learning by design

Cognitive and Emotional Factors Influencing Informal Learning Experiences in Interactive Environments

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executive summary

This white paper presents an overview of a study synthesizing current literature in educational and design psychology, information design, human-computer interaction, and museum studies in order to identify cognitive and emotional factors that influence learning (Leaper, 2011). The study presents a set of cognitive and emotional factors that museum educators, exhibit designers, information designers, and interaction designers (along with other key design stakeholders) should consider when designing informal learning experiences in interactive environments.

Information experiences are changing and require a deeper understanding of human psychology and behavior in order to successfully address the needs of learners in interactive environments. According to Lake-Hammond and Waite (2010), "an exhibition curator is still responsible for the collection and research of the exhibition's content, but increasingly draws on the interpretive abilities of communication designers to ensure that the exhibition audience can access, interact with, and form their own interpretations of the exhibition's message" (p. 81). This white paper presents a set of factors that museum educators, exhibit designers, information designers, and interaction designers should consider when designing interactive learning environments. The white paper is based on a study that identifies relevant factors in current literature, clusters them into factor groups, and provides an overview of how each fits into current academic research in a visual study results matrix (Leaper, 2011, Appendix A), showing emerging areas of overlap and omission between fields. This white paper offers a streamlined, high-level overview of the study which can be used to guide the creation of human-centered interactive learning environments.

According to the references selected for the study, design stakeholders should consider a range of interconnected, influential factors when designing informal learning experiences in interactive learning environments. These factors can be clustered into nine larger factor groups which include: affect, cognition, context, engagement, experiential learning, interactivity, narrative, self concepts, and usability. The factors identified in the study are interconnected and influence each other to produce experiences. As O'Brien and Toms (2010) suggest, "multiple factors of experience must be examined concurrently and are related to each other" and the "co-presence of multiple factors during experience will, in future, influence design guidelines" (p. 64). Designers and design stakeholders can consider the influential cognitive and emotional factors presented in order to create successful learning experiences in interactive environments.

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affect

Affect can be described as both affect (a response) and affective quality (stimulating a response) (Zhang & Li, 2005, p. 106). Although there are a number of similar terms, Norman (2002) uses the "reasonably neutral term "affect" to include "the concepts of affect, emotion, feelings, mood, motivation, and qualia" (p. 38). Affective quality can be described as "the ability of an object or stimulus to cause changes in one's affect" (Zhang & Li, 2005, p. 105). Notably, "objects, places, and events all have affective quality…[which enters] consciousness as they are affectively interpreted" (Zhang & Li, 2005, p. 106). This study includes the following individual factors in the Affect factor group: *aesthetics, affect, affective associations, affective quality, affinity, beauty, subjective satisfaction*, and *positive affect*.

Affect and humans. Emotion is "the conscious experience of affect…[humans] react emotionally to a situation before [they] access it cognitively" (Norman, 2004, p. 11). Subconscious experiences (such as affect) are "the most automatic, or fluent experiences" (Forlizzi & Ford, 2000, p. 421) and are inherent to meaningful human experiences since "positive emotions are critical to learning, curiosity, and creative thought" (Norman, 2004, p. 19). Affect makes humans "smart" (Norman, 2002, p. 39) by helping us judge experiences (Hassenzahl & Ullrich, 2007, p. 432). Affinity is a personal (and judgmental) affective response; humans are "often drawn to a certain design with a natural attraction simply because of its aesthetics and beauty" (Jordan, 2010, p. 6). Affinity can be defined as:

> The emotional connection someone feels for a product or service as driven by these notions of beauty and identity...affinity is about unexplained desire or want. It is often irrational, fluid, and intense. Affinity is the opposite of aversion, and affinity is always positive. (Jordan, 2010, p. 6)

Both positive and negative affect are important, for different reasons. A negative affective response "focuses the mind, leading to better concentration," which is good for dangerous, high-pressure situations (Norman, 2002, p. 38), while "positive affect broadens the thought processes, making us more easily distracted" which is useful for creative problem-solving and low-pressure situations (Norman, 2002, p. 39).

Affect and design. Because "the designed environment is the setting where our experiences take place and is impregnated with emotions" (Damazio et al., 2009, p. 2727), "understanding how and why things evoke emotions is…imperative to designing our environment" (Damazio et al., 2009, p. 2727). Interactions are "inevitably accompanied by affect" (Hassenzahl & Ullrich, 2007, p. 435) and studies have shown affect to be "the single best predictor for the retrospective product evaluation" (Hassenzahl & Ullrich, 2007, p. 434). Hornecker et al. (2007) describe different reflexive affective responses occurring in different situations; they found a "pulling" motion results in positive attitude formation, and a "pushing" motion results in negative attitude formation (p. 336). However, designing for affect and affinities can be "very challenging to include in a typical human-centered design approach" (Jordan, 2010, p. 8). Although recent attention has been given to the idea of experience design as a kind of theater where the participant plays a pre-orchestrated role, emotional experiences are more valuable when they are open-ended; Hennes (2002) notes that "pre-defining the outcome of experience is the goal of marketing; it is not the open-ended enrichment and pleasure that museums, at their best, can provide" (p. 110). In general, "pleasing things work better, are more regularly used, are easier to learn, influence future purchase choices, and produce a more harmonious result...thus affect and emotion have an important place in design" (Zhang & Li, 2005, p. 105). O'Brien and Toms (2010) describe "a more holistic representation of user engagement that indicates affect should be incorporated into interaction design and measurement" (p. 63).

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Affect and other factors. Affect is related to the Cognition, Experiential Learning, Self Concepts and Usability factor groups. Zhang and Li found that "a user's immediate and reflexive affective reaction to [information technology (IT)] has a positive impact on his or her consequent cognition-oriented evaluations" (Zhang & Li, 2005, p. 107). Affect is crucial to learning because "positive affect arouses curiosity, engages creativity, and makes the brain into an effective learning organism" (Norman, 2004, p. 26). In fact, "the act of learning needs to be pleasurable in itself…if the interactor is to remain engaged" (Polaine, 2005, p. 154). Affect is

affect (continued)

related to self concepts because "the act of choosing and making decisions is intrinsically related to emotions" (Damazio et al., 2009, p. 2730). Affect and usability are inherently linked; "true beauty in a product has to be more than skin deep, more than a façade...good design means that beauty and usability are in balance" (Norman, 2002, p. 42). However, Zhang and Li (2005) note that "empirical evidence is scarce on whether perceived affective quality of a system influences user perceptions of usefulness and ease of use of the system" and that in spite of "recent efforts to bring affect and emotion concepts into user acceptance studies, most of the existing studies are based on the assumption that human beings are rational and behave based on logical information-based thinking" (p. 106).

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cognition

Cognition is defined by Norman (2002) as a neurological response, which "interprets and makes sense of the world"; affect and cognition work together to help humans process information (p. 38). According to Richard Carlson's (1997b) theory of experienced cognition, cognitive experience is the stream of incoming information perceived by humans during consciousness. Cognition can also be described as happening during interactions which "require us to think about what we are doing [and] require attention, cognitive effort, or problem-solving skills [sic]" (Forlizzi & Ford, 2000, p. 421). This study includes the following individual factors in the Cognition factor group: *cognition, conceptual coherence, concepts, focused attention, knowability, immediate apprehendability, internalization, inquiry, interest, mental effort, novelty, organization of content, sub-conscious experience*, and *suspension of disbelief*.

Cognition and humans. According to Forlizzi and Ford (2000), "experience [is the] constant stream that happens during moments of consciousness" (p. 419). Humans become aware of experience through self-talk and narration (Ibid). While "the affective system is judgmental, assigning positive and negative valence to the environment rapidly and efficiently…the cognitive system interprets and makes sense of the world" (Norman, 2002, p. 38). Hennes (2002) contrasts unconscious experience against interrupted experience, the latter being where "memory is formed and growth occurs" (p. 115). Allen suggests "immediate apprehendability," defined as "the quality of a stimulus or larger environments such that people…will understand its purpose, scope, and properties almost immediately and without conscious effort," can reduce cognitive load and make learning possible (Allen, 2004, p. S20). Van Moer et al. (2008) note that encouraging "engaging and assimilated experiences while creating capacities of critical thought and judgment…result[s] in the transformation of visitors' attention into interest" (p. 44). Hennes (2002) discusses Dewey's concept of inquiry, which begins with a sense of unease or an intellectual conflict and includes the following "steps" in inquiry cycle, which is different for every learner (p. 117-118):

- "interruption, obstruction, breaking the normal flow"
- "observations" and "inference" (a desire to understand the nature of the problem)
- "alternative solutions" (questioning multiple hypothesis)
- "reasoning" (testing and measuring)
- "verification" (resolving unease generated by conflict)

The process as a whole begins as activity halted by obstruction, moves through a process of thought and concludes again as activity restored. The difference between the activity of the beginning and that of the end is a kind of transformational growth that affects experience in the future. (Hennes, 2002, pp. 118-119)

Cognition and design. In order to create a "full cycle of inquiry," museums should "promote reflection and inquiry [in] ways that are not simply 'hands-on'" (Hein, 2004, p. 424). It is important to note "a content-based exhibit need not have a content-based form" (Hennes, 2002, p. 114) and can utilize observation, experimentation, problem solving, pattern recognition. Hennes (2002) suggests "museums can offer experiences in which visitors participate in the formation of purposes driven by their own curiosity and interest" in order to create knowledge, rather than simply transfer it (p. 120). It is critical to "fashion engaging problems out of visitors' own experience, through which visitors are motivated to draw upon the material resources of the exhibit in a desire for resolution" (Hennes, 2002, p. 116).

Cognition "interprets and makes sense of the world"; affect and cognition work together to help humans process information. (Norman, 2002, p. 38)

Van Moer et al. (2008) note "the challenge for museums is to find ways to formulate exhibitions that start from genuine experiences and lead to inquiry" (p. 50). Exhibition designers should "provide a cognitive map but not…predetermine the route" (Lake-Hammond & Waite, 2010, p. 80). In fact, "exhibits built around problematic situations may provide impetus for visitors to explore content in a way that is most meaningful to them because they take an active role in determining the purpose and the nature of the activity" (Hennes, 2002, p. 117). Not all learners require the same cognitive experience, however; Renninger (2009) describes two phases of interest as it applies to learning:

cognition (continued)

> In earlier phases of interest development, learners may be most likely to benefit from external supports (e.g., group work, meaningful content) that trigger and help to sustain their interests… In later phases of interest development, learners already have questions about the content and understand that work with the discipline involves open questions that will lead them to challenge their ideas. (p. 112)

Cognition and other factors. Cognition is related to the Affect, Experiential Learning, and Usability factor groups. According to Norman (2004) "emotion and cognition are thoroughly intertwined" (p. 8), since "cognition interprets and understands the world, while emotions allow you to make quick decisions" (p. 11). Renninger (2009) describes interest as "both a cognitive and affective motivational variable" (p. 106). A cognitive experience requires thought and "may offer a learning experience" (Forlizzi & Ford, 2000, p. 421). Recognizing and designing cognitive tools such as "natural mappings…limiting available controls, [and] standardizing for consistency" help users apprehend, which affects usability (Allen, 2004, p. S21).

The difference between the activity of the beginning and that of the end is a kind of transformational growth that affects experience in the future.

(Hennes, 2002, pp. 118-119)

context

Although not always mentioned explicitly as an influential factor, many references imply that the context of a learning experience or interaction is critical to understanding its influences or outcome. This study includes explicit references to *context, contexts*, and *context of use* as individual factors in the Context factor group and also discusses indirect references to context.

Context and humans. Dewey's notion of experience "has a beginning and an end, and changes the user, and sometimes, the context of the experience as a result" (Forlizzi & Ford, 2000, p. 420). Forlizzi and Ford (2000) note "user-product interactions take place in a context of use, shaped by social, cultural, and organizational behavior patterns" (Ibid). Social contexts are important too, because experiences and "artifacts do not exists outside of social relationships" (Damazio et al., 2009, p. 2733).

Context influences experience evaluation, which is especially dependent on whether the experience is goal (or task) oriented. Hazzenzahl and Ullrich (2007) identify two ways of evaluating experience: experiential (in the moment) and retrospective (after the fact) (p. 431). Experiential measures in the study include mental effort, affect, and spontaneity; retrospective measures are evaluation (judged as positive or negative) and knowledge acquisition (Hassenzahl & Ullrich, 2007, p. 433). Hazzenzahl and Ullrich (2007) also identify two modes of experience: goal mode, where all activity is determined by pursuit of a goal, resulting in more mental effort and learning; and a more spontaneous action mode, where activity determines goals "on the fly" (p. 432). Results in this study show a "higher level of effort and better knowledge acquisition in the goal condition" (Hassenzahl & Ullrich, 2007, p. 433). Interestingly, spontaneity results in positive affect for no-goal interactions, but negative affect for goal mode (Hassenzahl & Ullrich, 2007, p. 436). In other words, a task (goal mode) makes users evaluate experience based on task fulfillment; in this case spontaneity becomes associated with more effort and negative affect. An absence of tasks (action mode) makes users evaluate a product (or experience) separately from learning or mental effort; in this case spontaneity is seen as positive (Hassenzahl & Ullrich, 2007, p. 435).

Context and design. Forlizzi and Ford (2000) discuss context in terms of shifts in the framework of use as important (p. 422). These include:

- Cognitive to subconscious shifts (learned experiences become automatic)
- Subconscious to cognitive (problem encountered; "can also signal that user is creating new knowledge, and that learning is taking place")
- Narrative to cognitive (re-examine established beliefs or processes)
- Subconscious/narrative to cognitive ("move user from the state of experience to having an experience…resulting in learning")
- Subconscious to storytelling (communicate experience)
- Narrative to storytelling (a formal process becomes personal through communication)

Hornecker et al. (2007) suggest museum protocol and organization, such as the implied idea of whether touch is acceptable, affects participant notion of "appropriate behaviors" (p. 340). In order to make museum experiences more accessible, Hein (2004) discusses "taking the museum to the community and the community to the museum" (p. 423). Museums should "formulate exhibitions that lead to inquiry and that guide visitors to apply the results of such inquiry to life situations" (Hein, 2004, p. 424). However, "the ability to relate the immediate outcomes of museum experiences back to life…remains a challenge" (Hein, 2004, p. 424). In terms of message context, museums have "become increasingly open to diverse interpretations of knowledge and more involved in sharing these with a variety of public audiences" (Lake-Hammond & Waite, 2010, p. 81).

Context influences all experiences.

Context and other factors. This study notes that context influences all experiences, and therefore is related to all factors, but is of particular concern to creating learning experiences. According to Hein (2004), "all structured, specialized learning environments, whether formal (schools) or informal (museums), need to test their activities constantly against a criterion of their relation for the world outside the specialized setting" (p. 423). Museums "require integrated settings that foster discussion, challenge the learner, make connections to issues of interest to the learner, and provide guidance for application in the world outside the museum" (Ibid, p. 424).

engagement

O'Brien and Toms (2010) note that engagement is a loosely-defined concept, which is problematic because "without a consistent definition of engagement, it is difficult to ascertain that the systems we design and market are, in fact, engaging, or to identify what aspects of the interaction with technology engage or fail to engage users" (p. 50). They define engagement as being comprised of six interrelated factors that culminate in a user's sense of endurability: "Endurability was predicted by the other five factors…Aesthetics predicted Perceived Usability, Focused Attention, and Felt Involvement; Novelty predicted Focused Attention and Felt Involvement" (Ibid, p. 62). This study includes the following individual factors in the Engagement factor group: *active prolonged engagement, engagement, endurability, felt involvement, flow*, and *playfulness* and discusses O'Brien and Toms' other factors as they relate to the affect, cognition, and usability factor groups (Leaper, 2011, Appendix A).

Engagement and humans. In order to identify six factors "that encompass the complex interaction between people and technology" which results in engagement, ten subscales of engagement were explored and refined (O'Brien & Toms, 2010, p. 65). The resulting factors of engagement are defined as: Focused Attention, Perceived Usability, Aesthetics, Endurability, Novelty, and Felt Involvement (Ibid, p. 62). Allen (2004) discusses Csikszentmihalyi's idea that ideal learning in a museum is "driven by curiosity and interest then sustained by a flow state" (p. S23). Flow can be defined as being "fully involved with mind and body in an intrinsically motivated activity" (Allen, 2004, p. S23). Allen (2004) also discusses "Active Prolonged Engagement (APE)," which includes access to phenomena along with opportunities for deeper cognitive experiences (p. S25). APE results in longer engagement times, elicits "driving questions" and includes physical interactions that vary in pattern and sequence (Allen, 2004, p. S25).

Engagement and design. A key to creating flow is matching challenge to skills, along with well-defined goals and rules (Allen, 2004, p. S23). According to Hennes (2002) "constructing activity with continuity of experience in mind demands that we find a way to provide visitors with a means of constructing the present experience out of what is already meaningful and important to them" (p. 113). This can be problematic in a museum environment since, "despite an expressed endorsement of visitor-focused experiences, exhibits in these institutions are largely shaped by pre-defined content rather than by experience itself" (Hennes, 2002, p. 110). This is unproductive because "information-based exhibits often create reactions without personal engagement and develop experiences not meaningful enough to capture visitors' attention and open up to further growth" (Van Moer et al., 2008, p. 44).

The more engaged the participant, the more real learning occurs.

Engagement and other factors. Engagement is related to the Affect, Cognition, and Self Concepts factor groups. According to O'Brien and Toms (2010) traditional ways of capturing data related to engagement "do not address the users' cognitive or emotional state, both of which are critical to engagement" (p. 52). For learning, "the most important thing is that tools should be developed to stimulate, improve, deepen and smooth the progress of visitors' engagement in the inquiry cycle" (Van Moer et al., 2008, p. 50). The more engaged the participant, the more real learning occurs; knowledge transmission is not the same as being engaged, because "visitors' attention is not transformed into interest" when "transmission of (factual) knowledge is achieved but understanding or engagement of thinking did not happen" (Van Moer et al., 2008, p. 46). Engagement is linked to self concepts because continuity of experience can result in engagement, therefore "constructing activity with continuity of experience in mind demands that we find a way to provide visitors with a means of constructing the present experience out of what is already meaningful and important to them" (Hennes, 2002, p. 113).

experiential learning

Experiential learning is the idea that humans create meaning from lived experience. Van Moer et al. suggest "visiting art museums is mainly about viewers making meaning of their experiences through interactions with artefacts [sic]" and note that "phrases such as 'visitor-focused' and 'openended' experiences, 'process of making meaning' and 'experience as a basis for meaningmaking' have roots in constructivist theory, hermeneutic philosophy and social semiotics" (p. 44). This study includes the following individual factors in the Experiential Learning factor group: *continuity of experience, diversity of learning modes, integrated learning theory, learning environments, learning styles, patterns of inquiry*, and *problematic experience*.

Experiential learning and humans. According to Hennes (2002), "an educative experience is valuable to the extent that it prepares one for broader, richer experiences in the future; it expands possibility"; in fact, "growth itself is both the means and the end" (p. 112). Museums have a mission to offer learning experiences; Hennes (2002) suggests rather than attempting to "impose their own priorities onto visitors, museums can harvest visitors' priorities and offer ways of expanding them into richer purposes and interests" (p. 112). Exploration, physical manipulation, and experimentation help museum visitors learn (Allen, 2004, p. S19). Learning experiences are participatory rather than passive; Hornecker et al. (2007) suggest co-creation of ideas can lead to learning (p. 336). An inquiry cycle can be driven by curiosity (Allen, 2004, p. S20) and sustained by engagement. It is interesting to note that comfort (both psychological and physical) is also a key factor for learning experiences (Allen, 2004, p. S24).

Kolb's Experiential Learning Theory (ELT) suggests learning happens through a process of grasping concrete experiences and abstract concepts and transforming them through active experimentation or reflective observation (Kolb et al., 2001, p. 228). Human preferences for recognizing and integrating information are known as learning styles, which ELT categorizes as diverging, assimilating, converging, or accommodating (Kolb et al., 2001, pp. 229-231). Recently ELT has intersected with integrated learning theory, which conceives learning as a "spiral" of experiencing, reflecting, thinking, and acting in active response to a learning situation (Kolb et al., 2001, p. 240). The degree to which learners apply styles holistically is known as adaptive learning; sophisticated learners apply learning styles in all four areas in an "adaptively flexible" way (Kolb et al., 2001, p. 244).

It is especially notable that problematic experiences may lead to inquiry, and "disequilibrium" can be used as a driver for learning (Allen, 2004, p. S18). In fact, "experiences felt as obstacles for interpretation are extremely suitable to stimulate, deepen and improve visitors' engagement in the inquiry cycle" (Van Moer et al., 2008, p. 43).

Experiential learning and design. Because "visitors vary in their preferences, styles and motivations for learning," multimodal approaches, including multisensory experiences, can be used to apply universal design principles in order to create universally effective learning (Allen, 2004, p. S28). ELT, especially as it applies to adaptive learning, is of particular interest for interactive environments, which are inherently self-directed and can potentially serve a variety of learning styles simultaneously (Kolb et al., 2001). This is easier said than done; "institutions continue to have a difficult time persuading visitors to "learn" while they're having their experiences" (Hennes, 2002, p. 110).

Problematic experiences which initiate resolution of cognitive conflict can encourage learning

Designers can harness problematic experiences which initiate resolution of cognitive conflict in order to encourage learning; Van Moer et al. (2008) describe Gooding-Brown's "disruptive model" based on problematic experience where multiple (and even conflicting) viewpoints are presented (p. 49). This suggests the participants create their own meaning through a resolution of conflicting opinions: "the basis for the disruptive model is found in the dilemma of authoritative interpretation and multiple voices' interpretation" (Ibid).

Experiential learning and other factors. Experiential learning is obviously connected with the Cognition and Interactivity factor groups, but also with the Engagement factor group. The "learning process is one of the key elements of engagement" because humans want to become "better" at interactions (Polaine, 2005, p. 154).

interactivity

According to Polaine (2005) "true interactivity is a feedback loop of action-reaction-interaction and involves collaboration or exchange" (p. 151). This study includes the following individual factors in the Interactivity factor group: *access point, entry point, honeypot effect, interactivity, physical interactivity, avoiding gratuitous interactivity, shareability*, and *spontaneity.*

Interactivity and humans. Sources identified by Birchfield et al. (2008) found "interactive media [and] active participation by visitors has been shown to increase audience attendance and appreciation in museum exhibits" (p. 965). This includes museums, since "exhibits are environments in which complex interactions occur among visitors, objects, environment, and meaning" (Hennes, 2002, p. 109).

Interactivity has a social component as well; shareability can be defined as "the extent that a system, interface, or device engages a group of collocated people in shared interactions around the same content (or object)" (Hornecker et al., 2007, p. 329). Fluidity of sharing affects "how easily people engaged in shared interactions" (Ibid, p. 336). Sharable interfaces mean "all group members can point to and manipulate shared content while simultaneously viewing the interactions and having a shared point of reference" (Hornecker et al., 2007, p. 329).

Interactivity and design. According to Lake-Hammond and Waite (2010), "interaction design is particularly significant to exhibition design in the way that it integrates visual communication and the design of material objects" (p. 88). Polaine (2005) notes that "the key to creating engaging interactivity is setting up the correct rules for a playful flow experience" (p. 153). Both "hands-on" and "minds-on" interactivity is important (Allen, 2004, p. S25). Familiar activities can be used as schemas: making a complex machine work, a competition, and watching and waiting, which is a surprisingly social activity (Allen, 2004, p. S22). Some interaction is key, but "exhibits may have an optimal degree of interactivity" (Allen, 2004, p. S25).

Entry and access are important aspects of interaction, because "offering a diversity of entry points enables different levels of engagement, allowing for gradual adoption and appropriation of a system" (Hornecker et al., 2007, p. 332). Shared interactions cause a visual draw to access points, creating a "honeypot effect" that encourages use (Ibid). According to Hornecker et al. (2007), "entry points invite people and entice them to interact with the system or product" (p. 331) and entry points differ by:

- intrusiveness (attention-drawing)
- richness (amount of information and memory triggers)
- visibility (how perceptible)
- freshness (newness/last use)

Designers should note that "the number and location of access points are important, as too is simultaneous access, which can distribute control in a group" (Hornecker et al., 2007, p. 334). In terms of information experiences, Hennes (2002) suggests creating "entry points into a body of intellectual content" (p. 113), such as:

- analogies (using everyday examples)
- breaking a subject into units that reference participants' prior experience

Interactivity and other factors. Interactivity is related to the Engagement, Experiential Learning, and Narrative factor groups. Polaine (2005) discusses the immersive quality of interactivity as being similar to conventional narratives:

> Conventional narratives attempt to mask the structure of the story (plot, characterisation, dramatic turning points) by using that very structure to create emotional hooks on which to hang our disbelief. When the structure starts to crumble we become aware of the printed page or the fact that we are in the cinema and we start to withdraw from the world of the story. This is often because the fine-tuning has gone astray; perhaps a typographic error, an unconvincing visual effect or an infeasible coincidence. When we find an interactive [element or] interface confusing and frustrating (and it is not deliberate) we have a similar experience; we are jettisoned back into real-world emotions and removed from those that we were experiencing in the represented world. (p. 153)

Social aspects of interactions are important to learning because "exhibitions that allow for multiple simultaneous users facilitate family learning" (Allen, 2004, p. S26). Birchfield et al. (2008) note that "constructivist learning [emphasizes] play and exploration in self-guided learning" situations (p. 966). Hands-on learning creates "an increase in motivation and engagement" with "younger visitors more willing to interact" (Ibid, p. 968).

narrative

In terms of exhibition design, narrative can be defined as a structure that "allows the audience to make sense of the objects on display, in relation to one another and their surrounding contexts" (Lake-Hammond & Waite, 2010, p. 91). This study includes the following individual factors in the narrative factor group: *narrative(s), storytelling*, and *subjective experience*.

Narrative and humans. Narratives are the stories that create meaning from experiences. Forlizzi and Ford (2000) discuss Roger Shank's idea of experience as story, explaining "stories are the vehicles that we use to condense and remember experiences, and to communicate them" (p. 420). Forlizzi and Ford (2000) "use the word narrative to represent experiences that have been formalized in the user's head…or in the world" such as product features and storytelling to define "the subjective aspects of experience," including context of use and subjective qualities such as emotion, to create "a unique and subjective story" (p. 422). According to Lake-Hammond and Waite (2010):

> A strong narrative enables the visitor to discover the exhibition's complete meaning, rather than viewing it as a series of separate entities. Narrative structure does not need to be explicit or complex. In fact, a subtle narrative tends to be more successful, allowing audiences access to the exhibition message without distracting them with excess information. (p. 92)

Narratives are the stories that create meaning from experience.

Narrative and design. "Personal storytelling" can be an effective learning tool, but needs to be better understood in order to "harness narrative in the service of helping visitors understand exhibits" (Allen, 2004, p. S29). Since "a coherent exhibition narrative [can] provide the audience with the necessary structure to formulate meaning," it is important to consider narrative from a participant perspective (Lake-Hammond & Waite, 2010, p. 91):

> The audience then is an active participant in the exhibition narrative. The design does not directly tell the audience a story, but implies that one exists, encouraging each individual visitor to interpret the exhibition concept and develop their own understandings. It is important that the designer recognizes that no two visitors will engage in the narrative in the same way. (Ibid, p. 92)

Narrative and other factors. Narrative is related to the Affect and Context factor groups. Forlizzi and Ford (2000) use storytelling to define "the subjective aspects of experience," including context of use and subjective qualities such as emotion, to create "a unique and subjective story" (p. 422).

self concepts

Self concepts address individual factors concerned with identity and self. The study includes the following individual factors in the Self Concepts factor group: co-authorship, externalization, identity and self-dependence.

Self concepts and humans. Designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions…both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences" (Renninger, 2009, p. 106). Damazio et al. (2009) discuss product experiences as co-authored, which creates a sense of self-ownership, since "to appreciate an object is a way of participating in its creation" (p. 2729). According to Jordan (2010):

> A design has the ability to take me back to a place, time, or experience to which I would like to return; it can allow me to be part of a community and can help define me in relation to others in a group; and it can even help me signify who I want to become. (p. 11)

Identifying closely with an experience can create an affinity, which is tied into a sense of self:

> Affinities based on self-image...may be nostalgic (past tense) and relate to who we thought we were or a fondness we have for past experiences. It can also be definitive (present tense) and help us communicate who we are and to which community we belong. And affinity may even be aspirational (future tense) and allow us to project who we want to be and our ideals for our future. (Jordan, 2010, p. 8)

Self concepts and design. Understanding participants and their ideas of self is critical, because "information about interest and identity development could usefully inform the design of tasks, exhibits, and activities; instructional conversations; and expectations for learner participation and achievement" (Renninger, 2009, p. 105). Shared authorship, co-authorship and "design in partnership" can be explained as "designing 'with' as opposed to 'for' people," and includes "collaboration between designers and future users" (Damazio et al., 2009, p. 2729). This participatory and inclusive approach is important for museums because "museums should grow out of life experiences and be used to reflect back on life" (Hein, 2004, p. 420). In order to create personal meaning, "museum experiences, even active ones, still need to be associated with richer, authentic life experiences" (Hein, 2004, p. 423). This implies an important and relatively newly-acknowledged significance for design:

> "bridging the gap between growing expert knowledge and satisfying an increasing desire for democratic participation in its dissemination can be seen as an important cultural role for design" (Lake-Hammond & Waite, 2010, p. 88).

Designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions... both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences".

(Renninger, 2009, p. 106)

Self concepts and other factors. Self concepts are related to the Affect factor group because affinity is comprised of an emotional response to beauty and identity, and "identity may be best explored in terms of the self image" (Jordan, 2010, p. 6). The amount of effort and self-investment in an experience can determine affective response, since "the effort exerted in the acquisition of an object is one of the aspects responsible for the feeling of independence that can be generated by the relationship of people with their objects" (Damazio et al., 2009, p. 2730).

usability

Usability can be described as the practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38). Usability derives from userfriendly, but "no precise definition of usability exists" (Alonso-Ríos et al., 2010, p. 53); many researchers rely on international standards (ISO) definitions (Ibid, p. 54). This study includes the following individual factors in the usability factor group: usability, *perceived ease of use, perceived usability*, and *perceived usefulness*.

Usability and humans. User-centered design can be described as an approach that promotes "the creation of objects that, by virtue of their physical forms and location invite certain kinds of use and not others," including the notion of "affordances" or interactions where intended use is natural and apparent (Allen, 2004, p. S21). Alonso-Ríos et al. (2010) found six areas that pertain to usability: knowability, operability, efficiency, robustness, safety, and subjective satisfaction (p. 60).

Usability and design. According to Forlizzi and Ford (2000), "a successful design will take into consideration all the components in the user-product interaction: user, product, and context of use" (p. 423). It's not enough to simply acknowledge the importance of usability; a more concrete and systematic approach is necessary because "designers need to demystify how we design for user experience and how the products we design achieve specific user experience goals" (Forlizzi & Ford, 2000, p. 419). According to Norman (2002), "human-centered design practices are most essential for tasks or situations that are stressful" since people can tolerate less-user friendly interactions in pleasant situations (p. 40). Usability is critical to museum experiences because a decline in interest and involvement known as museum fatigue can set in after about 30 minutes (Allen, 2004, p. S20).

Usability and other factors. Usability is related to the Cognition, Affect, and Context factor groups. Apprehension and usability "reduce the ever-present cognitive load on visitors, freeing them to focus on those aspects of the environment that are rewarding to them and worthy of their attention" (Allen, 2004, p. S24). O'Brien and Toms suggest "aesthetic judgments are not based solely on users' first impressions; the perceived usability of a system is intertwined with its visual presentation" (O'Brien & Toms, 2010, p. 63). According to Zhang and Li (2005), "IT designers or IT acquirers should pay attention not only to usefulness (IT suitability for tasks or jobs), and ease of use (the longtime goal of the human computer interaction field), but also to affective quality (the degree to which emotional reactions are evoked)" (p. 108). Context is a hugely important factor to determine what "usability" means in a given situation, hence "usability depends on context of use" (Alonso-Ríos et al., 2010, p. 60).

"Designers need to demystify how we design for user experience and how the products we design achieve specific user experience goals".

(Forlizzi & Ford, 2000, p. 419)

definitions

Active learning. Learning in a self-guided and problem-solving context, as opposed to learning through passive "tutorial-like, prompted interaction" (Van Nimwegen, Van Oostendorp, Burgos, & Koper, 2006, p. 786). Research suggests it's possible that "the more difficult condition perhaps instigates a deeper level of cognitive processing which eventually results in more effective learning" (Ibid).

Active prolonged engagement. Defined by Allen (2004) as creating both "minds-on" and "hands-on" experiences, especially those that combine "access to phenomena with opportunities for deeper cognitive experiences" (p, S25).

Affect. A "neutral" term describing "the concepts of affect, emotion, feelings, mood, motivation, and qualia" (Norman, 2002, p. 38). The "affective system is judgmental, assigning positive and negative valence to the environment rapidly and efficiently"; affect and cognition work together to help humans process information (Ibid).

Cognition. Defined by Norman (2002) as a neurological response that "interprets and makes sense of the world"; affect and cognition work together to help humans process information (p. 38).

Cognitive experience. The stream of incoming information perceived by humans during consciousness, according to Richard Carlson's (1997b) theory of experienced cognition. Also defined as interactions which "require us to think about what we are doing [and] require attention, cognitive effort, or problem-solving skills [sic]" (Forlizzi & Ford, 2000, p. 421).

Communication design. A holistic design approach which recognizes that designed information inherently exists inside of an experience; designers don't create artifacts but rather events (Frascara, 2004, p. 13).

Contemporary learning theories. Theories modeled on "contemporary research in the learning sciences [emphasizing] the importance of active learning, collaborative learning, and constructionist learning" (Birchfield et al., 2008, p. 965).

Context. For the purposes of the study, defined as influences surrounding and shaping experiences; Forlizzi and Ford (2000) note "user-product interactions take place in a context of use, shaped by social, cultural, and organizational behavior patterns" (p. 420).

Engagement. Can be described as prolonged interaction created by elements of "Focused Attention, Perceived Usability, Aesthetics, Endurability, Novelty, and Felt Involvement" (O'Brien & Toms, 2010, p. 62). Can include a flow state, which can be defined as being "fully involved with mind and body in an intrinsically motivated activity" (Allen, 2004, p. S23).

Experience. "A stream of valuable and not so valuable moments with a definite beginning…and ending" (Hassenzahl & Ullrich, 2007, p. 429). Defined by Dewey(1938) as "a transaction taking place between an individual and what, at the time, constitutes his environment" (p. 43); the environment is "whatever conditions interaction with personal needs, desires, purposes and capacities to create the experience" (p. 44).

Experience design. Creating interactive situations for humans (Forlizzi & Ford, 2000, p. 420); a broad term for design concerned with the "holistic user experience," with aspects that include information architecture, usability engineering, visual design, and interaction design (Morville & Rosenfeld, 2006, p. 10).

Experiential learning theory. An educational model based on the idea that humans create meaning from experience. Kolb created a formal Experiential Learning Theory (ELT) in 1984 based on the work of John Dewey, Kurt Lewin, and Jean Piaget (Kolb et al., 2001, p. 228).

Educational psychology. Applying psychological understanding to improve educational experiences; Entwistle et al. (2001) note that "educational research from a psychological perspective is generally directed towards a deeper understanding of teaching and learning processes in everyday contexts, with the ultimate intention of improving the quality and effectiveness of education" (pp. 103-104).

Human-centered design. "A multidisciplinary activity, which incorporates human factors and ergonomics knowledge and techniques with the objective of enhancing effectiveness and efficiency, improving human working conditions, and counteracting possible adverse effects of use on human health, safety and performance" ("UsabilityNet: Methods: ISO 13407," n.d.).

Human factors. The broad field of study concerning the cognitive, social and physical aspects of human systems and services, including ergonomics ("Human Factors and Ergonomics Society: Educational resources," n.d.).

Informal learning. Short-term, voluntary learning

definitions (continued)

which occurs outside of a formal curriculum; it can be self-directed, incidental, or socialized (Schugurensky, 2000).

Information architecture. "The structure and design of shared information environments," such as information products and experiences, that support the human-centered attributes of usability and findability (Morville & Rosenfeld, 2006, p. 4).

Interaction design. Creating interfaces for the "behavior of tasks and processes" humans encounter in an information system (Morville & Rosenfeld, 2006, p. 10).

Interactive environment. For the purposes of the study, defined as an environment that accepts and responds to input from humans ("Interactivity - Wikipedia, the free encyclopedia," n.d.).

Interactivity. "A feedback loop of action-reaction-interaction [which] involves collaboration or exchange" (Polaine, 2005, p. 151).

Narrative. In terms of exhibition design, a structure which "allows the audience to make sense of the objects on display, in relation to one another and their surrounding contexts" (Lake-Hammond & Waite, 2010, p. 91).

Shareability. A "design principle that refers to how a system, inter-face, or device engages a group of collocated, co-present users in shared inter-actions around the same content (or the same object) [sic]" (Hornecker, Marshall, & Rogers, 2007, p. 328).

Self concepts. For the purposes of the study, defined as influences on experience concerned with identity and self; designed experiences are inherently tied to the self, since "identity, like interest, develops through interactions…both interest and identity develop in relation to available experiences and to how learners perceive, understand, and represent these experiences" (Renninger, 2009, p. 106).

Social actor. "An organizational entity whose interactions are simultaneously enabled and constrained by the socio-technical affiliations and environments of the firm, its members, and its industry" (Lamb & Kling, 2003, p. 218).

Usability design. The practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38). Usability derives from userfriendly, but "no precise definition of usability exists" (Alonso-Ríos, Vázquez-García, Mosqueira-Rey, & Moret-Bonillo, 2010, p. 53); many researchers rely on international standards (ISO) definitions (Ibid, p. 54).

User-centered design. An approach that promotes "the creation of objects that, by virtue of their physical forms and location invite certain kinds of use and not others," including the notion of "affordances" or interactions where intended use is natural and apparent (Allen, 2004, p. S21).

White paper. An "authoritative" and "informative" publication which "argue[s] a specific position or propose[s] a solution to a problem" and often addresses an audience outside the originating organization (Sakamuro & Stolley, 2010).

subject overview

Human interactions with information. Human consciousness can be defined as "an organizing principle of information processing by individuals acting in environments" (Carlson, 1997a, p. 126). The great influx of information with which humans interact on a daily basis requires human-centered approaches to information experiences (Wurman, Leifer, Sume, & Whitehouse, 2001). In order to engage with information in a meaningful way, formal and informal learning experiences must be designed using experiential, human-centered approaches (Dewey, 1938). This approach is examined in an area of inquiry known as experience design, which can be described as creating interactive situations for humans (Forlizzi & Ford, 2000, p. 420), and is also a broad term for design concerned with the "holistic user experience" with aspects that include information architecture, usability engineering, visual design, and interaction design (Morville & Rosenfeld, 2006, p. 10). Experience design exists as part of human-centered design, which can be defined as recognizing human needs in order to "[enhance] effectiveness and efficiency" ("UsabilityNet: Methods: ISO 13407," n.d.) of an information experience. An important aspect of human-centered experience design is usability design, which can be defined as the practice of designing for ease of use, a field rooted in "cognitive sciences—a combination of psychology, computer science, human factors, and engineering" (Norman, 2002, p. 38).

Ideal learning experiences are a "spiral" of cognitive responses including "experiencing, reflecting, thinking, and acting".

(Kolb, Boyatzis, & Mainemelis, 2001, p. 240)

Human interactions with information are viewed as both cognitive and emotional experiences; for example, learning and recall are affected by emotions that are present when cognition occurs (Carlson, 1997a, p. 123), and "the arousal accompanying emotion has an informational aspect, constituting part of the information manifold in which experienced cognition occurs" (Carlson, 1997a, p. 113). Kolb et al. define ideal learning experiences as a "spiral" of cognitive responses including "experiencing, reflecting, thinking, and acting" (Kolb, Boyatzis, & Mainemelis, 2001, p. 240). Forlizzi and Ford (2000) define cognitive experiences as interactions which "require us to think about what we are doing…[and] require attention, cognitive effort, or problem-solving skills [sic]" (p. 421).

"There is an intimate and necessary relation between the processes of actual experience and education". (Dewey, 1938, p. 20)

Dewey (1938) proposed that "all human experience is ultimately social...it involves contact and communication" (p. 38). Human interactions with information are also social experiences; for example, humans consistently apply social rules (politeness, perceptions of gender) when interacting with computers (Lamb & Kling, 2003; Nass, Steuer, & Tauber, 1994). Lamb and Kling (2003) note that humans make choices about information communication technologies based on social aspects of their environment. Information experiences, like product experiences, exist in "a context of use, shaped by social, cultural and organizational behavior patterns" (Forlizzi & Ford, 2000, p. 420).

Experiential and informal learning. Experiential learning theory is an educational model based on the idea that humans create meaning from experience. Dewey's (1938) foundational work in this area suggests "there is an intimate and necessary relation between the processes of actual experience and education" (p. 20). Kolb created a formal Experiential Learning Theory (ELT) in 1984 based on the work of John Dewey, Kurt Lewin, and Jean Piaget (Kolb et al., 2001, p. 228). Both cognition and affect (emotion) influence ways humans process information (Norman, 2002, p. 38) and cognitive styles influence learning experiences (Kolb et al., 2001), including informal learning experiences. Informal learning can be defined as short-term, voluntary learning which occurs outside of a formal curriculum (such as classes, self-directed research, museums and galleries, etc.); this type of learning can be self-directed, incidental, or socialized (Schugurensky, 2000).

Interactive learning environments. Researchers exploring contemporary learning in museums suggest that informal learning is enhanced when humans partic-

subject overview (continued)

ipate in interactive experiences (Allen, 2004; Birchfield, Mechtley, Hatton, & Thornburg, 2008). Birchfield et al. (2008) note, "contemporary research in the learning sciences emphasizes the importance of active learning, collaborative learning, and constructionist learning" (2008, p. 965). Allen (2004) defines active prolonged engagement as creating both "minds-on" and "hands-on" experiences, especially those that combine "access to phenomena with opportunities for deeper cognitive experiences" (p. S25). Allen's (2004) work suggests "exhibits may have an optimal degree of interactivity, and that formative evaluation is essential for ensuring that the interactive features work together harmoniously" (Ibid).

Informal and experiential learning, in an interactive environment such as a museum, has the potential to be mutually beneficial for both the participant (the learner) and the experience provider (the museum); for example, participants often develop an affinity for or emotional engagement with the provider of a positive experience (Damazio, Dal Bianco, Lima, & Menezes, 2009). Van Moer et al. (2008) note, "information-based exhibits often create reactions without personal engagement and develop experiences not meaningful enough to capture visitors' attention and open up to further growth" (p. 44). Continued exploration results when human impulses and desires are recognized as motivating factors in an educational experience (Dewey, 1938).

Informal learning is enhanced when humans participate in interactive experiences.

(Allen, 2004; Birchfield et al. 2008)

research methods

RESEARCH PARAMETERS

The framing of this topic requires development of an intersection between the fields of human-center design (which encompasses information design (Morville & Rosenfeld, 2006; Wurman et al., 2001), human-computer interaction (Lamb & Kling, 2003; Nass et al., 1994), design psychology (Norman, 2004) and educational psychology (Dewey, 1938; Kolb et al., 2001), and museum studies (Hein, 2004; Hennes, 2002). The study is designed as a literature review, which enables the researcher to link pertinent information from these areas into a cohesive body of knowledge in order to "build bridges to related topic areas" (Cooper, 1998, p. 3).

RESEARCH QUESTIONS

Primary research question. According to selected literature, what cognitive and emotional factors should museum educators, exhibit designers, information designers, and interaction designers consider when designing informal learning experiences in interactive learning environments?

Secondary research questions.

- How do participants interact with information in a self-directed interactive environment like a museum setting?
- What outcomes define a positive informal learning experience in a self-directed interactive environment like a museum setting?
- How do selected current theories describe cognitive responses during informal learning experiences, especially in interactive environments?
- How do selected current theories describe emotional responses during informal learning experiences, especially in interactive environments?

RESEARCH DELIMITATIONS

Topic. The study identifies cognitive and emotional factors influencing informal learning experiences in interactive environments, as present in current scholarly literature, in order to provide an overview of an interdisciplinary topic. The intent is to synthesize current research (Cooper, 1998, p. 2) from four distinct areas (educational and design psychology, information design, human-computer interaction, and museum studies) and present it in a form applicable to both scholars and design practitioners in these areas. Individually, these subject areas explain aspects of a user's learning experience, but collectively current research provides a more complex and interdisciplinary overview of that experience.

The study centers on experience design and experiential learning theory, operating on the assumption that individualized, human-centered design will provide optimal outcomes for participants engaging in informal learning experiences. Experiential learning theory recognizes that the individual is an integral part of learning "situations" comprised of interactions and continuity (Dewey, 1938) and places a particular emphasis on individual needs and interactions (Kolb et al., 2001). Although there are numerous historical design theories and approaches that may provide positive human outcomes, this researcher believes a contemporary, human-aware design approach should recognize ways differing design theories serve the user, and apply sophisticated solutions balancing human needs with other concerns.

Focus. Focus of the study is on cognitive (Carlson, 1997b) and emotional (Damazio et al., 2009) factors which influence informal learning in interactive information environments, such as museums (Hennes, 2002) and not ergonomic or physical accessibility factors. Human factors research includes many human-related concerns in the designed world ("Human Factors and Ergonomics Society: Educational resources," n.d.), but this study focuses on information and learning psychology rather than physical engineering aspects of interactive learning environments. Although cognitive and emotional factors may influence physical design, this study identifies influential factors rather than suggesting physical applications. The study focuses on adult factors rather than those specific to children, early education, or higher education. In order to extract factors, references addressing concepts and theories are preferred to those describing product studies or licensed approaches.

Type of sources. Literature is limited to scholarly (including peer reviewed) literature addressing the cognitive and emotional aspects of information design practices applicable to informal, interactive learning environments. Peer-reviewed journal articles and references whose content addresses multiple keywords are preferred, and peer-reviewed association publications like ACM's *interactions* magazine (Jordan, 2010) are also included. Recent non-academic publications by respected scholars, such as Donald Norman's *Emotional Design* (2004), are included, along with respected publishers such as O'Reilly (Morville & Rosenfeld, 2006)

research methods (continued)

and Rosenfeld (Young, 2008), to provide definitions and context.

Type of research design. The research study is approached from a constructivist philosophical worldview (Creswell, 2009, p. 8). The researcher has a communication design and fine art background, so a qualitative research design is desirable and literature employing qualitative strategies of inquiry, including those describing experiences (phenomenology) and explaining or seeking to understand (ethnography) are emphasized in the study (Creswell, 2009, p. 13). The study is designed as research synthesis (Cooper, 1998, p. 3) and presented as an integrative literature review (Ibid, p. 2).

DATA ANALYSIS PLAN OVERVIEW

Data collection process. Creswell (2009) identifies qualitative research as an iterative process of reflection, questioning, and writing; he notes, "qualitative data analysis is conducted concurrently with gathering data, making interpretations, and writing reports" (p. 184). An initial group of references addressing the research question and sub-questions are collected, but the analysis and interpretation portion of the research process informs these questions and they evolve during the research process, leading to further data collection.

Data coding and analysis procedure. High-quality, relevant references are coded by topic using content analysis procedures (Busha & Harter, 1980). The goal is to "quantify and analyze the presence, meanings and relationships of…words and concepts [within a text], then make inferences about the messages within the texts, the writer(s), the audience, and even the culture and time of which these are a part" (Busch et al., 2005).

SIGNIFICANCE

Academic significance. According to Creswell (2009), literature reviews are inherently significant if they "add to the pool of research knowledge" (p. 24). This study contributes knowledge by synthesizing current research from multiple disciplines (educational and design psychology, information design, human-computer interaction, and museum studies) and identifying overlaps.

Practical significance. Human interactions with information are growing and becoming more complex (Wurman et al., 2001). Information should be designed from a human-centered perspective (Norman, 2002, p. 40) in order to provide learning experiences that encourage ongoing exploration (Hein, 2004). Studies show human creativity and learning is enhanced during positive emotional states (Norman, 2004, p. 19). Although the amount of research in the area of design and emotion has increased in the last decade, design theory and practice have not fully capitalized on the advances from the last 25 years regarding the biology and neurology of emotion (Love, 2009). In order to create these experiences, designers must have access to the findings of current scholarly research in a form that allows them to apply current knowledge to their practice (Kolko, 2010, p. 80). By identifying influential cognitive and emotional factors emergent in current research, this study brings academic knowledge to practitioners in order to encourage the creation of human-centered learning experiences with information.

See ***Learning by Design: Cognitive and Emotional Factors Influencing Informal Learning Experiences in Interactive Environments*** (Leaper, 2011) for complete research parameters, search results, data analysis, annotated bibliography, and review of literature associated with this white paper.

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