Bridging Designers' Intentions to Outcomes with Constructivism

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ABSTRACT
This exploratory study investigates the value of constructivist theory for the field of interaction design. In this paper we explore how designer intentions and outcomes can be expressed in constructivist terms, and how constructivism can describe the relationship of design intentions to outcomes. This study's findings point to the potential of an emerging constructivist framework. The authors present the findings of two case studies of designer intentions and outcomes from two museum design projects. The paper presents themes drawn from the analysis that include designing for personal experience, play, and social interaction.

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User Experience, Interaction Design, Constructivism, Epistemologies, design case studies, design intentions

ACM Classification Keywords
H.5.2. User Interfaces: Theory and methods

INTRODUCTION
The use of interactive technologies has become ubiquitous in our everyday lives. Where once only used by people with technical backgrounds to accomplish work-related tasks, interactive systems have moved outside of the professional environment, to public spaces and into the hands of millions of people. As designers of interactive systems seek to further integrate technology into people's everyday experiences, new approaches have become necessary in the design and evaluation of interactive systems, in particular, approaches that address personal and less defined user experiences.

The increased focus on a breadth of user experiences has created a need to adopt theoretical models to assist the development of design frameworks, and evaluation techniques. Though frameworks to understand experience currently exist, there is a lack of evaluative techniques to support existing efforts, which make it difficult to understand the outcome of certain design intentions and goals. One theory that is understudied, and has applicability to the understanding of the individual's engagement in designed spaces is constructivism.

Constructivism is a theory of knowledge or epistemology that argues that we generate knowledge and meaning through experience. It arose primarily through the work of Jean Piaget, Lev Vygotsky, and Jerome Bruner, among others [6]. The central concern of constructivism is how we create knowledge and how we learn; yet it is more philosophical than pedagogical. The different interpretations of constructivism share in the rejection of the positivist notion that a correspondence between knowledge and external reality is possible, rather knowledge is both individual and social [1]. For example, Cobb argues that knowledge is both constructed through social interaction and in the individual's mind. [2].

In order to understand the value of constructivism to interaction design, we investigated the relationship between design intentions, expressed by designers, and their subsequent outcome, as experienced by users interacting with the designed technology. Museums were selected as a context to observe this relationship, as museums provide a rich context to observe people interacting with each other and technology, in ways that are non-task orientated. Also, museums go beyond the development of technologies in the consideration of experiences by focusing on issues of learning, social interaction, and entertainment. Finally, museums and museum studies offer existing validated evaluation techniques based in constructivism that we have drawn upon and adapted for the purposes of studying design.

In this paper, we provide an exploratory qualitative study of designer intentions from interviews with designers involved in two independent design projects of interactive museum displays and guides. Through an analysis of the coded interviews, we developed themes that relate to a constructivist-determined view of user engagement: designing for personal experience, play, and social interaction. We map these themes and intentions to their outcomes, as expressed by family groups who experienced the designed technologies and museum interactives.

In addition to presenting our study, we provide a review of constructivism in interaction design and some inherent

challenges. We discuss theoretical implications of the study and potential benefits, and close with a discussion of future research. In shaping this research inquiry, we pursued the following questions:

- How well do designers' intentions connect to outcomes? Designer expertise is an under-investigated area of interaction design. A connection between what a designer sets out to do and the results is a descriptive affirmation of expertise in design.
- How useful is constructivism in describing the relationship between intentions and outcomes? Constructivism can be useful lens for evaluating designers' intentions with the outcomes of user experiences.

CONSTRUCTIVISM

Why is constructivism useful for interaction design? In many respects we started with a hunch. Our own experiences of speaking with interaction designers were that design intentions for user experiences were expressed in terms similar to constructivist ideas. As designers, we found constructivism to be a useful way to describe user experience goals and so the ideas began to shape our own intentions. Despite these experiences, we found little mention of the connection of interaction design to constructivism, particularly with respect to designer intentions. On a practical level, we experienced designers with constructivist intentions, but who then evaluated the outcomes of their design with evaluation techniques unrelated to constructivist ideas.

In order to provide a coherent understanding of the theory, Vrasidas [20] has developed a set of five philosophical and epistemological assumptions that are held by constructivists:

- A real world exists that acts as a boundary for what an individual can experience. Despite this, reality exists in the mind of the individual, necessitating multiple realities – one for each individual.
- The structure of reality is created in the mind through interacting with the world. The structuring of reality occurs through the use of symbols.
- The mind creates symbols by perceiving and interpreting the world.
- Human thought is developed through perception, sensory experiences, and social interaction.
- Meaning occurs through an interpretive process that is dependent upon an individual's previous experiences and understandings [20].

In summary, constructivism argues that reality is made up of multiple realities, each constructed within the mind of individuals through interacting (physically and mentally) with the world and others. Symbol systems like language are integral to structuring and interpreting reality. In fact, interpretation of reality and construction of knowledge is an ongoing process mediated by an individual's previous experiences as well as the immediate context.

Constructivism in Interaction Design

In the past decade, the field of interaction design and HCI have started to incorporate constructivist principles into the development of various types of systems, though the majority of these efforts has been placed on learning technologies. Within the field of computer supported collaborative learning (CSCL) many computer-based technologies have been developed for use within the classroom [11, 15]. Research of educational technologies has also moved outside the classroom where constructivist principles have been applied to mobile-based learning [16]. Researchers interested in virtual reality learning environments for children have adopted constructivism [18]. There are many other examples of CSCL or educational technology research where the value of constructivism for the development educational tools is clear. Unfortunately these examples also suggest a perceived limitation of constructivism–that its applicability lay only within the domain of learning. This is indeed not the case.

More recently, constructivism has been applied to non-traditional learning environments. The first example is a screen-based application that is used to construct virtual environments (VEs). The application has been designed explicitly with constructivist principles in mind, to improve the user interface and make it easier to use and maximize the user's potential to create new designs [21]. For example, the designers' apply the notion of multiplicity – that multiple truths exist – through providing various paths to construct VEs and multiple representation of a created environment. Constructivist principles have also been applied to augmented-reality applications, such as GeoNotes, which is a mobile service that runs on cell phones and allows people to leave virtual messages for each other in different places [17]. The designers purposefully designed the system to be open, allowing individuals to appropriate the technology and create social meaning from its use [10]. Here the designers apply the constructivist principles of creating open environments through providing flexible tools to emphasize the social co-construction of meaning. Moving into the everyday experiences, Lindström et al. have developed an interactive product that emphasizes self-reflection and meaning making through sensory experiences [12]. The authors designed the Affective Diary, which is a tool that allows one to view and reflect on bodily information collected by a series of wearable sensors throughout the course of the day [12]. The form in which this data is displayed can be altered and appropriated, allowing the user to create a representation of the information [12]. Further, the authors explicitly state that their model for understanding emotions is based on a constructivist perspective, whereby an individual makes

sense of these emotions through interacting with others and the environment, through the use of past experiences [12].

Constructivism and User Experience

In recent years experience design has emerged as a strategy within interaction design to better understand the interactions between people and the products they use. As McCarthy and Wright write, "We don't just use or admire technology; we live with it…technology is deeply embedded into our ordinary everyday experience" [13]. Within this emerging discipline, the notion of "experience" has been described in ways that relate to the constructivist principles outlined earlier. Forlizzi and Ford, in discussing the user experience, state that designers can create "situations" or "levers" that people can interact with, but they cannot design an outcome for a user to experience [5]. Such interpretations suggest that the authors acknowledge the uniqueness of the individual in making sense of the world, one of the fundamental principles of constructivism. Forlizzi and Ford continue to express the importance for the designer to consider the cultural background and prior experience of users when thinking about the user experience, which are also fundamental qualities of the constructivist approach [5].

Additionally, McCarthy and Wright acknowledge the subjective experience of the individual, and contend that users are not passive, but "they actively complete the user experience for themselves" [13]. Analyzing this statement, a clear relation can be made between the authors' understanding of the user, and the self-regulated, actively involved, constructivist learner. As a final point, Forlizzi and Battarbee provide a typology of experiences, one of which is co-experience. The authors describe co-experience as the making of meaning through product use, influenced by the physical or virtual presence of others [4]. The idea of co-experience that the authors describe, relates directly to the process by which constructivist theory explains the formation of knowledge, or what constructivist term the "co-construction of meaning".

SHORTCOMINGS IN THE UNDERSTANDING CONSTRUCTIVISM IN INTERACTION DESIGN

Few of the studies that have explicitly applied constructivist principles have evaluated their solutions from a constructivist perspective. The NICE project [18], GeoNotes [17], and the Savannah mobile experience [16], all use a constructivist approach, but fail to provide an evaluation of their systems. With regards to those studies that have discussed their evaluation, Liaw's system was evaluated using the technology acceptance model [11]. Morrison's evaluation took an activity theory approach. Other studies that have performed evaluations include Winterbottom's design tool [21], and the Affective Diary [19]. These projects both evaluated their systems qualitatively, but similar to the studies discussed above, they lacked a constructivist framework to guide their assessment, opting instead to ask questions on general usability, perceived usefulness or emotional affect.

The absence of a constructivist framework for evaluating interaction design artifacts is itself not odd given the relatively minor theoretical influence constructivism holds over interaction design and HCI. Again, we do find some instances of assessment based on constructivist principles however these tend to be in educational technology applications in the classroom [8, 22]. We see a need for future development of constructivist orientations for assessment that go beyond learning and have set that goal for our future research. However at this stage, what the lack of constructivist assessment reveals is: 1) that the designers themselves do not believe that constructivist intentions will manifest in observable ways in the design outcomes, and / or; 2) epistemological impediments may exist preventing researchers from seeing constructivist principles as a viable approach to assessing user experience and design artifacts.

DESCRIPTION OF STUDY

This research aims to describe the relationship between design goals and outcomes within the field of interaction design.

Qualitative research is valuable in explaining social phenomena, and uses multiple methods that are interactive and humanistic [3]. Case studies are an empirical method, well suited to investigate questions that cannot be addressed through controlled experiments. They rely on qualitative analysis, and can be mixed with quantitative methods, as we have done. Two cases were selected: Kurio, a tangible museum guide for families and BodyWorks 2, an exhibit about the human body. This study investigates the relationship between designers' goals and the design outcomes. In the study reported here, the unit of analysis is designers (individuals responsible for the creation of the exhibit and related technologies).

There are two conditions of these cases worthy of mention. In the first case, the design research team behind Kurio included the authors of this paper. However, the first author collected data for this study independently from the team and we coded the data using analysts not involved in the Kurio project. Having said that, it is common and at times even necessary for designers to invoke first-person research given that a reflexive orientation yields critical data (and insights) and design process is dynamic and key aspects can be hidden from a distant observer.

Secondly, the two cases are museum related and as such have learning objectives as a component of the design goals. We focused in our analysis on themes that emerge independent of explicit learning objectives in order to see if constructivism has greater breadth and applicability.

Description of Cases

Kurio at the Surrey Museum

The Surrey Museum features a number of exhibits that focus on various historical and present-day issues in the community. The museum has on display various artifacts from their respected time-period, text-based didactics and a series of audio kiosks where visitors can listen to interviews

of important figures in the community. A team of researchers from Simon Fraser University installed an interactive museum guide system in the museum, named Kurio, which augmented a number of exhibits. The system included several components including: a table-top display, tangible user interfaces, and a PDA device.

Within the Kurio project, the designers were selected based on their contributions to the design of the visitor experience and overall outcome of the project. Participant 1 is the most junior of all the participants and is currently a PhD candidate within the field of interactive technologies. Participant 2 was the principal investigator of the project and is a tenured design professor with 15 years of experience in academic research and professional practice of interaction design.

Family visitors in this case were recruited through local school boards and home-schooling contacts, and were all local residents. From this site, we recruited 3 families, consisting of 4 adults (3 females / 1 males) and 6 children (3 females / 3 males). The children's age ranged from 14 years old to 7 years old.

BodyWorks 2 at Telus World of Science

The second case that was selected for this study was BodyWorks 2 at Telus World of Science. The exhibit focuses on issues surrounding the human body, such as reproduction, bone structure, and the purpose of various organs. The exhibit was designed for both young and adult visitors. The exhibit hosts a series of artifacts that can be manipulated, text-based didactics along with a variety of interactive technologies, such as screen-based interactives, and tangible-based technologies that react to physical manipulation.

The designers of BodyWorks 2 included an exhibit designer (participant 3) and the content designer for exhibitions (participant 4). In the case of BodyWorks2, the two designers selected for participants in the study were those who were most influential on the project's outcome, in that they made the decisions on the visitor experience. Both designers have been working within their respective areas for many years, with participant 3 having 10 years experience in exhibit design, and participant 4 with over 21 years design experience.

Family group participants were recruited through the museum's membership list with help of a staff member. In total, we recruited 3 families, consisting of 5 adults (3 females, 2 males), and 6 children (4 females and 2 males). The childrens' age ranged from 12 years old to 6 years old.

Data Collection and Analysis Procedures

Designer data

A procedure was developed for the designer interviews, which was used to elicit information about their goals, and intentions. The interview was open-ended but we had the following questions in the interview protocol:

- What are the main ideas you wanted to communicate in your exhibit?
- What learning goals did you have in designing the exhibit?
- Who else worked on this project? How did you communicate these goals?
- Were there any principals that helped guide you in your design and concept planning?
- What areas did you research?
- What considerations were made so that the exhibit appealed to your audience?

Once the data was collected, the audio data was transcribed and the video from each session was digitized. The audio and video were enumerated using an identification number in order to conceal the identity of the participants. We analyzed the data collected on designers in three phases; i) descriptive accounts, ii) categorization of data into themes, and iii) development of assertions [14].

Providing descriptive accounts begins with the process of open coding. Open coding refers to the partitioning and labeling of collected data that helps to develop themes [3]. Open coding was used on the designer interviews and supporting documents provided from each museum site, because an existing code for assessing constructivist intentions did not exist. Two research analysts coded the interview transcripts independently, in order to highlight issues of interest that applied to the study's research questions. Independently and applying categorical aggregation, the codes were collapsed into a manageable set of categories, a process described by Creswell [3]. The codes were then reviewed and further aggregated, with any discrepancy discussed and resolved by going over the initially coded transcripts together.

Family data

The procedures that were used to collect data on the family groups were based on a constructivist method developed as part of the MARVEL project (museums actively researching visitor experiences and learning) [7]. The family data that was collected and coded consisted of observations and videos of family visitors interacting with the exhibits. In order to guide the observation sessions, the study used an instrument developed by the MARVEL project used to uncover indications of learning based on constructivism. The data collection involved recording both visual observations and auditory communication between members of the family, and coding the behaviors according to seven measures: *sharing learning with peers and experts, actively involved in learning, purposefully manipulating and playing with objects and ideas, showing responsibility for learning, showing confidence in personal learning activities, responding to new information and evidence,* and *making links and transferring ideas and skills.*

Additionally, a self-administered interview was conducted 2-4 weeks after the initial visit, which involved one family

member interviewing the others using an audio recording device that was later returned to the researcher. This data was coded with a modified version of the MARVEL instrument.

All of the data was coded by two researchers separately, and later compared using a consensus model for inter-rater reliability, that reached a reliability level of 80-85%.

SIGNIFICANT THEMES

The coded data for designers was synthesized into themes. This step involved comparing, contrasting and integrating the developed categories in order to aggregate them into higher order categories [3]. Of all the data collected, 25% was determined to be insignificant and not coded. These included things like introductory statements, misunderstood questions, or repetitions. We developed seven themes that accounted for 80-90% of each designer's statements. These include *designing for personal experience, design for play, design for social interaction, design for learning, storytelling, design for different audiences,* and *design for emotions*. See figure 1 for the average occurrence of each theme across the two cases.

In this paper we are focusing on the most significant themes based on frequency of coded occurrences. These include *designing for personal experience, design for play, design for social interaction* in order to provide detailed accounts. *Design for learning* was also a significant theme however there was a variance and lack of agreement among the four designers who were interviewed.

Figure 1 shows how the combined averages of the three significant themes account for over 60% of the occurrences. We used frequency as a quantitative indicator to make distinctions within the qualitative data. The notion being that the number of occurrences of similar coded data provide insight into themes relative importance on the part

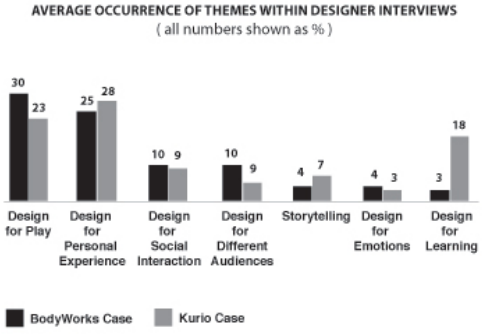

Figure 1 Average occurrence of themes within designer interviews

of the designer. We acknowledge the significance of the data can be interpreted differently.

Evidence of the importance of the themes, and the strength of the relationship between designer intentions and outcomes of user experiences is the degree to which the significant themes map to related occurrences in the user

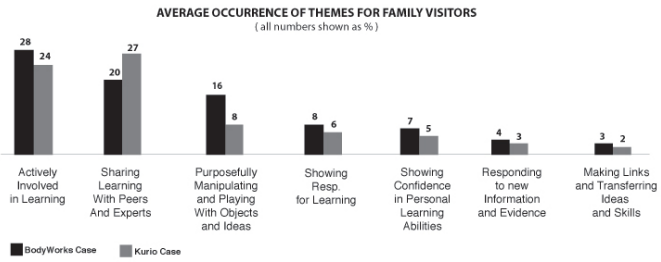

Figure 2 Average occurrences of coded data for family visitors

experience or family data. This data has also been quantified across all the types of data coded (video, audio, self-administered interviews) in order to make distinctions in the qualitative data. See figure 2 for the distribution of average occurrences across the measures coded.

The relationships between the coding of the designer and family data relies on analysis since we employed open coding with designer data and the MARVEL coding for user data. User experience codes have been mapped to the eight themes (see table 1). The average occurrences of coded measures in family data generally maps to the three significant themes.

The themes relate clearly to constructivist ideas, or constructivist language, and can be seen as a useful descriptor for designer intentions.

Table 1 Family coded data mapped to themes

Themes	Family Coded Data
Design for Play	*Making links and transferring ideas and skills*; *Actively involved in learning; Purposefully manipulating objects and ideas; Sharing learning with peers and experts*.
Design for Personal Experience	*Making links and transferring ideas and skills*; *Actively involved in learning; Purposefully manipulating objects and ideas; Sharing learning with peers and experts*.
Design for Social Interaction	*Showing confidence in personal learning*; *Making links and transferring ideas and skills*; *Responding to new information or evidence; Sharing learning with peers and experts*.

In *designing for personal experience*, experiences are personal and unique where meaning occurs through an interpretive process that is dependent upon an individual's previous experiences and understandings [20].

The theme of *design for play* maps well to constructivism. Play and manipulation motivate the interaction and interpretation of the world around us. The construction of experience is aided by ongoing perception, sensory experiences, and social interaction that can result from play.

In *design for social interaction*, the idea of social interaction is part of the development process for human thought in constructivism. Its not surprising that it readily emerged as a theme of its own in our analysis.

Theme 1: Designing for Personal Experience

In this theme, the designers wanted to provide a goal to work towards, provide visitors with the resources to achieve the goal, and provide the means to make sense of the content by situating the goal within previous knowledge or as one designer put it: "And you have to say: how does this fit with your life? So in other terms, what's the relevance here" (participant 4)? Designers spoke of creating design resources that fit people's past experiences and could be used to generate new understandings of things within the museums. For example, a designer commented on the intent of tangible devices: "it needed to be that resource for imagination, and so people still had to relate to it, and then take it somewhere else" (participant 2).

Focusing on or highlighting topics that are familiar and personal is seen as a means to create meaning through making personal connections within the museum visit experience: "So we put all the animals on the scale, and so you can see how much each animal weighs, and see how much your weight reflects the chicken or dog, or where you are in the animal kingdom" (participant 3). A key concern was to take into account previous knowledge as a starting point for enabling people to move from what they already know to something new. A designer of the BodyWorks 2 exhibit knew the advantages of working with the human body: "I think the thing about the gallery itself is that people can relate to it, because it's about yourself, right? It's about your body and it's something we all have" (participant 3).

Relationship to outcomes

The intentions related to design for personal experience corresponded to family data coded with the following measures: *making links and transferring ideas and skills*, *actively involved in learning, purposefully manipulating objects and ideas,* and *sharing learning with peers and experts*.

The intentions to provide familiar resources to the visitors afforded conceptual access, which in turn helped visitors make connections to previous knowledge and experiences. Several resources were considered in both cases. For example in Kurio, the system facilitated family interactions that made family histories more readily accessible as a point of reference for the exhibit. We observed how a mother was explaining how wool was made in reference to the child's grandmother: "where does she get her yarn?... but back in the olden days were there any stores?... No, so you had to raise sheep…" (Family 21).

In Bodyworks, participants often demonstrated a personal connection with the content. For example, one participant spoke about the aging interactive: "I like the aging thing… It was interesting to see what your face will look like in 30 years" (Family 5). The changing facial expression interactive was large enough to allow groups to crowd around. This caused discussions of comparisons of facial features and previously shared experiences that were particularly effective with families.

The technologies that were developed within each case were also designed to provide conceptual access, through employing metaphors that visitors could relate to, such as the appearance of the tangible devices in Kurio that looked like a magnifying glass, walkie-talkie, a stick, and a divining rod.

Theme 2: Design for Play

Metaphors were commonly discussed as a design strategy for creating a platform for imaginative play. The tangible forms of interactives can become mnemonic devices that help trigger people's memories of things, in ways that are often playful. For example, an interactive that featured a long rope that could be pulled was meant to communicate the length of the human intestine. The added visceral quality enhances the metaphor and encourages understanding: "But, I do think with the intestine stuff, if it is a literal connection it is a little bit easier for people to understand, not something that you have to know a bit of knowledge about to understand really what this thing is doing" (participant 3). The opportunity for a metaphor can shape the form of a tangible interactive to create imaginative space. For example, a designer of Kurio spoke of how one of the tangibles that could "read" text had a particular shape to it: "the reader was enough like a magnifying glass, but it wasn't a magnifying glass" (participant 2). Metaphors provide a ready understanding: "Then you don't have this huge instruction… people are like, 'oh I know' it's just like perfection" (participant 4).

Designers expressed the need to create something new through sparking the imagination with something familiar, for example game mechanics came up as an example of known routines that led to imaginative play. The expectation of designers was that people are going to try something new but the mechanism for interaction needs to be familiar. Aesthetics, familiarity, and imagination all played a role: "they [tangibles] had to be imaginative objects. You know my smartphone is a smartphone, so you can't imagine what else it could be. It needed to be that resource for imagination, and so people still had to relate to it, and then take it somewhere else" (participant 2). Imagination can create continuity between the experience and visitor's everyday lives: "It made it a little more playful and I imagine it was something that they talked about when

they got home – 'oh we got to be time travelers', time machines, that kind of stuff…" (participant 1).

Game-play is a way to create and shape engagement. For example, a BodyWorks 2 designer spoke about the aim of designing human reproduction as a game that drew in the visitor: "You choose if you're an 'x' sperm or if you're a 'y' sperm. Then you go through, because you have only so much energy, because that's what sperms do" (participant 4). Game-play required precision and to be matched to the situation or challenge in order to situate someone imaginatively: "Whether it's the digestive game – you could play that independently – you're working a ball through a tract avoiding the pitfalls of acid reflux… and I can just see someone looking at that thing and going 'oh, I had that'" (participant 3). Game-play can provide flexibility in the experience and structure: "So I think that there was sufficient structure that was required for the narrative and for the game that they were playing, but that they really had flexibility within that structure to take the time they needed to take and do the things they needed to do" (participant 1).

Designers discussed different strategies in the design of interactive artifacts that would result in a variety of interactions. For example, "we didn't want everything to be a flip panel" or "I think for me, always trying to deliver it in a different manner than the same old and so it's not the same as the computer over there" (participant 3). Variety enables visitors to make their own decision or construct their own interaction: You could also exercise preference… 'I like this one better than I like that one. And so people could interact with them in a different – piecemeal way" (participant 2).

Relationship to outcomes

The intentions related to design for play corresponded to family data coded with the following measures: *purposefully manipulating objects and ideas*, *making links and transferring ideas and skills*, *actively involved in learning,* and *sharing learning with peers and experts*.

Metaphors provided a conceptual bridge for participants to relate the novel and playful forms of the interactives to more familiar objects, which helped them understand how to use them. For example, one participant from the Kurio case had referred to the listener tool as "some telephone thing that you could listen to" (family 04).

In BodyWorks, metaphors were used to couple the interactivity with the content of the exhibit, such as the use of a hand pump that was used to communicate the pumping of the human heart. While using interactives that employed this principle, participants were observed using previous knowledge to imagine the phenomenon within their own bodies. The coupling of function and content further aided visitors of BodyWorks to be actively engaged because the interaction that was required was directly related to the content, whereas in Kurio, the interaction was a means to discover new information that was unrelated to the form of the interaction. The effect of this difference was observed within the self-administered interviews where children from the BodyWorks case talked about the phenomenon encountered in the museum through the use of the interactives, whereas in Kurio, the use of the tangibles were discussed separately from the content they encountered in the museum.

The use of game-play in the cases produced similar behaviors amongst the visitors through employing mechanisms that were familiar and understandable, such as puzzles, quizzes, and scavenger-hunt type games, which visitors were overheard comparing to games they had previously played. For example in the BodyWorks case, an adult from one family at the skeleton interactive said: "this is how they do it on the TV show" (Family 4). The familiarity with these types of mechanisms afforded a ready understanding and playfulness that engaged visitors in the museum content. In the Kurio case, family groups also commented on the designer's approach "it's like a game, you have to work together to solve this puzzle" (Family 15). In both cases, families were observed engaging with these types of interactives in a collaborative manner, which was often accompanied with family members talking to one another.

The provision of different kinds of hands-on technologies, and text-based information created opportunities for individual family members to make decisions on what they wanted to see and do next. One participant from the Kurio case appreciated this intention when they said "I didn't expect that many ways of looking at things. But that's good because some people are more auditory, some people are more visual, so it covered all those things" (Family 15). Family members used the physical interactives to spark their memory, as one family member stated in the self-administered interview: "I remember the skeleton, that we arranged, and the heartbeat…that it takes the same amount of muscles to frown" (Family 5). In both cases, the experience was designed to be open-ended, where families could wander through the space for things of interest. The variety of interactives encouraged movement and choice through offering ways to explore the museum content. Also, families were observed using hands-on interactives, reading, and looking at video displays.

Theme 3: Designing for Social Interaction

In the coded statements, designers expressed the aim of designing interactives that foster social interaction and collaboration between visitors. For example, participant 4 commented on a design that supports this aim: "we have echo monitors, sometimes you can see what other people are doing. That encourages more social interaction, and also that you can just sit right beside them, and you both stare at the same sort of thing" (participant 4). The aim of shared experiences between family members was met by creating resources and situations to allow people to interact and learn from each other: "So I think that the best thing that we did about the design…is that we forced people to talk to each other" (participant 1). Creating interactions that

allowed for conversations to take place that related to the family was seen as valued in terms of creating meaning. The intent can be to create competitive as well as cooperative situations that in turn lead to social interaction or to implicitly challenge people to interact "Well, what we do sometimes in team meetings, when an interactive comes up, we discuss how many people will be involved in it, and what kind of experience do we want it to be. And we wanted a great big scale because how many people can get on that thing? I can see a group trying to 'let's try to get up to the elephant weight'" (participant 1).

Relationship to outcomes

The intentions related to design for social interaction corresponded to family data coded with the following measures: *showing confidence in personal learning*, *making links and transferring ideas and skills*, *responding to new information or evidence,* and *sharing learning with peers and experts*.

The designers' intention to foster social interaction succeeded through creating situations such as the event where children collected artifacts and shared them with peers via the PDA in Kurio. For example, one family while at an exhibit began to collaborate with each other in deciding which item to select, when the father said: "A ladle… it's not made of wood now is it?", which incited the children to think about the artifacts on display more critically (family 21). This type of activity also appeared in Bodyworks, especially during the manipulation of large, multi-person hands-on exhibits. Adults would often respond to their children's questions, sometimes explaining complex information that arose through reading or interacting with exhibits, resulting in children learning something new.

In Bodyworks, the designers expressed that they had written content to foster this type of interaction between parent and child, whereas in Kurio this often emerged through the exposure to existing museum content that was facilitated by the system. Additionally, social interaction together with the personal experience intentions provided situations that positioned parents as facilitators in their child's learning. This was evident in the form of adults explaining ideas using experiences that their child had previously encountered. In this way, social interaction provided an avenue to make connections to previous knowledge. Within Kurio, social interaction was designed to foster collaborative interactions with peers, whereas in BodyWorks, the designers expressed the desire to engage families in both collaborative, and competitive interactions. At the exhibits that used counters and timers, competitive behaviour did emerge among the family visitors, such as when a child spoke to her mother at the heartbeat drum: "You can't make it go as fast as mine", to which her mother replied "see, when your heart beats slow, mine beats hard" (family 5). This type of interactive provided both playful, game-like, discussions, along with opportunities to share learning regarding the content of the actual interactive.

Other Themes

The other themes that emerged from the coding of designer data are equally constructivist. They are evidenced in the data, however not with the same frequency of occurrences and with a less strong mapping to the family data.

The other themes include: *Design for learning:* This theme occurred from the designers' intention to create a learning experience that was long term, and integrated into their everyday life. *Storytelling*: Storytelling in constructivism is part of the interpretive process and use of representation to structure reality. *Design for different audiences:* This theme manifested from the designers' intention to design for different individuals within the family group. *Design for emotions*: In constructivism, emotions focus on limiting frustration and increasing curiosity.

DISCUSSION

The findings are useful to interaction design practice in at least two ways. First, the study's results contribute to existing works where constructivism has been applied to interaction design, while also extending the use of such principles outside of traditional learning environments. Secondly, the resulting themes uncovered in this study begin to draw an outline of a constructivist framework for describing and assessing interaction design.

Contributing to Previous Constructivist Interaction Design Practices

The findings from this study contribute to the existing research in interaction design where constructivist principles have been employed in practice. One such context that this research directly contributes to is that of museums, and museum learning technologies

In recent years museum staff have increasingly adopted constructivist principles in the design of exhibits, however little research has explored how these principles are employed in the shaping of interactives, nor has previous work explored the correspondence of the principles with their outcome as experienced by visitors. For example, Hein provides a variety of principles to help guide the design of exhibits, but they lack the specificity to enable designers to understand how to make use of them, especially within an interaction design context. Within the semi-structured interviews that we conducted, designers spoke of the difficulties in applying existing principles, as there was no clear example to base design decisions on. Through this research study, many of the principles that Hein [9] discusses become evident in practice within the designer interviews, providing future museum interaction designers an understanding of how they might employ constructivist principles in practice. In doing so, the study acts as a bridge between theory and practice, as it demonstrates how designers interpret constructivist principles to form intentions, and organizes these intentions into patterns that interaction designers can use to help them in creating constructivist experiences. More so, through investigating the relationship between design intentions and their outcomes, designers can better understand how their design

actions will impact various aspects of an experience within a museum.

Beyond the museum, the findings from this study contribute to existing research in the area of constructivist learning technologies. As learning technologies have been increasingly a subject of investigation in the field of HCI, people have adopted constructivist principles to help guide their design. This research relates to existing approaches, such as the use of game-play, narrative, and multiple senses to engage participants, as seen in the Savannah project [16]. This research contributes by helping to situate these design choices within a larger design pattern. For example, the use of game-play was shown to play a role within the theme of *design for play*, while facilitation of groups was discussed in the theme *design for social interaction*, when these themes are used together, they can provide a learning experience that affords social interaction, engagement with exhibit content, and conceptual access to a wider variety of visitors. The findings also contribute to existing models that have been employed such as Zurita and Nussbaum's model for handhelds in constructivist learning environments [22]. Their model shares similarities with the findings from this study, however they provide less guidance for designers. For example, Zurita and Nussbaum's model includes the principle of collaboration, which is shared with the *design for social interaction* theme uncovered in this study, however there is a lack of detail on how to employ the principles. By providing detailed qualitative findings on how constructivist principles are in operation, this study may serve useful to future interaction design practice within the area of constructivist learning technologies.

Additionally, previous studies that have used constructivist principles have neglected to use a constructivist evaluation strategy, opting instead to use more traditional HCI methods of evaluation, which make it difficult to draw relationships between the use of constructivist intentions and their outcomes. This exploratory investigation makes it possible to begin to understand how certain constructivist intentions relate to specific aspects of a constructivist experience. This is useful not only to help designers understand what a possible outcome may be when employing constructivism, but is also helpful to researchers who seek to develop a more comprehensive model for constructivist learning technologies, where particular design actions can be analyzed more thoroughly.

Finally, the study contributes generally to current work within interaction design. Within this study, the findings point towards providing design examples of how to employ constructivist principles through the various themes described, while also moving towards the development of a framework to address various aspects of a constructivist experience through highlighting the interrelation of themes and revealing how they impact various aspects of the visitor experience. For example, in applying the theme of *design for social interaction* and *design for play*, a designer might choose to create a large interactive to provide the affordance for collaboration, while also using mechanisms to encourage the interaction between peers, such as the use of a timer. In applying these principles, the designer could expect that the resulting outcome of interaction, from a participant's perspective, would involve an increased level of physical interaction with the artifact that would be accompanied by related discussions about the content of the interactive.

The Themes and Towards a Framework

The themes we discussed above begin to draw an outline of a constructivist framework that in part describe and assess interaction design. The themes detail and mobilize the principles of constructivism in terms of interaction design. An underlying assumption is that the themes constitute an analytical description of user experience and we can see how the dimensions of constructivism, can articulate both designer intentions and assess the design of user experience. However, it is important to note that the themes interrelate with each other to the point of interdependence. For example, play and emotions in our own study can be seen to be reliant on an understanding of previous experience. The holistic nature of constructivist experience points to a different type of assessment framework that does not lend itself to experimental methods but requires an approach that respects the natural setting, synthesis of principles in actions and artifacts, and a means of reporting that maintains the descriptive whole of the experience.

We are approaching an understanding of a constructivist framework, but make no claims to one in this paper. In part, the question is a matter of understanding first the underlying assumptions or epistemology from which a theoretical orientation for assessment may emerge.

LIMITATIONS

There are limitations inherent to our choice of cases in this study. The museum setting makes it hard to separate out implicit learning goals typically assumed within museums. Cases in different settings such as offices or homes may have different results. Some readers may question the applicability of exhibit design or the role of content to interaction design. Yet, we feel that a museum setting brings to the fore user experience and the interactions between people, artifacts, and surroundings all of which are highly critical to interaction design.

In terms of the details of the study itself, it is clear that evidence for each of the seven themes is not consistent or of equal measure. Additionally, the emergent themes of designer intentions may be seen to have mapped too broadly to the explicit constructivist measures of the family data. While we wanted to respect the interdependency of the constructivist attributes, the mapping of the same measures of the family data to the themes of *design for play* and *design for personal experience* may need further detailing and articulation in future research.

CONCLUSION

In this paper, we reported on our study on designers as an object of study in order to illuminate the idea of designer intentions and user experiences. We assume in this study that designers embody expertise and knowledge that is comprehensible in design intentions and design outcomes. We studied intentions and outcomes through a constructivist lens since constructivist principles appeared to us to be in concert with ways designers discuss goals of projects, particularly in respect to user engagement. We found that constructivist themes did emerge as a descriptive language for designer intentions. We also found that constructivist language is valuable in describing the link between designer intentions and the outcomes of user experiences. We concluded with design themes related to interaction design and a discussion of the emergence of a possible constructivist design framework.

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