The Perception of Domed Environments

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Abstract: The field of immersive domed augmented virtual environments (DAVEs) has not taken full advantage of research into other technologically mediated experiences. It is also true to say that fields of research centred on other mixed reality technologies have remained unaware of developments in DAVEs. This paper reviews research on the role of experience, action, presence and affect in perceptual and cognitive processes. Our aim is to suggest how this research might apply to DAVEs – to begin to demystify ambiguities surrounding immersivity. Also presented are early attempts to apply research findings to content creation within an experiential learning context.

DAVEs can be defined as a shared virtual environment within the virtuality continuum. This concept provides a framework to understand the similarities and differences (perceptual, cognitive and social) that exist between DAVEs, their virtual and mixed reality cousins, and reality itself. We investigate: research on habitualisation to virtual environments and alternatives to the 'suspension of disbelief' model; the claim that perception is 90% memory; the pursuit of realism in simulation; and the impact of social presence in virtual environments and its relation to collaborative learning.

There has been significant investment in technologically mediated immersive learning environments across the educational spectrum in the UK. Government and academia aspire to transform student learning, to offer more diverse, personalised and novel learning experiences. In amongst this ongoing shift, DAVEs are emerging as a space for learning, but there has been a marginal application of theoretical methodologies beyond craft knowledge and anecdotal evidence of their success for this function.

The Planetarium at the University of Plymouth dates back to 1967, when the University was a Naval College, used to teach stellar navigation. As the Naval College progressed through Polytechnic, and eventually given University status, the Planetarium fell out of use. In 2004 the University was awarded four Centre of Excellence in Teaching and Learning (CETL). One of which was the Experiential Learning CETL (EL CETL), created to further the University’s expertise in teaching Earth Science and Oceanography based fieldwork. To investigate how immersive media could enhance fieldwork, the Planetarium was refurbished to a fully digital fulldome theatre. The refurbishment included ‘tilting’ the dome to 25º, and moving from concentric to 40 forward facing seats. An SXGA+ 180ºx135º single channel projector and a QXGA ‘inset’ projector was installed. The choice of single channel main projector, with a relatively modest
resolution, was key to the accessibility of the dome.

The DAVE at the University of Plymouth has no commercial remit, our revenue stream is instead measured in learning outcomes and dissemination of research and visualization content to academia. This privileged position enables us to focus exclusively on the design and evaluation of the user experience within an educational context. Outside our primary function, we liaise with a wide breadth of disciplines including, though not exclusively, Neuroscience, Computational Neuroscience and Psychology, Media & Arts, Computer Music Research, Engineering, Architecture and Robotics.

The EL CETL does not suppose that the DAVE can provide the entire learning process, but attempts to understand the place it is most useful within the social, affective and cognitive processes required. The study and production of immersive environments for learning necessitates a convergence of established research methodologies employed across a range disciplines, namely psychology and cognitive science, to understand fully the scope of learning potential - in this instance, for the shared, co-located virtual environment supported by the DAVE. This paper considers the role of perception in DAVEs, to start to understand how space, time and forms are perceived, with a view to later determining how these elements influence the cognitive processes in learners. At this stage, we are conducting secondary research to locate relevant areas of knowledge that warrant further investigation.

Establishing a framework for perception in mediation

In technological practice, immersion is a much-overused phrase - the ubiquity of use has rendered it quite meaningless in an academic context. Instead, the term presence carries more value. Presence is conceived in multiple, overlapping terms, but is singularly defined as being there and is the application of social and cognitive psychology to technologically mediated experiences.

Perceptual immersion, "the degree to which a virtual environment submerges the perceptual system of the user" (Biocca & Delaney, 1995 cited in [4]), can be objectively measured by counting the number of the users' senses that are provided with input and the degree to which inputs from the physical environment are "shut out" (Kim, 1996 cited in [4]). Not only immersive virtual reality systems but also simulation rides, IMAX theaters, and even standard movie theaters can be said to immerse the senses of media users [4].

The question of “presence” arises for virtual environments (VEs) because VEs override sense impressions from the real world with those generated by computer display systems in (ideally) several sensory modalities [8].

The degree of presence in a given environment inversely correlates with the degree of awareness of the mediation.
The presence community work to provide methodologies for inquiry with more exacting definitions and measurements to evaluate the impact of the mediated experience, and consequently to determine the extent users feel perceptually present in the virtual / augmented environment. It is widely applied to all technologies across the “virtuality continuum” [5], from cubic augmented virtual environment (CAVE) and head mounted display (HMD) to social networking groups, though anecdotally they seem to be unaware of DAVEs [7].

There has to date been very little academic research into perception in DAVEs. Though DAVEs have unique characteristics that set them aside form other immersive environments, much can be re-appropriated from other research into experiences that are technologically mediated. Our research looks to absection existing bodies of work from other types of virtual and augmented reality systems. Here, there is a sizable body of work within academic practice, where we can make use methodologies and frameworks to provide a research context to investigate the visual and aural perceptual processes in DAVEs. There are some critical similarities and comparative differences in terms of perceptual presence from VEs (CAVE / HMD), which could begin to ground investigation into the user experience.

A central principal, which unifies the scope of this interdisciplinary study, is that cognition is recognised as a cultural, socially distributed and embodied phenomenon. This perspective rejects a separation of mind and body, in favour of a view of consciousness as a parallel development of cognition, perception and action. Distributed and embodied theories hold that thought and knowledge do not occur separately, but take place within the context of our semantic knowledge of, and interaction with, our environment, objects and other people [2, 9].

In the absence of direct interaction, the DAVE experience is considered to be a passive acquisition of knowledge. Whilst on the surface this is appears to be true, it fails to accommodate embodiment in perception. 'Perception is not something that happens to us, it is something we do' [6]. It is an activity where we bring to bear the extent of our world knowledge - without knowledge, perception has no meaning. Richard Gregory's work in experimental psychology, makes evident how meaning is interpreted based on the strongest hypothesis derived from prior experience. We do not perceive what is actually there, but instead filter stimuli depending on our expectations and contextual information. Perception, according to Gregory, is 90% memory. He provides the example of viewing a physical model of a concave face, this is a form humans are unfamiliar with as our reinforced experience dictates that faces are convex, and therefore that is what we see regardless of what we are presented.

A recent experiment by Blake et al [1] into habitualisation in VEs supports Gregory’s

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1 Richard Gregory is an Emeritus Professor of Neuropsychology at the University of Bristol, UK, and has written at length on machine intelligence, perception and optical illusions. Published works include “Eye and Brain: The Psychology of Seeing” (1966) and “Mind in Science: A History of Explanations of Psychology and Physics” (1981). Website: http://www.richardgregory.org/index.htm.
view. This study compared two opposing models of how a subject’s growing experience in a simulation affects presence: Firstly, the classic SoD (suspension of disbelief) model, (based on Coleridge\textsuperscript{2}) predicts that subjects expend effort to suspend their disbelief during a simulation – the artifacts of mediation are filtered out. Secondly, the ‘Spin’ model (based on Spinoza\textsuperscript{3}), which predicts that subjects begin as present and then learn to become non-present – effectively they become more sophisticated in their perception of the technological mediation. Blake et al \cite{Blake2007} concluded that the Spinoza model – start as a naïve viewer and lose presence when expert - was more accurate. These results run counter to established wisdom, and unquestionably require further investigation. This is however a concern for those that work in VE and / or experience them frequently. It is possible to enter into a technological arms race with one’s own perception, trying to recapture that initial naivety. Further, as technologies for fulldome video capture become more accessible, we need to be aware that we could be placing people in environments in which the viewer is already expert.

Unlike the VEs provided by technologies such as CAVEs and HMDs, DAVEs have a social advantage, where users can experience \textit{being there together}. This is significant feature, especially for learning. One concept which frames the current practice of presenter led planetariums, and which capitalizes on the social attributes of the space and networking potential, is a theory put forward by Lev Vygotsky, termed the Zone of Proximal Development (ZPD). ZPD is defined as the distance between the actual developmental level as determined by independent problem solving, and the level of potential development as determined through problem solving in collaboration with more capable peers \cite{Vygotsky1978}. ‘The ZPD applies not only to experts working with novices, but also to collaboration among peers, and to the influence of absent others by means of the artifacts they created’ \cite{Vygotsky1978}. Vygotsky, writing in 1920’s USSR, could not have predicted the relevance of this theory to the facilities afforded by the Internet, and the Internetworking of learning spaces – something that Planetariums are arguably spearheading.

**Future work**

The above represents the end of a preliminary phase of secondary research. The next phase is to test these findings using a range of methods, but with caution. Presence can be measured through any combination of the following – subjectivity through self-reporting, behaviorally through observation, and physiological through biofeedback \cite{Blake2008}. A multiple threaded approach will be conducted and contrasted, though we are mindful that no method of measurement is without issue. Self-reporting has been shown to be fallible, it cannot be done during experimentation as this would interrupt the experience, and can be problematic after, due to post hoc rationalization \cite{Parkinson2000}. Although behavioral measurements are more shielded from subject bias than subjective measurements \cite{Blake2008}, and managed well

\textsuperscript{2} A ‘willing suspension of disbelief for the moment’ is a phrase coined by philosopher Samuel Taylor Coleridge in “Biographia Literaria” (1817).

\textsuperscript{3} Benedict de Spinoza, Ethics Part Two, Proposition 17, see Parkinson, G.H.R., (ed) “Spinoza – Ethics (1677)” (2000).

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they can be non-intrusive during the virtual experience, they can also suffer the impact of the observer’s interpretation. Biofeedback potentially offers solutions to problems with the previous methods, but it can be incredibly difficult to interpret data and the DAVE is an electromagnetically noisy environment probably ruling out EEG / MEG. That said, the DAVE at the University of Plymouth has been designed to accommodate physiological investigation, as the dome is fitted with USB sockets in every seat and is in the process of building the supporting infrastructure. However, this is a non-trivial task, as biofeedback measurement on this scale has, to our knowledge, not yet been attempted.

References


