Engagement with an Interactive Museum Exhibit

Naomi Haywood, Paul Cairns

UCL Interaction Centre, 31–32 Alfred Place, London, WC1E 7DP

Tel: *+44 20 7679 5208*
Fax: *+44 20 7679 5025*
EMail: *Naomi.Haywood@web.de, p.cairns@ucl.ac.uk*
URL: *http://www.uclic.ucl.ac.uk/paul*

Learning and engagement have been recognised as very important in defining the effectiveness of interactive museum exhibits. However the relationship between these two notions is not fully understood. In particular, little is known about engagement with interactive exhibits and how it relates to learning. This paper describes a hypothesis seeking approach to find out how children engage with an interactive exhibit at the Science Museum. Engagement is found to be described in terms of the three categories: participation, narration and co-presence of others. These aspects of engagement can be seen to arise from specific aspects of the interaction design of the exhibit. Moreover, they also overlap with features required for a positive learning experience. These findings suggest many fruitful directions for future research in this area.

Keywords: Immersion, Interactive Exhibit, Narrative, Learning, Co-presence

1 Introduction

Museums are a major source of public education outside of the formal schooling system in the UK [Teachernet, 2004]. However, rather than competing with formal education, they provide a complementary resource for both formal and informal learning. For example, many museum visitors are groups of school pupils who visit the museum as part of their formal education. Further, many museum visitors are

families, with parents aiming to allow their children to encounter areas of informal education that they may not otherwise encounter [Jensen, 1994]. Museums also function as source of leisure and entertainment. Indeed, museums are one of the central provisions for entertainment which are widely accessible to the general public [Falk & Dierking, 2000]. Thus, museums must aim to provide entertainment that is simultaneously informative and educational. Increasingly, museums look to interactive exhibits to fulfil this aim.

For the purposes of the current discussion, we take interactive exhibits to be exhibits that allow for interaction in some form other than mere visual perception. Frequently this interaction involves physical manipulation, such as visitors clicking buttons or flicking switches in response to specific questions or demands presented on screens. Interactivity therefore allows visitors to determine what the exhibit presents. For example, many interactive exhibits allow visitors to determine the order of presented information and whether they want to obtain more information concerning a specific area of interest [Vom Lehn, Heath & Hindmarsh, 1999]. It must be noted, though, that not all exhibits that claim to be interactive would actual meet this criterion. Indeed, the recent "interactive exhibit" at the British Museum, [British Museum, 2004], was a purely visual experience albeit some of it in 3d computer animation.

The general aim of these interactive exhibits is to allow for learning and entertainment. For the consideration of interactive exhibits, Falk & Dierking [2000] define learning broadly in terms of how users are able to comprehend the presented information. For example, a visitor may interact with an exhibit presenting images of the human heart, its functions and individual parts. If this visitor is subsequently able to note that the heart is a muscular organ which pumps blood around the blood vessels, then learning can be said to have occurred. Falk and Dierking also broadly define entertainment in terms of the exhibit being engaging. For example, if visitors spend time interacting with an exhibit without taking part in other activities, then this exhibit can be said to be engaging.

Recently, museums have made frequent use of interactive exhibits and generally consider their use to be successful in terms of learning and engagement [Gammon, 2003]. However, the precise nature of how learning and engagement occur and how they may relate to each other remains uncertain. For example, it is possible that visitors spend long durations of time interacting with exhibits without reading the presented information. Therefore while the exhibit may be engaging, it may not encourage visitors to learn. Further, it is possible that visitors may learn from an interactive exhibit despite spending only a short duration of time interacting with it and simultaneously being involved in other activities.

The goal of museums is to produce successful exhibits and therefore to be able to reliably design exhibits for learning and engagement. Much research had been and is being done on investigating the educational effectiveness of museums. Indeed, this is the sole focus of the *Journal of Education in Museums*. However, though engagement has been identified as significant, it is not known how to design exhibits for engagement. In particular, we were unable to find a clear discussion of the role of interaction in making an exhibit engaging. In part at least, this seems to be because

it is not really understood what engagement actually is [Brown & Cairns, 2004].

The purpose, then, of this study is to develop hypotheses of what it means for an interactive exhibit to be engaging, how engagement as understood from the study may relate to learning and, where possible, what elements of the interaction could lead to engagement. The hypotheses found suggest avenues for future research. This hypothesis seeking approach is necessarily qualitative and we have developed a grounded theory [Strauss & Corbin, 1998] in order to elicit and organise a conception of engagement based on first hand accounts of using an interactive exhibit. Though learning is important, it was probed for rather than measured as it was felt that an explicit measure of learning would interfere with the participants' experience or reporting of engagement. Instead, the relationship of the theory of engagement to learning is developed and explored in the discussion.

As is well known in HCI, the context of use can strongly influence specific interactions. Museums present quite specific contexts. As noted by Gammon [2003] individuals in museums frequently behave in a considerably different manner from when they are in other contexts. Moreover, vom Lehn et al. [1999] found that the learning experience of an individual was also determined by collaboration with others. For example, adults may point out key features to children, and visitors may observe each other interacting with exhibits. This suggests that any learning occurring by means of interactive exhibits is embedded in the social context.

For this reason, the study was conducted with a specific exhibit, the Energy Everywhere exhibit, in the Science Museum, London. Ten children were recruited to interact with the exhibit and then interviewed about their experiences. The grounded theory developed centred around three concepts of participation, narration and the co-presence of others. A key finding, which contrasts with vom Lehn et al.'s studies [1999], is that co-presence is an important factor in the theory of engagement rather than collaboration which was considered important for learning. These concepts will be explained and demonstrated in the results section. The succeeding section discusses these concepts in terms of how interaction with the exhibit relates to engagement and learning and, therefore, possible lines of future research. The discussion will also be used to recontextualise the theory within the existing literature.

2 Energy Everywhere

Before describing the methodology of the study, it is useful to briefly describe the actual exhibit studied. The exhibit is part of a permanent exhibition, *Energy — fuelling the future*, at the Science Museum in London. This exhibition was developed by Science Museum staff in collaboration with educators, scientists and consultants experienced in exhibition design. It opened in July 2004 and includes a total of six interactive exhibits, various information terminals and works of art relating to energy. The present research focuses on one specific exhibit, named Energy Everywhere. This exhibit is positioned at the entrance of the exhibition and is aimed at pupils of key stages two and three of the National Curriculum and families with children between seven to fourteen years old.

The exhibit is an animated film with a linear structure that starts when it detects

the presence of a person in the vicinity of the exhibit. The person is invited to stand on a flashing yellow square in front of the screen and to clap their hands to start. This sets a sequence of animated scenes with sounds and a voice-over describing how energy is present in the scenes and how it is being transformed from one form to another. The graphics for the scene are quite abstract where iconised forms such as trees and landscape are depicted but made up from words for the object itself. For example, the sun appears at the beginning and is drawn from many instances of the word 'energy.'

At three specific points in the sequence, the visitor is invited to interact with the exhibit by making gestures. The three gestures are: digging for coal; spinning your arms around to generate wind; and clapping hands to make lightning strike.

The exhibit also prompts the visitor if they do not do the appropriate actions, for instance, it may display and say "Clap louder" if the visitor does not clap loud enough for it to detect. Successfully completed actions are also acknowledged with "Well done!" both appearing on the screen and being spoken.

In all the exhibit takes around five minutes to complete the full sequence.

3 Method

In order to formulate hypotheses of engagement in an interactive exhibit we used a grounded theory approach [Strauss & Corbin, 1998]. The basis for data gathering was interviews with museum visitors. Grounded theory allows for quite flexible interviewing that could be open to examining the specific concept of engagement but also exploring other concepts should they appear related to engagement in the minds of the interviewees. Also, grounded theory allows for an acceptable and rigorous working up of the interview data into a robust framework that could be used as the starting point for further studies.

The basic approach of the study was to have visitors use the Energy Everywhere exhibit and then to be interviewed afterwards about their experience. Due to the timing of the project and the Science Museum's development of the exhibit, the earlier interviews were performed with a prototype in a special evaluation room out of the context of the full exhibition. The later interviews were done based on the actual exhibit in the exhibition gallery when it had been installed. Potentially, the visitors using the prototype could have had an unrealistic experience but the theoretical sampling approach of grounded theory allowed the later interviews to fully explore the effect of the exhibition context on the overall experience. Additionally, there is the risk that, by knowing they were participants, the children might have engaged differently with the exhibits. In the prototype this was unavoidable but with the final exhibit, children were only approached once they had finished using the exhibit. As their experiences were integrated in the results with those of the earlier participants, it is hoped that any artificiality has been ameliorated.

The interested reader is invited to contact the authors for full details of the method, ethical clearance, consent and transcripts of the interviews.

3.1 Participants

Since research on learning suggests that there are age and sex differences in terms of how learning occurs (e.g. Richardson & Sheldon [1988]) the present research aimed at recruiting a balance of girls and boys. Further, recruitment was based on ensuring that a wide range of ages within the target age group was considered.

The children were recruited from the visitors to the Science Museum. Both the children and their guardians were approached. The general purpose of the interview was explained to them and consent was obtained from both rather than just the guardian.

In total ten children participated, six interacted with the prototype and four interacted with the final exhibit. Of the six children who interacted with the prototype three were girls and three were boys. Their ages ranged from ten years to thirteen years. Of the four children who interacted with the final exhibit three were girls and one was a boy. Their ages ranged from nine years to twelve years. The age range does present a risk that engagement could be a significantly different experience particularly if individual differences are also taken into account. However, the grounded theory should bring out both the commonality and divergence of experience that could be attributed to age. As it happened, there was no evident simple relationship between age and the sense of engagement.

All children were native English speakers and went to schools in the UK. Further, all children took part in the research individually though under supervision from their accompanying guardian. That is, guardians were explicitly discouraged from using the exhibit themselves.

Ten children is a somewhat small sample but recruiting children in the main exhibit was problematic. It was felt that the children who took part should have completed using the exhibit as a sign of at least some degree of engagement. Unfortunately, not many children who used the exhibit did actually complete the full cycle of use.

Nonetheless, the grounded approach provides assurances that the description of engagement developed is at least faithful to the experience of the ten children who did take part. This is sufficient for the goals of the study to develop *some* notion of engagement that can be developed in future research. It should also be noted that the experiences of those children that did not complete the exhibit would make an equally fascinating study but it would be orthogonal to the goals of the current work.

3.2 Interviews

The grounded theory was constructed on the data gathered from semi-structured interviews focused around three key areas. Engagement clearly was a key area that the interviews tried to address. Initially, the questions on engagement were very exploratory. For example, children were asked to compare the experience with watching television or reading.

Learning was also included as a focus for the interviews because it clearly is intended to be an important aspect of the exhibit. However, no effort was made to rigorously measure learning as this could easily result in changing the experience of engagement. For example, if a visitor was pre-tested before using the exhibit, they

might suppose that they would be post-tested and so alter their natural behaviour with the exhibit. Alternatively, it would seem unethical to spring a test on a child after using the exhibit but prior warning of the test could either put children off from participating in the study or again alter their approach to the exhibit. Thus, learning was probed but not measured. Even so, we found it was still possible to find quite concrete examples of good and bad learning.

Collaboration was also considered a key area for consideration as it had been identified by von Lehn et al. (*op. cit.*) as important for the success of museum exhibits. For example, questions specifically asked about how the children talked with others around them whilst using the exhibit.

Naturally, as the interviews progressed, it became clear that these key areas were different from what had been expected. Grounded theory recommends that interview schedules should change to adapt and fully expand the dimensions emerging from the data. Thus, final interviews changed the emphasis towards ideas that had emerged in earlier interviews. For instance, children were no longer asked to compare their experience with television or reading but instead asked to relate their experience to playing. Also, the notion of collaboration mutated into that of co-presence and children were asked more about what the presence of others meant rather than how they specifically interacted with others.

The interviews lasted between fifteen and twenty minutes. They were recorded with consent from the children and their guardians. Video recording was not used as it was felt that the interview data was the primary source. Indeed, the interviewer did attempt to note particular attitudes and facial expressions of the children as they used the exhibit but it was not possible to meaningfully interpret them for the aims of the study.

3.3 Analysis

The analysis of the data followed the usual grounded theory practice of analysing as interviews were done. Thus it was possible to adapt the interviews over the course of the study. Microanalysis and open coding were used extensively at the start of the interviews in order begin to define concepts, dimensions and categories in the data. Axial coding was also done as the data accumulated in order to bring out the relationships between the emerging concepts and to gain a holistic sense of the data.

As expected, once interviews were underway, common themes began to emerge. The later interviews, where they reiterated already identified concerns, were not fully coded. Instead, the focus of the coding was on the more novel areas, in particular, on the differences betweeen the prototype and exhibit contexts. This approach concerning the analysis of interviews stands in accordance with suggestions by Glaser [1992] and Dick [2002] who propose that it is advantageous to consider key parts of interviews rather than coding entire interviews.

4 Results

The process of gathering, analysing and interpreting the results is inherently integrated in the grounded theory approach. This means that it is not easy to present how the central categories of the theory emerged. Instead, we present a (necessarily

linear) account of the three categories, namely *participation*, *narration* and *co-presence of others*. These arose from the data as being the main distinct concepts that underpin the engagement of the children with the exhibit.

The categories are derived from the transcripts of the interviews but again it would be neither possible nor appropriate to present these in full. Therefore, important quotes from these transcripts are presented in order to provide examples of the obtained results.

4.1 Participation

For the present research participation is defined as a playful process during which information is made personal by children becoming part of the presented scenes. It emerged that children had a sense of participation while interacting with Energy Everywhere and that this sense is determined by the concepts of *simple graphics* and *power*.

Simple Graphics Participation in Energy Everywhere seems possible based on the simplicity of the presented graphics. The children seemed able to feel part of the presented screens and they indicated specifically that it was the graphics that encouraged this. Further, it emerged that children enjoy sensation. For example, one child noted,

> "Everything was painted in words, that's so unreal [...] it made me think of different kinds of things I know [...] when moving around I felt like I could be part of these things [...] I liked it."

Further, when talking about the simplicity of the graphics, children frequently noted that this allowed them to play. Therefore it seems that children conceptualise their interaction with Energy Everywhere in terms of play. For example, one child noted,

> "[The exhibit] was like a game, you play with it and because it's so simple you have to develop it further in your head."

Another child noted,

> "The small words were like a puzzle to play with [...] I liked playing with it."

However, some children perceived the simple, iconic graphics as confusing and therefore felt detached from Energy Everywhere. Specifically, some children noted that the use of small words to form graphics made it difficult to simultaneously read the words and perceive the picture. It seems that this made it difficult for these children to participate in the learning experience presented by the exhibit. For example, one child noted,

> "I didn't know whether to read the words or look at the whole picture first [...] That was confusing [...] and made it difficult to learn."

Power An important aspect of children's interaction with Energy Everywhere is their experience of power. In many instances children related their enjoyment of the exhibit and their participation in it to the power that it made them possess. The following dialogue expresses this point:

Child: "It was cool [. . .] I made energy [. . .] I forgot that other children can do that too [. . .] That's cool."
Researcher: "Did you also have power when you made wind?"
Child: "I had power because I made the wind [. . .] It's not real power because it's only a simulation [. . .]. That's cool."

When questioned if there were specific features of the exhibit or specific times during their interaction that they felt powerful, children noted times when they were able to directly interact with the exhibit. Specifically, many children noted that they felt powerful while pretending to dig up coal, moving their arms to make wind or clapping their hands to make lightning hit a tree. For example, one child noted,

"It was when I made the lightning finally hit the tree and it exploded [. . .] That was when I felt like I had lots of power."

Importantly, children frequently related their experience of power to there being nothing between them and the screen. It seems that this allowed children to pretend that they were carrying out the activities in real life. For example, one child noted,

"There was no mouse or anything [. . .] so it didn't feel like it was a computer. It's much more like really pretending you're digging."

4.2 Narration

Narration can be defined as the formation of stories and accounts of events. The present research indicates that for interactive exhibits narration is conceptualised in terms of *linear structure* and *fantasy*.

Linear Structure Children frequently referred to Energy Everywhere as a story in terms of it possessing a beginning, a middle and an end. It emerged that this perception of Energy Everywhere as a story possessing a linear structure shapes children's interaction with the exhibit. For example, one child noted,

" [The exhibit] is like a story of how energy moves [. . .] in the beginning it shows how energy comes from under the ground, then it moves [. . .] in the end it shows how energy can become lightning [. . .] that shows you what you have to do."

The linear structure of Energy Experience also seems to have allowed children to learn the connectivity of the presented information by creating stories around this structure. The following dialogue is indicative of this suggestion:

Child: "At first the energy is stored in the sun. This allows for coal to be created under the ground. Miners must then dig it up so that it can be used [. . .] Then coal can be burned and used by people, for example to heat houses in the old days [. . .] Energy moves around differently, depending on what kind it is."
Researcher: "So the things you saw were connected?"
Child: "Yes, they were connected by energy moving and the things that can happen to energy, like lightning and fire."
Researcher: "Can you tell me how you know this?"
Child: "It showed it on the screen [. . .] I connected things by looking at it."

However, in some cases children made incorrect causal inferences. These incorrect inferences mainly relate to perceived causal relationships between features of the presented information. In particular, some children's narratives expressed that the energy of some features presented on the screen leads to the movement of other features, which is not always correct. For example, one child's narrative includes the statement

> "The clouds in the air make energy for the waves to move."

When asked if there was anything about the exhibit that confused her, this child stated that there was not. Therefore it seems that children may make incorrect inferences without perceiving Energy Everywhere as confusing.

Fantasy It emerged that children's narratives are not based merely on following the linear structure provided by the exhibit, but rather that children's narratives frequently include fantasy. For example, one child created a story, in which she imagined herself flying over the presented landscape. Specifically, it emerged that in creating these narratives children frequently extend the presented information to include their own fantasies. For example, one child noted,

> "The waves looked silly, like in a cartoon [...] not the real thing [...] That was funny [...] and it made me feel like I was part of a cartoon [...] I like that."

Another child noted,

> "The trees made up of words made me think of children's books [...] here trees move because of the wind [...] I make the wind."

Another fantasy seems to be triggered by the exhibit demanding that children pretend to dig up coal. Pretending to dig up coal necessitates the ability to fantasise that the action of moving ones arms resembles digging up coal. Children frequently noted that moving their arms seemed to make sense only when imagining what it is like to dig up coal in reality. Further, children frequently noted that after having imagined what it is like to dig up coal, they imagined the impact of other information presented. For example, one child noted,

> "It [moving his arms in pretence of digging up coal] made sense only if I imagined what it is really like [...] it must be hard for miners to dig for so much coal [...] When I was swinging my arms to make wind I thought of how strong wind can make trees fall [...] I imagined what it is like for firemen to clear them off roads."

However, it must be noted that the information that made up these fantasies was not always correct. For example, one child stated,

> "I was flapping my arms like a bird. I guess birds make wind in the air by flapping their wings."

4.3 Co-presence of others

The present research suggests that the co-presence of others, but not collaboration is an important feature of children's interaction with Energy Everywhere. This is surprising since questions concerning collaboration were an important feature of

the initial interview guidelines. However, children did not mention collaboration from their own initiative and did not consider collaboration to be an important aspect of their experience when prompted by the researcher. This suggests that collaboration is not an important feature of children's conception of their learning experience in this exhibit. Therefore collaboration does not seem to be important in connecting learning and engagement. Instead it emerged that in order to adequately conceptualise children's experience with interactive exhibits it is essential to consider the co-presence of others. It seems that while there are no specific features within Energy Everywhere that allow for this co-presence of others, the exhibition as a whole does. This is expressed clearly by one child:

> "There was space for others to stand around [...] and I could see them when I looked."

It emerged that this category of co-presence of others is based on the concepts of *reassurance and feedback*, *distractions*, *attracting attention* and *communication*.

Reassurance and Feedback Children frequently noted that other visitors provided them with reassurance and feedback concerning their actions.

> "I wanted to know if I was doing it right, so I turned to my mum [...] She nodded and smiled so I knew I was doing it right."

Further, children frequently noted that the mere presence of others reassured them and provided them with feedback. It emerged that in many cases this reassurance and feedback is more important than reassurance and feedback provided by the exhibit. This is expressed in the following dialogue:

> Child: "Since there were so many people watching me, it must be interesting and I must be doing a good job."
> Researcher: "And the words 'Well done!' [presented on the screen], did they tell you that you were doing a good job?"
> Child: "Yes, but I wasn't so sure, it might always say that."

Distractions It emerged that the possibility of distractions caused by the co-presence of others allows children to increase their engagement with the learning experience. For example, one child noted,

> "There was so much noise and stuff happening [around the exhibit]. I had to just look at the screen and not look away so that I would not miss bits of what is being taught [...] That was like in the cinema when you can't see around you."

However, it also emerged that actual distractions seem to reduce the experience of engagement. For example, after another child walked between him and the screen one child noted,

> "I turned to look at who was watching me and then didn't know what I had to do any more [...] It felt like it would be best to start again because I forgot what I had learnt."

These negative effects of distractions seem to relate not only to children's physical actions, but also to their creation of narratives and their experience of enjoyment. For example, after another child repeatedly clapped his hands, one child noted,

> "The whole thing about what was happening to the energy seemed less real [. . .] and was not so much fun."

Attracting Attention Children frequently noted that their interaction with Energy Everywhere attracted the attention of other visitors. It emerged that some children enjoy this attention.

> "Clapping my hands was really cool. It was noisy and many people turned to look at me."

Also, attracting the attention of others frequently motivates children to spend time with Energy Everywhere and examine it in more detail. For example, one child noted,

> "I liked the sound and the pictures [. . .] another child watched me clap to start [. . .] that made me want to take a closer look."

Additionally, attracting the attention of others motivates children to perform actions correctly. For example,

> "My friends were watching me so I didn't want to make any mistakes."

It emerged that the time, at which the attention of other visitors is attracted is important. For example, children frequently noted that attracting the attention of others by clapping their hands to initiate their interaction with Energy Everywhere encouraged them to continue this interaction. Further, it seems that attracting the attention of others early during their interaction allows children to gain reassurance and feedback concerning whether their actions are correct. This is expressed in the following dialogue:

> Child: "I clapped my hands to start. This made my friend turn to look."
> Researcher: "And how did it make you feel that your friend turned to look?"
> Child: "Good [. . .] She must like the exhibit so I wanted to continue."

In contrast, during later stages of interaction attracting the attention of co-present individuals made children feel embarrassed. This could be due to the length of time spent interacting by that stage or possibly the gestures made. For example, one child noted,

> "When I was spinning my arms my mother looked at me funnily [. . .] I felt stupid and would have preferred to stop."

Another child noted,

> "It was a bit strange waving my arms in front of everyone [. . .] People were staring [. . .] I felt a bit silly and wanted to stop."

Communication It emerged that the co-presence of others is associated with children's desire to talk to others about their experience with Energy Everywhere. Further, it emerged that this desire to talk to others is related to a desire to learn. For example, one child noted,

> "Seeing my friends [who were interacting with another exhibit] made me want to tell them what I learnt [. . .] I wanted to learn a lot so that I could tell them lots."

Moreover, children seemed to consider learning in terms of what they can later communicate to others. For example, one child noted,

> "I like how I learn about energy moving [. . .] so that I can tell my friends how it changes."

For some children this learning seems to be important only if they are able to communicate this learning to others. This was expressed clearly by one child:

> Child: "There were so many things to learn and do."
> Researcher: "Can you give me an example of something you learnt and did?"
> Child: "I learnt about the wind moving the sea, and clouds forming, and many other things."
> Researcher: "Would you be able to explain what you have learnt to someone who doesn't know about energy?"
> Child: "Yes, I think most of the things I saw and what I then did [. . .] I must be able to explain to others what I saw otherwise there is no use in learning things."

5 Implications for Engagement

In order to understand how interactive exhibits may lead to engagement, we discuss how the categories underpinning engagement arose from the interactive structure of the Energy Everywhere exhibit. Of course, these relationships are based only on the experience of the children who participated with this exhibit. The discussion is therefore couched in terms of areas for further exploration rather than definitive design guidelines for interactive exhibits.

Though no effort was made to formally measure learning in this study, it is worth drawing out the relationship between the theory developed here and existing theories of learning in children. In particular, engagement as described here is commensurate with supporting learning though whether it supports learning the right thing is another matter.

The following two subsections make the links from interaction to engagement and from engagement to learning. The discussions will also be used to contextualise the results in the existing literature related to this area.

5.1 From Interaction to Engagement

The basic interaction of the children with the Energy Everywhere exhibit is that they perform physical actions in order to both take part in the scenes presented and also to allow the sequence of scenes to progress. The present results suggest that these initial physical activities make sense to children only if they use fantasy to imagine how these activities are carried out in real life. This indicates that while performing initial actions children use fantasy to make sense of their actions. Fantasy seems to be an important feature of engagement since it is associated with enjoyment and allows individuals to step into their own imaginary world [Jones, 1997]. Since children continued to make frequent use of fantasy, it is possible that the initial necessity to fantasise may encourage the use of fantasy throughout their interaction with Energy

Everywhere. This suggests that this early physical interaction could be a useful feature of interaction to encourage engagement.

In addition to the association between fantasy and sense-making, fantasy also seems important by allowing children to become part of the presented scenes. For example, when moving their arms in the pretence of digging up coal some children perceive this in terms of "really" pretending to dig up coal rather than as part of their interaction with the exhibit. The children clearly make the distinction between really pretending and somehow 'humouring' the exhibit. Thus, to some extent, it is not just that the children have power through the immediacy of their interaction but that immediacy relates directly to their sense of fantasy. The two concepts work together to reinforce the feeling of engagement.

One of the more surprising concepts to emerge was the use of a narrative to also help make sense of the exhibit. The linear sequence of the exhibit contrasts with other sorts of interactive exhibits where children are free to select the information presented. This could be considered as a constraint and so reduce the possibility of engagement. Instead, it seems that the continuous use of fantasy is related to the linear structure of the exhibit. Specifically, it seems that children create narratives, which allow for the use of fantasy while still following the linear structure.

Interestingly, the narratives that the children create do not necessarily match with the narrative intended by the exhibit. This may be because the exhibit's narrative is not always clear and the children are having to fill in the gaps to continue making sense of the exhibit. This suggests that a more clearly defined narrative could actually reduce the engagement by removing the need for the children to fantasise. In any case, this result has theoretical implications since it suggests that the common notion that fantasy is largely free from external constraints (e.g. [Piaget, 1951; Singer, 1994]) may not hold true for fantasy occurring in interactive exhibits.

The simple graphics also seemed to have the drawback of disorienting some children. This disorientation seemed to be somewhat akin to the Stroop effect [1935] in that children could not choose whether to attend to the words or the pictures made from the words. The resulting confusion is likely to reduce engagement [Douglas & Hargadon, 2000] and so perhaps these simple graphics may actually not be simple enough.

Though not related directly to the interactive element of the exhibit, the co-presence of others is a feature of the construction of the exhibit. The unmediated interaction requires space around which others can stand and this space is a clearly defined area which should be for the child using the exhibit. The co-presence then allowed for other possibilities that would support engagement with the exhibit.

Falk & Dierking [2000] discuss the importance of providing cues and encouragement for developing engagement. Though the exhibit does provide these things, the children seem wise to the possibly superficial nature of the encouragement. Fortunately, they are able to seek it from the people they do trust who are around them and watching them. The encouragement may be explicitly provided or implicitly, inferred from the interest and attentiveness of those watching.

The presence of others though was not always positive. As the exhibit progressed, the children were required to make some quite large movements that

would possibly draw unnecessary attention to themselves and perhaps make them look "silly." It could be that this was due to the length of time for which the children had been the centre of attention. Initially, being attended to may have been motivating but over a longer period, it may be too much attention and the children become self-conscious. Alternatively, it could simply be that the children do no like making large and unusual movements. In either case, it seems exhibits need to balance the opportunity for being "in the spotlight" with the over-exposure that this might entail.

It is worth noting that both the positive and negative aspects of co-presence correspond with the findings of Brown & Cairns [2004] with engagement in games. There, engagement occurred when players were motivated to learn to play the game but full immersion would not occur unless the player were able to reduce self-awareness. Co-presence seems to be both motivating and heightening self-awareness and so is equivocal in its effect on engagement.

5.2 From Engagment to Learning

Narration is known to be an important element in learning. Plowman et al. [1999] studied multimedia learning environments such as CD-ROMS and proposed that narration is linked to learning by making the presented information personal. Similarly Falk & Dierking [2000] proposed that the establishment of personal context leads to deeper learning by allowing individuals to attach meaning to the presented information.

Further, it seems that by means of narration children are able to consider events and actions from various perspectives, a process known as decentering. For example, decentering is evident when children consider the presented information from the perspective of a coal miner or a fireman clearing trees off roads. As noted by Piaget [1951] fantasy is important for decentering in terms of its relationship to the process of assimilation.

Vygotsky [1978] also considered fantasy to be important for general learning since it allows for the creation of novel cognitive structures. Vygotsky notes that fantasy is thus essential for the separation of meaning from origins and is based on changes occurring within the Zone of Proximal Development, that is, the difference between children's actual level of achievement and children's potential level of achievement. Vygotsky argues that, while fantasising, children are no longer constrained by their surroundings and are instead able to explore the limits of their own understanding.

Thus the features of the interaction that lead to narration are therefore supporting personalisation of the information and hence could lead to a good learning experience.

Co-presence can also be understood to be important for learning. The presence of others clearly motivated children, at least initially, and motivation has been identified as key to learning [Piaget & Inhelder , 1999]. Moreover, the children also reported that doing well at the exhibit meant that they would be able to tell others about it. This is not only motivating but Gammon [2003] argues that an increased willingness to discuss information subsequent to interacting with an exhibit is an indicator of personal learning. Geier [2004] also notes that in many instances

narration allows for first-person experiences to be communicated to others.

Thus co-presence of others not only motivates children but also gives them the opportunity to consider and actually communicate their experiences to others. However, the mere fact of co-presence contrasts with the importance of collaboration [Falk & Dierking, 2000]. This research confirms that learning from exhibits is a social experience, though socialisation may not be so explicit as collaboration in order for learning to occur. Jackson & Fagan's [2000] notions concerning the importance of collaboration for enhancing the educational value of engagement may need to be extended to include the importance of the co-presence of others.

Of course, it should also be noted that the narratives that children created did not always correspond with what was being taught and that others around them could be a source of distraction and inhibition. This suggests that engagement can lead to positive learning experiences but that the focus of engagement needs to be considered carefully when designing the exhibit.

6 Conclusion

The grounded theory described here suggests that children's engagement with interactive exhibits can be understood in terms of three key categories: participation, narration and co-presence of others. These categories can be clearly related to some aspects of the exhibit design and so suggest fruitful areas for future research into the design of interactive exhibits and the nature of engagement with them. In particular, the theory suggests that it may be sufficient to design only for co-presence of others rather than collaboration in order to provide an engaging experience. Moreover, engagement with the exhibit does have parallels with what is needed for successful learning, and this was not previously known. Thus, this research provides many new questions whose answers could lead to the improved design of museum exhibits for engagement and learning.

Acknowledgments

Many thanks to the Science Museum for the extensive support provided and to all of the participants and their guardians who took time from their visits to talk to us. Thanks also to Sarah Faisal and Lidia Oshlyansky for their helpful comments on this paper and the anonymous referees for their substantial feedback.

References

British Museum [2004]. *Mummy: the Inside Story*. Accessed 7th Feb, 2005. www.thebritishmuseum.ac.uk/mummy/

Brown, E. and Cairns, P. [2004]. A Grounded Investigation of Game Immersion. *Extended Abstracts of the 2004 Conference on Human Factors and Computing Systems*. ACM Press, 1297-1300.

Dick, B. [2002].*Grounded Theory: A Thumbnail Sketch*. Accessed 1st Mar, 2004. www.scu.edu.au/schools/gcm/ar/arp/grounded.html

Falk, J. H. and Dierking, L. D. [2000]. *Learning from Museums: Visitor Experiences and the Making of Meaning*. Walnut Creek: Altamira Press.

Gammon, B. [1999]. Everything we currently know about making visitor-friendly mechanical interactives. Or 28 painful lessons learnt. Accessed on 9th Feb, 2004.
www.big.uk.com/knowledgebase/exhibits/mech_interactives_v1.htm

Gammon, B. [2003]. Assessing Learning in Museum Environments. A practical guide for museum evaluators. Accessed on 10th Mar, 2004.
www.ecsite-uk.net/about/reports/indicators_learning_1103_gammon.pdf

Geier, M. [2004]. Role-playing in Educational Environments. Accessed 10th July, 2004
www.cc.gatech.edu/megak/7001/Roleplaying.html

Glaser, B. [1992]. *Basics of Grounded Theory Analysis: Emergence vs. Forcing*. Mill Valley: Sociology Press.

Jackson, R. L. and Fagen, E. [2000]. Collaboration and Learning within Immersive Virtual Reality. *Proc. of 3rd Int. Conf. on Collaborative Virtual Environments*, ACM Press, 83-92.

Jensen, N. [1994]. Children's Perceptions of their Museum Experiences: A Contextual Perspective. *Children's Environments*, 11 (4), 300-324.

Jones, M. G. [1997]. Learning to Play; Playing to Learn: Lessons Learned from Computer Games. Accessed 22nd July, 2004.
www.gsu.edu/ wwwitr/docs/mjgames

Piaget, J. [1951]. *Play, Dreams and Imitation in Childhood*. London: Routledge and Kegan Paul.

Piaget, J., Inhelder, B. [1969]. *The psychology of the child*. New York: Basic Books.

Plowman, L., Luckin, R., Laurillard, D., Stratfold, M., Taylor, J. [1999]. Designing Multimedia for Learning: Narrative Guidance and Narrative Construction. *Proceedings of CHI 1999*, 310-317.

Richardson, K. and Sheldon, S. [1988]. *Cognitive Development to Adolescence*. London: Lawrence Erlbaum Associates.

Singer, J.L. [1994]. Imaginative Play and Adaptive Development. In J.H. Goldstein (Ed.) *Toys, Play and Child How do these aspects inform engagement and learning?*. Cambridge: Cambridge University Press.

Strauss, A., Corbin, J. [1998]. *Basics of Qualitative Research. 2nd Edition*. London: Sage Publications.

Stroop, J.R. [1935]. Studies of Interference in Serial Verbal Reactions. *Journal of Experimental Psychology*, 18, 643 - 662.

Teachernet [2004]. *Museums Moving with the Times*. Accessed 7th Feb, 2005.
www.teachernet.gov.uk/teachingandlearning/resourcematerials/museums/

Vom Lehn, D., Heath, C., Hindmarsh, J. [1999]. Discovering Science: Action and Interaction at the Exhibit-face. Accessed on 3rd Mar, 2004.
www.kcl.ac.uk/depsta/pse/mancen/witrg/pdf/vlehnDiscover.pdf

Vygotsky, L. [1978]. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, London: Harvard University Press.