

Chapter 2

Investigating an Online Museum's Information System

Instructional Design for Effective Human-Computer Interaction

Asmidah Alwi and Elspeth McKay

Abstract Information and communications technology (ICT) tools have completely altered the way museum curators design many of their exhibits. The literature reveals many interesting studies, which explain the unique nature and characteristics of the Web-based environment, to provide many educational advantages. As a consequence, online learning is now an important agenda for many museums. They have become learning institutions in their own right as they enhance their exhibits to leverage the opportunities offered by ICT tools; thereby providing a wider (cognitive) thinking space for their online visitors. Although the role of museums in supporting the formal education of the general population is usually associated with visits to a physical museum, the online museum environment is now playing an important part in providing more information to people, as well as further enriching their life-long learning experiences. Nevertheless not enough is known about the educational effectiveness of online-museum exhibits. This paper describes a doctoral project, underway in Australia that examines the human-computer interaction (HCI) which occurs when people access online museum exhibits.

Keywords Instructional design · Instructional architecture · Web-based learning · Cognitive preferences · Human-computer interaction · Online museums

1 Introduction

The Web-based technologies offer opportunities to enhance the design of online learning environments. As a result, many museums around the world are now adopting information and communications technology (ICT) tools that emphasize the use

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of Web-based multimedia to enrich and fulfil their visitors' learning experiences. Nevertheless, awareness of the complexities of human-computer interaction (HCI) presents a new dilemma that challenges the design and development of museums' online learning systems. As tempting as they are, the adoption of these emerging ICT tools for displaying a museum's exhibits needs to align with appropriate instructional strategies to ensure the effectiveness of their visitors' learning experiences. This concept underpins a doctoral research project underway in Australia that is investigating the interactive effects of a museum's online exhibits with students' cognitive style preferences on their participation outcomes.

It is reasonably well known that the teaching style will influence a learner's experience and level of engagement with their subject content (Anderson & Elloumi, 2004). To ensure that online-learning promotes enhanced learning experiences, instructional strategies are needed to differentiate between the 'approach' or 'view' of the online-activities and the supporting instructional architecture. Taking a passive/absorption approach will work best in some circumstances, while at other times there is a need for more interactivity. According to Clark (2003):

The absorption view-of-learning requires clarity about the difference between learning and instruction. Learning in this view, is about assimilating information; while instruction is about providing information to learners. Some call this approach to learning design, a transmission-view of teaching (Mayer, 2001). Courses that rely on lectures or videotapes to transmit information generally reflect this view.

The behavioral view-of-learning was promoted in the first part of the 20th Century. Behavioral psychology promoted a different view: one that considered learning to be based on the acquisition of mental associations. This view-of-learning is about correct responses to questions and instruction; providing small chunks of information followed by questions and corrective feedback. In the process of making many small correct responses, learners generally build large (memory) chains of new knowledge. To promote mental wellbeing this type of behavioral-view can be reflected in programmed instruction.

The cognitive view-of-learning has developed in the last part of the 20th Century, when learning was again re-conceptualized (McKay, 2008). This time, the emphasis concentrates on the active processes learners use to construct new knowledge; construction of this kind requires an integration of new incoming information from the environment with existing knowledge held in a person's memory. In the cognitive-view, learning is about active construction of new knowledge by interacting with new information, while instruction is about promoting the psychological processes that mediate that type of knowledge construction. It is very important in this approach to encourage the student with an apprehension to online instruction (McKay, 2008), to build upon their individuality and enable them to wander around the learning materials at their own pace.

It is essential however to differentiate between the type of learning and the technical means or instructional architecture to support it. Take for example the analogy of designing specifications for building a house. In this scenario there is an overarching purpose to provide specific prescriptions for the building process. When building a family home, we create different rooms for different purposes:

kitchens for our cooking, bathrooms for cleaning our body, and bedrooms for sleeping. Similarly we can describe experiential learning environments, by concentrating on the type of cognitive activities required by a learner to develop knowledge and skills. Although the active construction of knowledge is commonly accepted today as the mechanism for learning, that construction can be fostered through four diverse instructional environments: receptive, directive, guided-discovery, and exploratory (Clark, 2003). Each of these unique instructional architectures reflects different 'views' or 'approaches' to the learning context. They also require different instructional prescriptions to enhance the effectiveness of their particular instructional architecture (McKay, 2008).

- *Receptive architecture*: supports a transmission-view of learning, which is characterized by an emphasis on providing information for a learner. For online museum exhibits this screen-based information may be in the form of words and pictures that are both still and animated. A good metaphor for the receptive architecture is that the learner is a sponge and the instructional strategy pours out knowledge to be absorbed by the receiving learner. In some forms of receptive instruction, such as lectures or video-lessons; learners have minimal control over the pacing or sequencing of their learning environment. In other situations such as a text assignment, learners control the pace and can select the topics in the book of interest to them. Some examples of this architecture include a traditional (non-interactive) lecture, an instructional video, or a text assignment. Sadly, many online/eLearning programmes, which are known as 'page turners', lack interactivity. As such there is no corrective feedback given to the learner. For the student who may feel a little cognitively-fragile, this ability to revisit the instructional content many times (in the privacy afforded by working alone) may be beneficial.
- *Directive architecture*: supports a behavioral-view of learning. The assumption is that learning occurs by the gradual building of skills starting from the most basic and progressing to more advanced levels in a hierarchical manner. The online-lessons should be presented in small chunks of knowledge, providing frequent opportunities for learners to respond to related questions. Immediate corrective feedback should be used to ensure that accurate associations are made. The goal is to minimize the aversive consequences of the learner making errors that may promote incorrect associations. Programmed instruction that was popular in the 1950s and 1960s is a prime example of directive architecture. Such lessons were presented in books originally; with the advent of ICT tools, they migrated to a computerized delivery.
- *Guided-discovery architecture*: using job-realistic problems to drive the learning process, learners typically access various sources of data to resolve problems and receive the instructional support (sometimes called scaffolding) that is available to help them. Unlike the directive architecture, guided-discovery offers learners the opportunities to try alternatives, make mistakes, experience consequences of those mistakes, reflect on their results, and revise their approach. The goal of

guided- discovery is to promote construction of mental models by helping learners experience the results of decisions made in the context of solving realistic cases and problems. Guided-discovery designs are based on inductive models of learning; that is, learning of concepts and principles from experience with specific cases and problems.

- *Exploratory architecture*: also known as open-ended learning, the exploratory architectures rely on a cognitive-view of learning. Clark (2003) identified that out of these four instructional architectures, the exploratory models offer the most effective opportunities for providing high levels of learner control. Instruction should therefore be designed to provide a rich set of instructional/learning resources including: learning content, examples, demonstrations, and knowledge/skills building exercises that are complete with the means to navigate the materials. Architectures of this type are frequently used for online-courseware.

2 Online-Museums

Web-based museum exhibits that are designed to enhance the public's information and knowledge have been found to be extremely successful. For example, Museum Victoria in their 2007–2008 annual report records a triple number of online visits compared to the number of their physical visits. This report also shows a doubled increase in the number of visitations to their 'Discovery Program' compared to the previous year. Another example is Virtual Museum of Canada (VMC) that records millions of visits each year as listed in their website. With such an outstanding result, the potential to promote this type of online-learning environment has become important agenda for many museums around the world (Copeland, 2006). As the virtual museum users/visitors emanate from the formal educational sector (Peacock, Tait, & Timpson, 2009), museum curators need to be mindful of how to present their exhibits to afford effective learning experiences.

The rush towards creating online-museums presents fresh dilemmas and challenges for museum curators and their exhibit designers (Brown, 2006; Marty, 2004; Soren, 2005). As a consequence, they require a deeper understanding of how people interact with the Internet. According to McKay (2003) there are critical design factors which should be in place to ensure effective learning takes place with Web-mediated instructional materials. The HCI literature looks into this dilemma (Elsom-Cook, 2001; Sharp, Rogers, & Preece, 2007). These researchers examine human mental models, describing how human beings process their information. Such research into cognitive ability provides a rich collection of very detailed information and knowledge about how to improve the educational technology design process (Elsom-Cook, 2001).

In general, museums design their interactive exhibits for a broad range of visitors. Instead of seeing how to cater for a diverse number of participants, the literature emphasizes a more formal educational view of such participatory museum visits. Hence, to set the scope for this research the participants will be school students in a

specified age range. The principal aim of this doctoral project, (which is underway in Australia at the time of writing), is to investigate the effectiveness of the museum's exhibit information systems interfaces (ISIs), for enhancing school students' cognitive performances. The main objective of the research is to consider how differently human beings process their Web-mediated learning experiences by investigating the online-instructional-strategies implemented as ISIs for the museum exhibits.

2.1 Preparing the Cognitive Space in Online Exhibits

The literature shows that there is previous work relating to the museum context that recognizes the online-environment as a 'cognitive space' in which a museum operates to deliver pertinent information and exhibit their artifacts. This new online-role has also been highlighted in the definition of emerging museum roles as defined by the Museums Australia Constitution in 2002. Historically, the use of ICT tools to enhance the museum learning experience started in the early 1990s. Back then, the potential of interactivity and multimedia were well considered (Schweibenz, 1998) and embedded in the delivery mode of the museum's exhibitions (Witcomb, 2007). Even as the role of museums grow with the advent of their ICT exhibiting tools, we see museums only taking advantage of these tools to merely record their collections in electronic databases or to embed the exhibition itself as an ICT artifact. Instead, we suggest that museums can play a more important role in facilitating the process of learning through the use of the newest Web-mediated ICT media tools which offer new learning opportunities (McKay, 2003).

2.2 Considering Learners' Differences

The differences in human cognitive preferences, which some people call learning styles, are well acknowledged. For instance, Kolb's theory is well known as an example that considers learning styles to assist in the design of museum learning experiences. According to Kolb's theory, there are four learning styles: the divergers who are the 'why' people, the assimilators who are concerned with the 'what,' the convergers who are more interested in the 'how,' and the accommodators who are concerned about 'what happens' (Black, 2005). It is possible to see the characteristics of this model reflected through the various exhibit designs that museums make when constructing their visitors' learning experiences. Taking a generic approach such as this to their instructional decisions is understandable as it is very difficult to design one instructional programme to suit everybody (Schaller & Allison-Bunnell, 2003; Schaller, Borun, Allison-Bunnell, & Chambers, 2007).

The way learners process their information depends upon their individual mental model. Often the discussions in the literature are based on the differences between human cognitive preferences. Others indicate that information representation can be designed in two ways: for instruction (delivery) or for learning (knowledge acquisition) (Berry, 2000; Mayer & Moreno, 2002). Mayer and Moreno (2002) assert

that if the learning goal is to promote knowledge construction/acquisition, then the design process should take the cognitive-view rather than an information-delivery-view. Hence the way information is presented to the learner should not only deliver the information but should be designed in such a manner to help the learner to process the information in meaningful ways (Berry, 2000; Inglis, Ling, & Joosten, 1999; Mayer & Moreno, 2002) depending on an individual’s mental (information processing) model.

2.3 Cognitive Style Construct

There is a vast amount of literature that discusses the differences in how human beings process information. Cognitive style is understood to be an individual’s preferred and habitual approach to organizing and representing information. Measurement of an individual’s relative right/left hemisphere performance and their cognitive style dominance has been a target of researchers from several disciplines over the last decade.

Table 2.1 Well known research terms for humans’ processing information (McKay, 2000)

Terms describing cognitive differences	Researchers
Levellers-Sharpeners	Holzman and Klein (1954)
Field dependence-Field independence	Witkin, Dyke, Patterson, Goodman and Kemp (1962)
Impulsive-Reflective	Kagan (1965)
Divergers-Convergers	Guilford (1967)
Holists-Serialists	Pask and Scott (1972)
Wholist-Analytic	Riding and Cheema (1991)

Over the years, various terms have been used by other well known researchers to describe the same cognitive (learning) strategies (Table 2.1), into which Riding and Cheema (1991) were able to condense the earlier researchers’ style constructs into two families (dimensions) of cognitive style, which Riding called Verbal-Imagery and Wholist-Analytic (Fig. 2.1). The latter describes the way an individual processes the information they receive for recall purposes, while Riding maintains that the Verbal-Imagery dimension represents the information representation strategy an individual may use during thinking. According to Riding, this choice will differ according to the task at hand.

Attempting to address the issues discussed earlier highlights the need for further investigation of the interaction between the effects of learners’ cognitive preferences and information representation formats to help to untangle and understand the likely educational outcomes from museum visits. The following conceptual research framework is underway to accommodate the online-museum’s instructional strategies (Fig. 2.2).

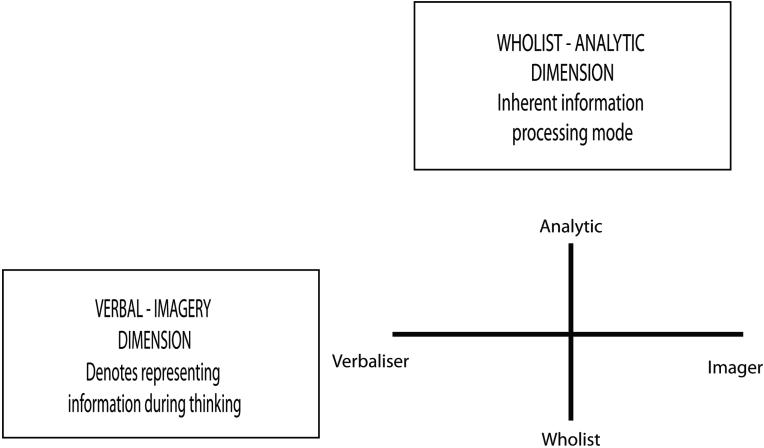


Fig. 2.1 Cognitive styles construct (Riding & Cheema 1991)

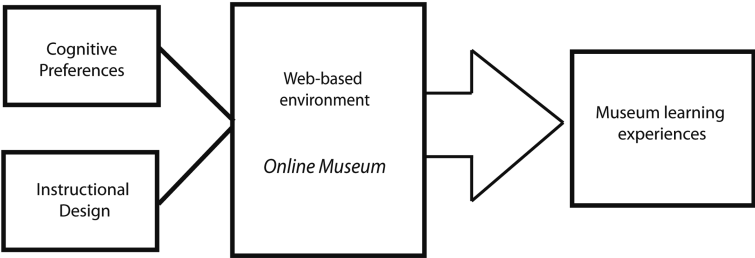


Fig. 2.2 Conceptual research design model

Based on this conceptual framework, this doctoral research aims to investigate how the different instructional strategies adopted by ISIs may facilitate online-museum learning experiences for both cognitive preferences (on the Riding’s Verbal and Imagery dimension). It is anticipated that learners’ cognitive preferences and the way an exhibit’s information is represented may affect the learning experiences in a Web-based environment. We are suggesting that the learning experiences derived from an online-museum may provide a predictable measure of the instructional outcomes, thus providing the much needed finer details to inform the design and development of effective online-museum learning experiences.

3 Experimental Design

We employ a quasi-experimental design and the research will be informed by two independent variables: the ISI media access, which is the information representation formats (online- and physical-museum), and an individual’s personal cognitive preference (Verbal-Imagery). A three-phase experimental design will be carried

out. The first phase involves a screening test to measure cognitive style using the Cognitive Styles Analysis (CSA) tool, devised by Riding (1991), followed by a pre-test to determine the participant’s prior domain knowledge portrayed by the museum exhibits. Based on the CSA ratio, which identifies cognitive style preferences (Verbal-Imagery and Wholist-Analytic), participants will be divided into two museum treatment groups (online or physical visit).

The second research phase will be the actual museum activities (visiting) period in which treatment groups will be given access to either the online-museum or the physical museum respectively. The final research phase will be a post-test to measure any improvement in the cognitive performance (or learning outcomes) derived from the museum’s learning exhibits. The experimental design is illustrated in Fig. 2.3.

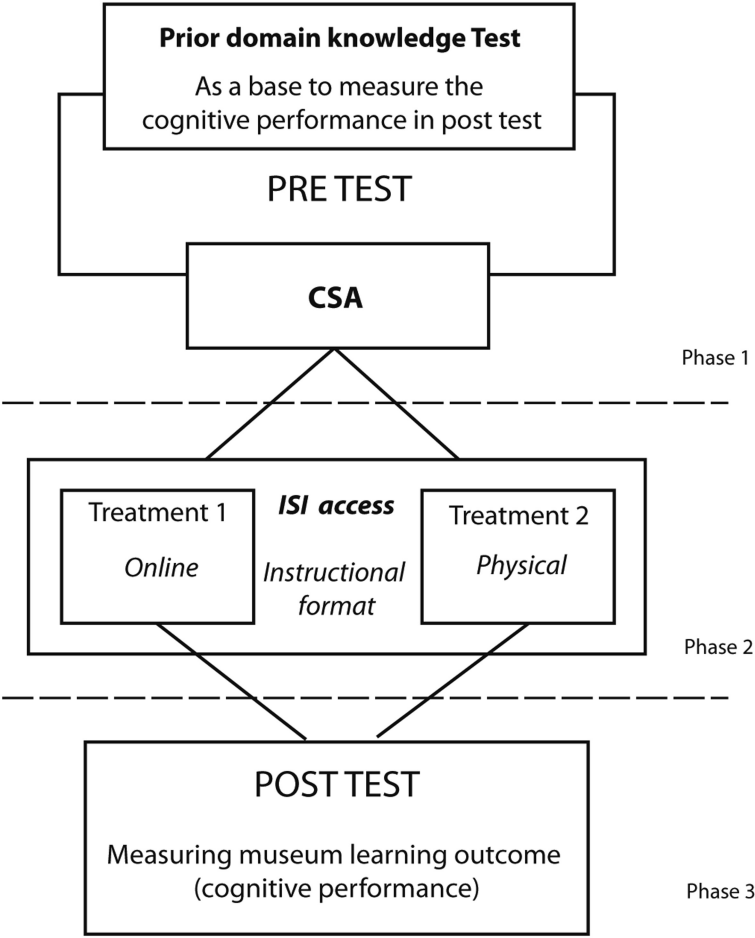


Fig. 2.3 The experimental design of the doctoral-study

Validation and reliability testing (calibration of the test instruments) for both pre-test and post-test will be conducted in a preliminary experiment prior to the main data collection process. This preliminary experiment will provide evidence of whether the test-items can distinguish effectively between those participants who lack knowledge pertaining to the museum's exhibit and the knowledgeable participants. This experiment is also important to test out the research design, to ensure there is enough time for all activities required for the experiment.

4 Discussion and Conclusions

Over the years, museums have been implementing various instructional strategies in the arrangement and organization of their educational programs, with specified learning objectives (Hein, 1998). For instance, museum exhibits have been organized using a transmission view of learning for educational programs with specified learning objectives. If museums wish to achieve discovery learning exhibits they should be arranged in such a way as to allow for knowledge exploration using various active learning modes. Museum curators who implement exploratory exhibit architectures will ensure a typical constructivist environment. In an approach such as this, there is no specific learning path expected. Instead, the exhibit presents a range of points of view that afford the museum visitor to delve into their own experiential learning. With the increased popularity of Web-based ICT tools, understandably, many museums are adopting constructivist learning environments that provide open ended options for their visitors to experience learning events through both their physical and online-visits.

In adopting technologies to support the constructivist-museum context, the roles of ICTs need to be reconceptualized as effective HCI tools for learners to construct their own meaning (Jonassen, Peck, & Wilson, 1999). Fundamentally, technology is used to support the acquisition of knowledge (Inglis, Ling, & Joosten, 1999), involving information a learner receives, stores and retrieves. There is an instructional imperative to understand both how the technology should present information that may be gleaned from museum exhibits, and how a learner's mental model may work in processing screen-based information that is a complex cognitive-environment. Recent research has shown that learning is accepted as an active and ongoing process, as well as being a final outcome (Black, 2005). As information assimilates between the various contexts of a learning experience in a museum, this process may depend heavily on one's mental structure/capacity (Falk & Dierking, 1992). Learning events that are stored within an individual's mental structure might be interpreted in parallel as it potentially matches with their existing prior knowledge or resides as (unprocessed) information until it meets a situation that may turn it into knowledge. Cognitive psychologists say this human-dimension provides valid techniques for us to understand the museum learning process (Hein, 1998). The findings from this doctoral-study will serve to inform museum staff involved in exhibit design and development.

These days, ICT tools provide the means to produce instructional packages with relative ease. Multimedia accentuates a highly graphical (or visual) approach to screen-based instruction. Typically, little consideration is given to the effectiveness of screen-based visual stimuli, and curiously, learners are expected to be visually literate (McNamara, 1988), despite the complexity of human-computer interaction (Dreyfus & Dreyfus, 1986; Tuovinen & Sweller, 1999). However, visual literacy is much harder for some people to acquire than for others (McKay & Garner, 1999).

In the past, verbal (or analytic) ability was taken to be a measure of crystallized intelligence, or the ability to apply cognitive strategies to new problems and manage a large volume of information in working memory (Hunt, 1997), while the non-verbal (or imagery) ability was expressed as fluid intelligence (Kline, 1991). As online-learning environments lend themselves to integrating verbal (textual) and non-verbal (graphical) instructional strategies, which generate novel (or fluid) intellectual problems, more research needs to be carried out to provide instructional designers with prescriptive models that predict measurable instructional outcomes for a broader range of human cognitive abilities. Picking out these important instructional variables (spatial ability, and method of delivery for instance) for some types of instructional outcomes progresses our ability to provide instructional environments for a broader range of novice-learners, thereby giving them a choice of screen-based instructional strategy, and control over their choice of delivery format. Both cognitive-dimensions must be considered for developing tailored instructional strategies for Web-mediated online-museum exhibits of the future.

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