter hypothesis we have developed a further study which aimed to try and identify the parameters/metrics for presence.

**Probing computer experts’ notions of presence**

In order to rate different VLEs with respect to the users sense of presence, ten experts took part in an interview study. We undertook this study because if we can rank programs with metrics of presence, we can start to evaluate the importance of this parameter with respect to Virtual Environments for conceptual learning. In order to begin to understand what degree of presence is required not just for training, but for conceptual learning—the research questions for this study were:

1. How can we measure the sense of presence within a Virtual System?
2. What background experiences contribute to the notion of presence?
3. What sorts of metrics could we apply to a system to measure presence?
Methodology
Users immersed in Virtual Systems spend a lot of time looking around and attending to feedback and visual learning has an important role to play. Richard Riding (Riding et al., 1989, 1993) says it is Imagers who learn much better when information is presented in a text-plus-picture mode rather than a wholly verbal mode. It can also be said that science particularly lends itself to visualisers, since they use imagery to develop ideas (Miller, 1996). For the environments we are researching this may impact on the types of learning that take place.

It does however, pose the problem that imagery is essentially a “private” or “subjective” experience. To get to know about people’s images necessitates attempts to collect verbal accounts of people’s phenomenal experience (Richardson, 1999). Due to these difficulties we decided to conduct a qualitative study using a phenomenographical approach. Phenomenography is associated with phenomenology, and as such is experiential and content based. A feature of phenomenography is the discovery of different conceptions of reality, and how some particular phenomena are perceived by people of different ages, cultures or subcultures (Marton, 1988). The aim of phenomenography is to try and describe an aspect of the world as it appears to the individual and to clarify how people define a specific part of their world. Therefore an interview technique was used to probe participants’ understanding of the notion of presence in a phenomenological tradition.

Procedure
Ten participants were interviewed. They were all experienced computer users, familiar with multimedia systems, although at differing levels of competence. Their employment roles varied from secretary to IT facilitator, and academic to software designer. All of the interviews were transcribed for analysis. All participants were asked the same questions which probed their notions of presence in a virtual environment, and to define the functionality of their ideal system in which they would feel truly present.

Findings
The table below outlines our initial findings, and it is not surprising that both interaction and feedback were considered to be the most important parameters to experience presence.

<table>
<thead>
<tr>
<th>Measure of Presence</th>
<th>N  =  10</th>
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<tbody>
<tr>
<td>Audio feedback</td>
<td>10 interviewees</td>
</tr>
<tr>
<td>Ease of navigation</td>
<td>10 interviewees</td>
</tr>
<tr>
<td>Feedback</td>
<td>9 interviewees</td>
</tr>
<tr>
<td>Interactivity</td>
<td>8 interviewees</td>
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<tr>
<td>Previous experience</td>
<td>8 interviewees</td>
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<tr>
<td>Persistence</td>
<td>7 interviewees</td>
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Here are a few of the verbal comments which support the 6 measures we have identified:

Audio feedback:

This was a must for all of the experts interviewed.

“Incidental noises are always missing. There is an eerie silence, or electronically generated. For example birds, radio playing. There’s usually a deathly hush.”

Ease of navigation:

Again rated as important by all of the experts.

“I think the thing is probably the fact that you can influence what is happening there. I mean there is some sort of consequence of you doing something, there are controls that you can operate. I mean clearly panning around and being able to look at different things is important.”

Feedback:

“... it’s almost like you can see yourself or you can see behind you which is a little bit what I’m trying to say that some of these systems don’t give you enough presence of your part ...”

Level of interactivity:

“I mean if you can imagine virtual systems that were potentially a laboratory where you are in control over an experiment or apparatus or whatever, where you may well want more control than just the simple look, you want the ability to press buttons, to increase the current or whatever ...”

Previous experience:

all had used computers and 8 had used VE games.

Persistence:

“It is not so much the quality, it is the inspiration. It can be an awful interface, but if it is intriguing then you’ll put up with it.”

It is the interacting with others, together with tangible evidence for this collaborative interaction that was emphasised by our interviewees, for example one interviewee responded:

“If we take the example about the fire station. If you could see your colleagues then you’d feel you are there just as in reality. We feel comfortable if we see people we know or whatever ...”

More importantly it is the audio feedback which provides the “feeling of presence” more that any other parameter. Participants did mention representational fidelity as a salient variable but they did not emphasise its role in the feeling of presence. It is the audio feedback that provides aid to navigation, tells the user they are in a dynamic environment and also provides an emotional response. This study has led to the development of a series of metrics which will be developed further through future work.

**Metrics**

From this data we suggest the following offer a cluster of metrics to assess Presence:

- Audio changes
- Level of interactivity
- Feedback
• Ease of navigation
• Persistence with program, i.e., not to give up working with the program when difficulties are met
• Correlations between previous experience and presence.

Future work
Interest in the use of audio in virtual environments has led to discussions about the type and quality of the audio feedback provided to the user. A further study is to be completed with the aim of providing users with two versions of the North Atlantic Ridge environment. One will include background audio and the other will have the audio removed. We aim to measure students learning gains in both environments and also to probe their notions of engagement, presence and previous game playing experience. In this way we will endeavour to tease out the importance of presence in the design of virtual environments. Presence is indeed a difficult concept to define and more empirical work is needed in order to understand its value and necessity for conceptual learning environments.

References
Whitelock D (1999a) Investigating the role of task structure and interface support in two virtual learning environments IJCEEL 9 No 2.