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Perceptions of Impactors to User Experience inside Immersive Projection Environments

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Contents

1 Literature Review & Relevant Prior Work

1.1 Background

Between the months of September 2015 and September 2017 this research was embedded within an industry partner, Soluis. A UK leader in the 3D visualization and animation industry, Soluis offer a comprehensive service in application development, motion graphics, augmented reality, virtual reality and visualisation within IDEs. Having developed a fixed 4-meter diameter part-sphere dome they sought to explore the latest in interaction, experience and technological research to improve their client offering.

Transferring their dome technology into a “pop-up” 4-meter geodesic structure, they now operate one of the world’s only 90º orientated, four projectors, 180º domes. Using an innovative negative pressure system and seamless cinema screen technology they are able to present fisheye and 360º footage within a 4k projection screen. The ‘Portal’ structure can be seen in figure 1.

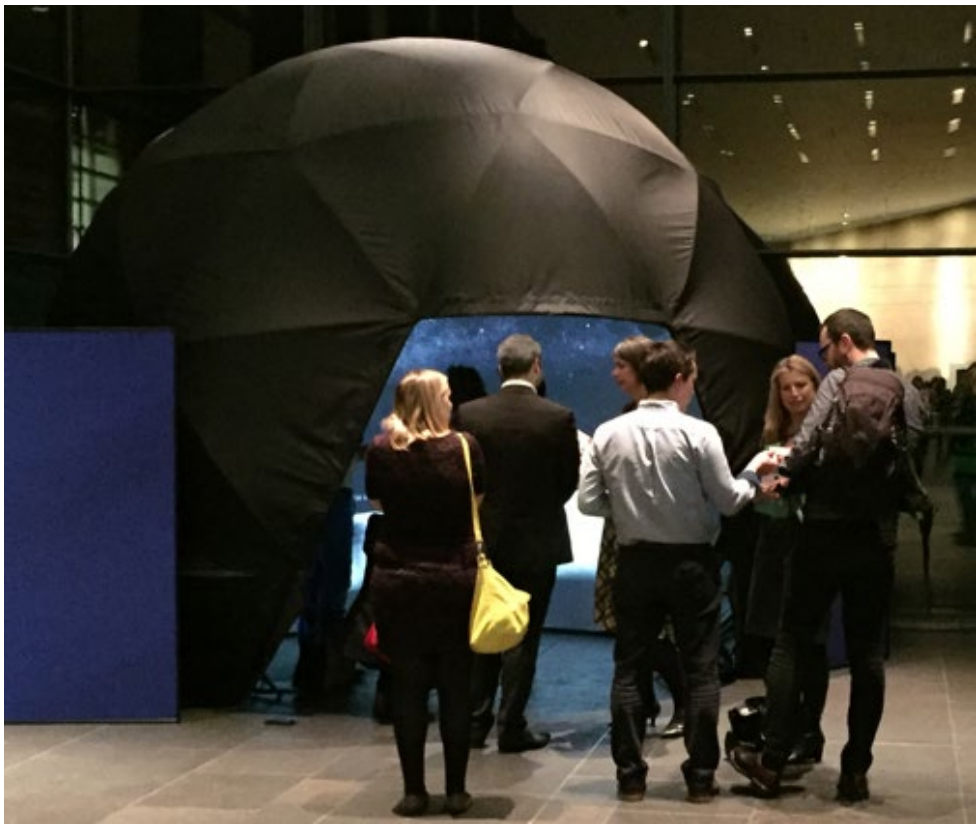

Figure 1: External shot of pop-up structure

Via partnership through Innovate UK's Knowledge Transfer Partnership (KTP) scheme Soluis and Edinburgh Napier University commenced on a joint venture to develop the dome product offering, referred to as the 'Portal'. Utilising key skills of the author in the interaction and creative computing domains, Soluis were able to rapidly accelerate the development and design of the Portal. The work undertaken during this partnership forms the basis for this research.

1.2 Immersive DOME Environments

Spatially immersive environments such as CAVEs (Computer Automatic Virtual Environments) and Head Mounted Displays (HMDs) have existed for a number of years. However, these are essentially individual environments. Whilst we can create shared virtual worlds in which people can come together, immersion comes at a cost of lack of social experience (Schnall, Hedge, & Weaver, 2012). In contrast, immersive dome environments create a shared, virtual experience for a group of people (Koleva, Schnädelbach, Benford, & Greenhalgh, 2000). One of the most common application of IDEs are planetariums which are noted for their ability to transport an audience into impossible to reach places or times (Buczek, 2012b, 2012a). However, the UX of planetariums is more like being in a cinema than being in a shared space. Immersion is foregrounded over interaction.

Due to their origin and history in planetariums IDEs are seen as a very narrow medium, that are both expensive and difficult to manage, often requiring architectural integration into structures (Buczek, 2012b). But this is no longer the case. There are currently more that 700 digital dome theatres in the world being used for a variety of purposes (Lochnessproductions, 2016). They include everything from large fixed facilities designed for large scale public interaction such as The Vortex Dome, Sat.qc.ca, or Fulldome.pro (Fulledome.pro, 2017; Http://sat.qc.ca/en/satosphere, 2017; VORTEX, 2017) and smaller more experimental installations such as EON Reality, Holovis or Igloovision (EONReality.com, 2017; Holovis.com, 2017; Igloovision.com, 2016).

For example, Holovis recently launched what they describe as the world's first interactive gaming solution within a 3D dome (Youtube, 2017). Similarly, the Vortex dome in Los Angeles, USA, is a renowned venue for hosting the latest experiential DJs and visual experiences (VORTEX, 2017).

According to Grant & Lei, during the end of 20th century VR was the subject mass exploration, due to the decreasing cost and increasing power of computers (Grant & Lai, 1998). During this time VR was successfully integrated into many industries including medical (Hollands & Trowbridge, 1996) and manufacturing (Systems, 1995) addressing the special needs in areas such as training, design and testing (Psotka, 1995). Now we are seeing a resurgence in the exploration of VR. The launch of the first consumer grade HMDs are imminent with the Oculus Rift, HTC Vive and Sony's PlayStation VR all battling for headlines (Facebook.com, 2017; HTCvive.com, 2016; Playstation.com, 2016) with ground-breaking uses in Health & Safety (Sharma, Rajeev, & Devearux, 2015) and in the recreation of heritage monuments (Alavi & Kunz, 2015).

1.3 Presence

In the nineties, one of the main reasons for the popularity of VR was its ability to convince the participant that he or she is actually in another place (Heim, 1998). In modern literature, this is the described through the concept of presence (Friedmann & Regenbrecht, 2001; Mcmahan, 2003; Schnall et al., 2012; Slater & Wilbur, 1997).

Presence is the use of immersive technologies to establish the illusion of entering a remote environment, allowing a user to orient themselves as if actually within a real space (Draper, Kaber, & Usher, 1998; Koleva et al., 2000; Remann, 2008). Some argue that to design for a strong sense of presence one must be prepared to envelop a participant's sensory data gulling them into believing they are within the virtual world (Snibbe & Raffle, 2009). The philosophy of 'sense of presence' is extensive with some researchers highlighting the 'book problem'; how an experience such as reading a book can sometimes effectively transport readers to another world (Turner & Turner, 2006a).

In their 1992 paper Held and Durlach discuss the concept of presence in experience, and the lack of empirical evidence explaining the underlying phenomenon (Held & Durlach, 1992). While this is largely still true, there are a number of growing studies exploring the factors influencing presence. Technical limitations such as screen resolution and framerate are commonly cited impactors (Slater & Wilbur, 1997). Similarly, there is no association directly between presence and IDEs. It is hypothesised that how engaged a user feels within the space will have a large impacting factor on their experience.

Presence is also referenced in a variety of other immersive space literature in the same, experience limiting scope. Flach & Holden discuss how UX in VR is influenced by the user's ability to complete actions unhindered (Flach & Holden, 1998), implying that the control methods within IDEs must be carefully considered. Moreover, this can be seen as an extension of historic VR theory - external distractions or 'breaks in presence' are one of the main concerns for participants in VR (Turner & Turner, 2006a). Breaks in presence come in a variety of shapes and forms, such as physical interference from background noise, visible cables, having to look at an interface (Chung & Gardner, 2012; Slater & Steed, 2000; Usoh et al., 1999) or technical issues such as poor frame rates, rendering errors or unresponsive input. Breaks in presence result in an impoverished UX.

1.4 Control and Interaction

Control as a concept, more than just control method, is another area of extensive research in both VR and more generally in collaborative environments. Yuill & Rogers (Yuill & Rogers, 2012) and Rogers & Lindley (Rogers & Lindley, 2004) highlight the importance of control in co-located collaborative systems, noting that poorly implemented interfaces that allow multiple users simultaneous control, can cause frustration, anger and disengagement. This understanding of control is not new, in 1998, Flach & Holden comment that poorly implemented control can have a detrimental effect on the feeling of being immersed within an environment (1998). Similar comments are still being made in modern literature. Turner and Turner (2006a) found that users who could not engage or actively control the interaction were left feeling as if they were only peering into a different world rather than moving into it.

> *"I'm kind of chained to this place. I would love to explore"* (Turner & Turner, 2006a).

Additionally, Park et al. (2008) note that this control, or lack thereof, can physically effect participants in the form of sickness and disorientation.

The effects and causes of motion (or simulator) sickness both physically and psychologically, are well documented in literature both new and old (McCauley & Sharkey, 1992; Sharples, Cobb,

Moody, & Wilson, 2007; Suma, Finkelstein, Reid, & Ulinski, 2009). Recent work, reviewing a range of studies from multiple authors, concluded that 80-95% of participants will experience some level of unintended side effect when viewing a virtual space through head mounted solutions (Sparto, Whitney, Hodges, Furman, & Redfern, 2004). Wiederhold et al. discuss in detail the causes and aggravators of simulator sickness, such as; visual refresh rate, number of degrees of freedom in control and the field of view in an environment (Sparto et al., 2004; Wiederhold & Bouchard, 2014). While there is evidence to suggest that large immersive spaces, such as an IDE or CAVE, help negate these by offering participants the ability to see both their own physical self and the bodies of other around them. Users' must still comprehend access to multiple degrees of freedom within virtual worlds. Attempting to reduce the levels of sickness and increasing user experience falls, in part, to the interaction within an IDE (Cruz-Neira, Sandin, & Defanti, 1993).

Interaction design in IDEs is constantly developing. Designs have progressed from tethered, wired solutions, such as games controllers, to gestural and sensor based input (Alavi & Kunz, 2015; Aslandere, Dreyer, Pankratz, & Schubotz, 2012; Barrera, Takahashi, & Nakajima, 2004a, 2004b; Subramanian, Beaudoin, & Levin, 2008). Snibbe and Raffle show that the same GUI metaphors that exist for conventional human computer interaction do no work in VR (2009). Users do not want to engage with the technology as if it was a computer, they want to engage with the world they are within (Snibbe & Raffle, 2009).

Tamborini et al. argue that involvement and decision making within VR environments requires much more focus and attention than simply observing (2004). As such, users who actively and directly manipulate the interaction report much higher levels of enjoyment and immersion, a better UX, within environments.

By thinking about new, novel ways of controlling our IDEs, such as Kinect and wearable sensors we are beginning to form a more detailed understanding of the interactivity an IDE can offer, how to reduce adverse feeling and improve the UX.

1.5 Narrative

Rambli & Muhaiyuddin argue that passive experiences that do not directly require user input require a more story-driven narrative to be successfully interactive (2014). The level of engagement within an IDE will also depend on the sense of how 'real' the narrative appears. Another view of presence is the concept of being caught up in the story or setting (Mcmahan,

2003; Schnall et al., 2012; Slater, 2004; Slater & Wilbur, 1997) Presence is one of the main facilitators of an immersive experience but it cannot be directly assumed that it is the only factor(Slater & Steed, 2000). Spagnolli and Gamberini (2002) note that while users may be present within a virtual world they may not be immersed as their experience may have been broken by an internal break in presence. This withdrawal from the virtual world whilst remaining focused on a task is what they describe as 'hybridity'. The ability for a user's mind to flow out of being immersed within a virtual environment but remain focused and attentive to a task. It is important that the narrative story delivered by content within an IDE is able to delivery both this sense of real, and engage the user in the story as outlined by Rambi & Muhaiyuddin (2014).

1.6 Social and Blended Spaces

This leads another feature of interaction within IDEs; communication and socialising between participants. In their various presence and place experiments, Turner & Turner (2006) identify how users act in VR. In their theory of sense of place, physical attributes, activities and social interaction were all key to a deeper sense of presence. They highlight the change in terminology and association that users have within spaces, as well as how participants referred to other (generated) people in the environment.

We use Benyon & Mival's idea of blended spaces (Benyon, 2014; Benyon & Mival, 2015; Mival & Benyon, 2013) to help understand the sense of being in an IDE. Blended spaces consider the design of spaces where a physical space is closely connected to a corresponding digital space (Benyon, 2014). For example, some digital tourism experiences fit into this notion as they blend digital information with physical points of interest. Smart meeting rooms offer another type of blended space as technology and digital content is embedded into the physical fabric of a meeting room. New retail experiences provide another example.

Benyon and Mival (Benyon & Mival, 2015) identify that one of the challenges for these blended spaces is that users have no mental model, no conceptualisation of the space or how it works when they first arrive. They also highlight the social space that is an essential part of collaborative environments. They develop the TACIT framework for looking at the design of collaborative environments that aims to focus designers on the key aspects of these interactions. TACIT stands for territory, awareness, control, interaction and transitions. The framework offers interesting insight into the development of an IDE, but does not fully encompass its requirements as explored

above. TACIT, in part, discusses environmental space (or territories) and user awareness to tasks within an interactive collaborative environment. However, these are non-issues within an IDE due to the absence in ability to facilitate simultaneous actions and lack of dynamic working area.
The lack of direct compatibility with frameworks like TACIT give rise the research questions outlined above where this thesis will use practical embedding to explore both the constructs of experience within an IDE and understand how they relate to other existing theories.

1.7 Technical impact on experience

The literature on technical limitations on a user's overall engagement with immersive content is very ubiquitous within presence research. (Examples such as Grant and Lai, 1998; Spagnolli and Gamberini, 2002; Boussemart *et al.*, 2004; Buczek, 2012a). Resolution, framerate and FOV (field of view) are often listed as the main technical elements to consider within an immersive fulldome space (Schnall et al., 2012). Most research agree that technical limitations and poor technical implementation within fulldome environments are one of the main reasons for issues with experience. For example, using a model such as Bilda's Creative Engagement Model (Figure 2) to evaluate experience depends on a user having a completely unobstructed user journey to fully engage (Bilda & Edmonds, 2007). This thinking connects the understanding of 'breaks in presence' back to the research on the ability for a user to become present within an engagement.

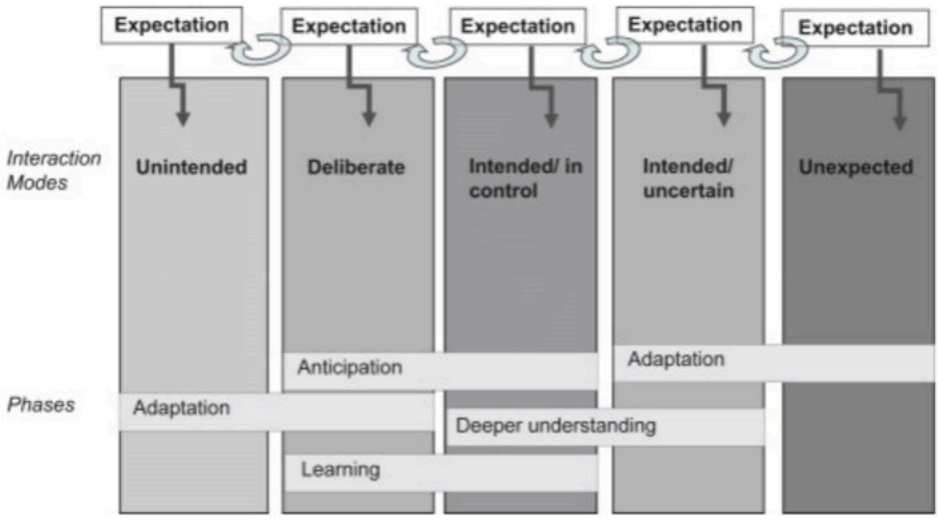

Figure 2: Model of Engagement: Interaction Modes and Phases (Bilda Et Al, 2007 :53)

Studies, such as those by Kozak et al., explore the concepts of using virtual environments for complex teaching tasks (1993). They note that both the general use of VR as engagement tool is questionable and highlight technical inability or failings in design lead to little or no improvement in skills taught. More recent research into very specific use cases (Aggarwal et al., 2006; Seymour et al., 2002) have started to see the technical impactors lessen and training skills pass between virtual and real world. One of the cited reasons for this is the advancement to technical systems and overall graphics performance.

As far as this research could find, there are no existing empirical study that cover the measured improvements to an immersive systems technical design and the resulting changes to end user experience. As such, it will be a main part of the body of work to compound our theoretical learning into technical improvements in the later chapters.

2 Experiential focus for end users

2.1 Understanding the IDE UX

Through the background and literature review several key characteristics of both the technical and user requirements of the UX in immersive environments and virtual reality, and how to relate them to immersive digital domes, were identified. Due to the novel area that immersive domes represent, most of existing research and assumed knowledge comes from the fields of interactive spaces and collaborative working.

It is via this syphoned knowledge that a recognised gap in the industry learning is identified. There is not currently a systematic method for measuring the user experience inside immersive digital domes.

Thus, it is an aim of this section of work to attempt to define an understanding of how to evaluate the UX for IDEs and looks to develop an instrument that is able to measure UX. Following on from the above literature review and analysis we moved to hosting several discussions amongst experts in user experience, interaction design and HCI (human-computer interaction).

2.2 Defining the constructs of user experience

Due to their work with interactive collaborative environments in recent years, and the creation of the TACIT framework (2015) Benyon and Mival were invited onto an advisory panel as industry experts to serve as part of the commercial development required within the knowledge transfer partnership and supply invaluable knowledge in the defining of the constructs of immersive dome environments. The panel met on average for two hours, fortnightly, between January 2016 and June 2017. These meetings covered the cultural, research based and technical impactors on UX within domes spaces – and what makes IDEs different from other interactive or collaborative spaces. It was determined that there are five main constructs required in the understanding of user experience inside an IDE, they are:

- **Presence** deals with the use of immersive technologies to elicit the feeling of entering a remote environment.
- **Interactivity** deals with users being engaged and involved in actively doing within the IDE. A planetarium, for example, has no active interaction

- **Narrative** concerns the delivery of content in a coherent and understandable way. It concerns the flow of the UX across devices and over time.
- **Control** concerns how users physically interact and manipulate content within the IDE. Do users feel in control and are they in control of how content is delivered.
- **Social** aspects concern how users discuss, comment and share observations and data within the IDE and how aware they are of others and their actions.

With the characteristics of user experience within IDEs proposed, work moved to understand how each of the characterises were expected to influence the end user involvement within the interactive space. The following hypotheses were extracted:

Using the outline definition of presence as derived from Draper; Kaber & Usher; Koleva et al. and Remann (1998,2000,2008) presence is established that by curating an IDE with the correct experience-enabling technologies users will be able to become more present. Therefore, it is presumed the more present a participant within an IDE the better the UX will be.

It is believed that promoting interactivity will lead to an enhanced UX through felt involvement and decision making, as outlined by Yuill & Rogers (2012) and Rogers & Lindley (2004). Actively engaged participants will be less effected by breaks in presence and will be more invested in the virtual environment, as demonstrated by Flach and Holden in their tests about 'breaks in presence' (1998).

UX will be enhanced if users are offered a compelling narrative. The idea of narrative goes beyond storytelling and make believe and includes the coherence and structure of any interaction (Mcmahan, 2003; Schnall et al., 2012; Slater, 2004; Slater & Wilbur, 1997). The higher the quality of content delivery within an IDE, the more positive the experience for participants. Without fulfilling story, content and facilitation those that disengage may find it hard to reengage, and detract from the experience of others (Spagnolli & Gamberini, 2002).

Users should be able to interact with an IDE in a natural way, otherwise they will feel outside the experience. STAG interaction allows users to focus on the content rather than on the input devices and delivers a better feeling of control. Control methods should be seamless, unobtrusive and natural to all that engage with the IDE, otherwise the UX will be effected in a negative manner (Alavi & Kunz, 2015; Aslandere et al., 2012; Barrera et al., 2004a, 2004b; Subramanian et al., 2008).

Finally; learning from the TACIT framework, Benyon and Mival propose the social dynamics of space should be considered vital. It is assessed that participants will socialise as if they are all within the same physical space and share the virtual environment, even if they are generally unaware of what is happening (2014). It is suggested that the discussions, observations and comments within the shared experience will not cause breaks in presence, but will contribute to an enhanced UX.

Using the five outlined constructs; Presence, Interaction, Narrative, Control & Social Dynamics as well as the housing hypotheses of their influence on UX a bank of tests and refinements will run in parallel to assess the validity of each construct. The final aim is to refine each construct into clearer understandings of the influencers and impactors on end user experience within immersive digital domes.

2.3 Refining Constructs via Investigation

To refine the initial constructs and begin validating whether the appropriateness for describing the UX within IDEs, two parallel methods of reviewing the processes were initialised. One in the form of expert analysis with the assembled team of experts. A second using the commercial activity and deployments of the Soluis digital dome to gather information from actual users of dome spaces.

On paper, and in discussion, the constructs seemed valid and justifiable, especially considering the nuances of immersive dome design. It was agreed that no single experience definer such as those described in various pieces of literature ('sense of place' (Turner & Turner, 2006b), 'break in presence' (Chung & Gardner, 2012; Slater & Steed, 2000; Usoh et al., 1999) or 'sense of flow' (Rambli & Muhaiyuddin, 2014b)) were enough to fully encompass the impactors on users inside a dome space. It was also agreed that alternative existing constructs to collaborative environments, such as TACIT (Benyon & Mival, 2015), did not incorporate enough focus on experiential content to fully evaluate immersive domes.

With this expert justification, the constructs were validated in the real world to test their practical application. Analysing the experience of others is a well-documented task and something that the research into IDEs had to be very aware of. 'Mental manifestations', or self-reporting, feelings such as presence, social & narrative all have to be carefully recorded and analysed as they are specific to each individual (Sheridan, 1992). Research must capture as much detail about an area,

without obviously asking a user about it. Tools such as 'Did you feel present?' would not provide any insight into the genuine experience felt by the user.

2.3.1 Interviews with 'Advanced Dome Users'

In the first main empirical study associated with the development of the IDE, a sample of 10 'advanced dome users' were assembled to participate in long form qualitative interviews.

The goal of the interviews was to capture opinions and feedback on the issues and noticeable features of the Portal (Soluis' immersive dome) without preloading the participants to the goal. Users were classed as advanced if they met several key Criteria: they had to be at least 18 years old; frequently use computer technology in their daily life or job and have experienced the digital dome on more than two occasions.

This limited the sample but ultimately afforded that users had experience of digital domes enough to be able to influence the understanding of the constructs of user experience.

The interview was prepared utilising the methods for qualitative interviewing as outlined by Hunter (2006). Following a general introduction and demographic data capture, participants were asked to think about any specific time they had experienced the digital dome, no matter the content[1], providing they were able to remember it in detail. Interview questions where left open-ended to facilitate the interviewee's ability to personalise the responses. Information about the interviewees can be found in 11.1.

The interviews were transcribed & analysed using theory-driven coding (DeCuir-Gunby, Marshall, & McCulloch, 2011; Ruggunan, 2014) in line with thematic techniques as outlined by Flick (2013). This form of interview analysis allowed for a context aware study of the responses and user data. The initial hypothesis of UX within IDEs were used as the starting themes. Presence, interaction, narrative, control & social dynamics were shortened to the acronym PINCS for clarity during review. Each construct was reduced to capture the essential element of the theme. The results of this reduction, as well as example codes for each theme can be found below in Table 1 .

Theme	Description	Codes

[1] At the time of interviewing only a handful of content had been developed for the Soluis dome (so participants were only going to have comments on one or two examples).

Presence	Participant states or alludes to a belief or feeling as though they were in the represented place. Discussion or statements that refer to the virtual environment as physical, real or a sense of being.	Present, Real, 'there', sense of being, reality, world, encapsulating, immersion
Interaction	Participant references or states feeling actively involved, or a key part of the represented place. Discussion around engagement, natural feeling or creation.	Interaction, direction, engagement, involvement
Narrative	Participant references or alludes to a specific article or item facilitating their connection to the represented place. Discussions or statements that refer to creating connection, tethers or understanding.	Surround, quality, understanding, goals, excitement,
Control	Participant states or references a natural ability to achieve their goals or target within the represented place. Discussion around physical input, movement or tactile response.	Tactile, movement, control, input
Social Dynamics	Participant references or states the existence of a shared experience within the experience. Alluding to the presence of others, social interaction or group participation.	Social, together, group, sharing, chatting, conversation, open experience

Table 1: Initial themes used in first pass thematic analysis

After agreeing the themes, labels and definitions, the first iteration of reviewing the interview data set out to validate that users raised concerns or referenced the effect on their end user experiences as defined in the research questions. This first pass also utilised and open-coding approach as defined by Corbin and Strauss (2008), to look for new undefined codes and create missing themes within the research.

2.3.2 Analysis of Interview Data

Using the key data as outlined in Table 1, the interviews provided otherwise un-observable data regarding user's personal experiences and feelings on experience. The formatting of the open questions allowed for maximum direction on a variety of key subjects capturing 'mental manifestation' data required to understand the Portal experience.

After initial review, Presence and Social where the key factors to all participants, regardless of background or working discipline. The recurring themes of being present in the remote space,

feeling connected to the virtual world and the attraction of social communication and co-location. We take these results as a validation of the Presence and Social construct hypothesis of immersive dome environments, due to their prevalence across the responses. The coding tasks also alluded to the fact that participants put much less emphasis on the Interaction, Narrative and Control themes, with control and interaction almost being indistinguishable when reference by respondents.

This proximity between both the hypothesis and codes for interactivity and control produce an argument for their reduction and re-labelling to address the more 'feeling' orientated responses that emerged across the interview data, as seen in Table 2.

Quote	Codes	Participant
[reference to the best experience they've had] Just video, not doing anything, not having any control to run about, not doing anything but just to watch. Just like cinema experience.	Control, Movement, Experience	9
the dome feels more natural, you know? it feels that its like a theatre experience you are watching something and its not - its surrounding you but at the same it doesn't feel like you're attached to it	Feeling, Experience, Attachment	4
<Project Name> had a lot of movement that generated a lot of excitement. It was something unnatural to the body so automatically you were in shock of the way you were moving	Movement, Shock [wow]	4
So depending on the type of content so if it was something that I could explore myself that I probably might of had more of a desire to take control - that's probably more of a personal thing.	Control, Personal, Feeling	6
whatever your content is, whatever the feeling, whether it's empathy, whether it's happiness, whether it's whatever you're trying to get your audience to feel at that time, that is your space to create that feeling.	Feeling, Space, Control	1
The controller experience again, I think when there is more than one person - and I don't what the technical term is to describe that feeling	Control, Feeling, Social	7

Table 2: Example of 'feeling' within the dome responses

These newly emerged codes address the concept of Agency as described by Benyon (2014). Agency refers to what users can do within a space. Their cultural and social setting, the meanings of interaction they make as well as the activities they undertake all while within a space. Agency is an appropriate describer for IDE interaction and control as it encompasses a user's ability to be a passive participant as well as the nuances with directly driving the experience. This is the 'opportunity for action'.

A second finding from the coding data, in line with the initial hypothesis on presence, is the technical factor contributing to a user's sense of being 'in the virtual environment'. All bar one of our participants referenced a break in presence, detractor from the experience or a removal from the environment based on a technical aspect of dome construction. While some participants struggled to define why an experience was positive or they felt present within the virtual space, they were all able to pin point specific technical aspects of the experience that removed them from the interaction. Table 3 shows several examples highlighted in the negation of their user experience.

Quote	Code	Participant & background
…you were seeing what I call the beach-ball effect… [the dome screens] had this kind of circle right in the front where everything was meeting, and if it was bright enough you were seeing [the stitching], and then it's not becoming a projection screen as such, it's an object that you're focusing on.	Technology, Break in presence, Screen, World	8 - Director
things I would say I think bad projections are BIG aspect … …the stronger the projector the better the experience you'll get. Sometimes that wasn't the case.	Technology, experience, presence	4 - commercial
If the resolution was better or the core content was better - so anything that wasn't sharp and or hit you in the middle of the forehead detracts from it [the experience].	Technology, Experience, Being there, Narrative	7 - commercial
it was just quality. It was disappointing. I think it was disappointing, but, the fact that the actual plug-in we've created doesn't really allow you to add post-processing stuff. [referencing the core hardware technologies in dome content creation]	Quality, Technology, Experience Negative	9 – Artist/Developer

Table 3: Examples of technical failing

2.3.3 Analysis Discussion

The results from numerous iterations through the interview data show consistently that the hypotheses for both presence and social dynamics are correct and encompass the same scope as users report via questioning. The main disparity that emerged between expert analysis and interview breakdown was the weighting placed on constructs by users. Initial discussion presumed even weighting. However, the feeling of being present, social interaction and co-location appeared as the main aspects that users refer to in their understanding of 'good experiences'. The cross over and invalidation of interaction and control as main constructs also appeared and will be factored in going forward with PINCS (that will be readdressed). While the hypothesis of both interaction and control stand as concepts, they do not translate to user understanding of their experiences while within an IDE. Aligning with the codes presented under the themes, and the general attitudes that emerged during analyses Control and Interaction should be merged into a single construct, with Agency as described by Benyon (2014) being the optimal descriptor for this new construct, a user's opportunity for action within an IDE.

The final key result from the interview analysis was the profound connection between technical failings and lower engagement, immersion and lowered end user experience within the dome. While users were not able to describe their feelings or understandings of being within the presented virtual world articulately, any technical or physical fault that removed them from the presented experience stuck with them, down to the specific detail that caused it.

As for the meaning regarding the development of understanding in IDE user experience, the hypotheses that bound this research and the future of the constructs of IDE UX are all concepts that will be explored further in the next chapters. Understanding how to suitable define the newly re-aligned constructs, their weighting against each other and the incorporation and importance of back-end technical development of IDEs will all be explored.

2.4 Development of PINCS

As a result of the detailed interview based on thematic, core and open analysis of data. The initial constructs of PINCS have been explored, refined and redefined. While the initial hypothesis of presence, social and to some degree narrative have been confirmed. Interactivity and Control where deemed to close and indistinguishable to users that the concepts on their effects on IDE UX need to be re-examined.

This chapter will also explore the inter-relationship between constructs and try to begin forming an understanding of hierarchy and importance in regard to the facilitation of better UX within IDEs from an end user perspective. It will also conclude in the perceived next steps for the constructs of IDE UX and ways in which to measure the perceived experience of users going forward.

2.4.1 Refined Constructs of IDE UX

Based on the initial hypothesis, expert panel and qualitative interview data analysis theories it can be derived that there are four main constructs as perceivable by end users, as well as the identification and clarification of how important the technical facilitation of an experience. The four constructs as finalised by this research are as follows:

> *Presence: The 'feeling' of being physically located in the remote or virtual environment.*
>
> *Social: The ability or facilitation of participant co-location within virtual environments.*
>
> *Agency: A participant's ability to act or control a space, interaction or experience.*
>
> *Narrative: A participant's understanding of the experience and the context of Agency around them.*

The research and analyses also highlighted the difference in weighting as applied by interview participants responses to general questioning. Presence and Social were clearly listed above and beyond any of the other constructs and should be treated as such in the design of future IDEs. These constructs and this knowledge of weighting are used to create the visual representation of impactors on IDE end user UX, as seen in Figure 3.

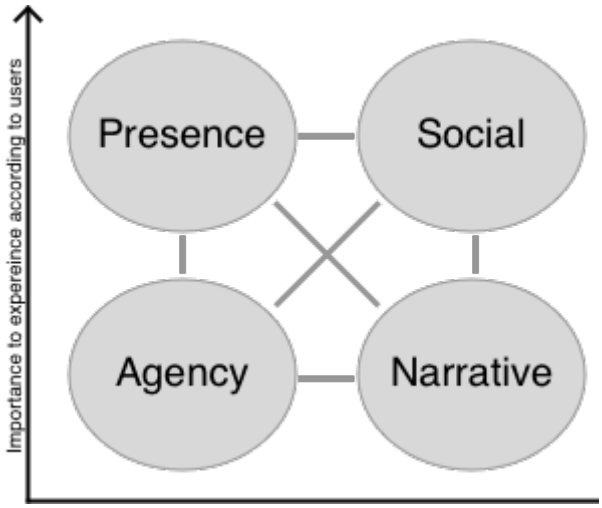

Figure 3: Constructs and weighting of impactors on end user experience.

This figure attempts to capture the constructs of IDE UX as well as their internal relationships as contributing factors as syphoned from end user analysis. The figure is based on the weighting of user coding data for presence (p) & social (s) vs agency (a) & narrative (n), each horizontal level is equal in influence on experience. The constructs can be referred to as PANS.

2.5 Current Position on PANS in IDE development

Although, it has been derived that the constructs of PANS are what makes up the end user experience within immersive dome environments, one of the most prolific findings may relate to the preference for top down design vs bottom up design in the dome experience. The end experience (regardless how its served) being more important than the components that make up the environment. We draw this conclusion due to the continued and persistent data indicating that detractors from experience have a much higher bearing on experience than flawlessness in individual elements of experience.

Whereas an IDE could offer a perfect social experience for all involved. If there is no agency, narrative or feeling of presence within the environment, then a user will not have a positive experience.

Future work should focus on attempting to measure the relationship between the four constructs in more detail. It should attempt to create ratios of ‘acceptable’ experience between constructs, by

helping to understand the weighting placed on them. What will users forgo in terms of agency or narrative to earn social interaction or a stronger feeling of presence?

Additional work should also explore the ability to capture and evaluate a user's rating of experience further through refinement of the PINCS questionnaire.

The next portion of work within this thesis will focus specifically on the designer (or creator) controllable influence of user experience via technical, hardware and interfacing factors. Exploring the causes of 'breaks in presence' exposed above and understanding the ways to reduce, alter or adapt modern IDE systems to cater for better technical user experiences.

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