Information Systems Design Theory for Location-Based Educational Services in Informal Learning Environments

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Abstract

Mobile technologies are deeply embedded in the daily lives of young people. The ubiquity, portability and functionality of these devices present new opportunities for enriching learning. Yet, to date there has been little theory development to guide the application of location-based technologies (LBT) in informal learning environments. To address this gap, we propose to (1) develop an IS design theory for the application of LBTs for education in cultural institutions, (2) pioneer the use of advanced combinatorial methods to improve the technical design process, and (3) instantiate the resulting IS design theory within two leading Australian cultural institutions. The findings will inform policy and the future use of LBT for education.

Keywords

Location-based services, education, informal learning, information systems design theory.

INTRODUCTION

The provision of engaging educational services for young people is a key priority for all Australia's cultural institutions. The reach and impact of these services is underscored by figures showing that last year more than 165,000 school students from all over Australia visited a cultural institution on an excursion to Canberra. Educational research tells us that for educational outcomes to be maximised, the learning environment must be learner-centred, well-designed, personalised and social in nature (OECD, 2010). According to Packer and Ballantyne (2002), learning in leisure settings is characterised by most, if not all, of the following:

- Learning is stimulated by the needs and interests of the learner (Hooper-Greenhill 1995);
- The setting provides direct experience with real objects, people or places (Falk et al. 1995; Hooper-Greenhill 1995);
- Learning is often socially mediated (Falk et al. 1995);
- Learning is voluntary (Falk et al. 1995);

- Visitors come alone, in small or family groups of mixed sexes, ages and subject expertise with very diverse learning styles and prior learning experiences (Anderson 1995).

While learning within cultural institutions is generally informal (i.e., takes place outside of a classroom), it can take either a structured, semi-structured or unstructured format. For instance, school groups visiting a cultural institution will often participate within a structured learning experience that has some identified learning outcomes, and has been designed to support curriculum-based objectives. Though this learning is not undertaken in a classroom, there is a structure and purpose to the learning experience. On the other hand, unstructured learning is typically undertaken by independent visitors, with the learning objectives driven by their personal learning agenda. In this sense, the quality of the learning experience is much more difficult to anticipate, and therefore, can have a significant and detrimental influence on a visitor's overall satisfaction.

As cultural institutions recognise the importance of learning to the visitor experience, they will often respond to this uncertainty by designing a suite of products (i.e., exhibitions and programs) to support learning. These products are increasingly becoming essential tools to guide and engage visitors in activities that are intended to reflect their personal expectations. Packer et al. (2002) assert that such products need to provide visitors with experiences that are object-oriented, cognitively demanding, that promote introspection, and that are social in nature. This provides visitors with the opportunity to engage in a semi-structured learning experience, where the breadth and depth of engagement is dependent on the visitor preferences and their personal appetite for learning.

ICT enabled learning in cultural institutions

Mobile technologies are deeply embedded in the daily lives of young people. The ubiquity, portability and functionality of these devices present new opportunities and new challenges for enriching learning in diverse settings. For Kress & Pachler (2007), mobile technologies create a "new habitus of learning" in which learners create meaning through their purposive interaction with cultural resources. There is an ever increasing recognition of the important role these technologies can play in enhancing learning in cultural institutions. In this regard, it is important to acknowledge that cultural institutions have often been at the vanguard of technology adoption. For instance, Parry and Sawyer (2005) report that ICT enabled visitor experiences date back to the dawn of the personal computing revolution in the early 1970s.

In his report to the UK Government's Joint Information Systems Committee, Benford (2005) asserts that location-based technologies have the potential to radically transform education. He defines location-based technologies as consisting of three core components: mobile devices, wireless networking and location-sensing. Mobile devices include current commercial products such as mobile phones, personal digital assistants, laptop computers, mobile gaming consoles and personal media players, as well as alternatives that have not yet left the research labs, e.g. wearable computing, smart fabrics, tangible and embedded interfaces, and mobile 3D displays (IEEE, 2002). Wireless networking includes: three generations of mobile telephony–GSM, GPRS and 3G (as commercial services for mobile phones); the 802.11 family of wireless network protocols which can be deployed directly by users and their organisations; and local ad hoc mechanisms such as Bluetooth (Anderson and Blackwood, 2004). Finally, a very wide range of location-sensing technologies are available (GPS, cellular positioning, WiFi triangulation, Ultrasonic, RFID, video-tracking and others), though they differ greatly in coverage, accuracy and cost (Roussos, 2002).

According to Benford (2005), location-based experiences extend digital media out into the physical world, with users interacting and engaging with technology as they go about their daily activity. Sensors capture information about their current context, including their location, and this is used to deliver them an experience that changes according to where they are, what they are doing, and maybe even how they are feeling. As a result, the user experiences digital media that is interwoven with the everyday world, and that is potentially available in any place and at any time.

In recent times, there have been calls for more research into the role of location-based technologies. For instance, Dribin and Rickhoff (2011) argue that we need to better understand the value of such technologies, contending that more research is needed into the use and impact of location-based technologies in cultural institutions. They conclude that more needs to be understood regarding the "interwoven nature of media resources, particularly those found in digital environments" (p.221).

Evidence is only now beginning to emerge regarding the use of such technologies within cultural institutions (Pujol-Tost 2011). For example, Karl-Højland (2010) recently shared information on the development and use of an interactive gaming platform (EGO-TRAP) to create individual and cooperative learning experiences at a science museum (The Experimentarium) in Copenhagen. The game, which was delivered via smartphones, provided users with a series of location-based learning challenges as they moved through the exhibition space. Assisted by augmented reality, the game demonstrated that location-based technologies can be used to create a new type of narrative—an interactive narrative—which can help to create a more meaningful learning experience. Our only criticism of this work is that, apart from mentioning that an iterative design research

approach was used to develop the artefact, little information is provided on the specifics of how the artefact changed over time. While details of the artefact and the design context are given, and a general description of the design process is provided, there is insufficient information to provide theoretical guidance to others on the development of location-based educational interventions. Another interesting application of location-based technologies is that of the co-visitation project at the Glasgow Lighthouse Museum (Brown and Jones, 2001). This project utilised WiFi enabled PDAs to track the movements of visitors through the museum. This information was then shared in real-time with two different types of online visitors—one group using a traditional web-based interface, and the other group participating within a virtual 3D version of the museum (similar to Second Life). All users were able to communicate with one another and to exchange perspectives on their respective experiences.

While the findings of such projects provide insight into the potential for location-based technologies within cultural institutions, and do provide some evidence regarding the benefits of using location-based technologies to enhance learning, they do not provide theoretical guidance on how best to design a location-based education system. Though such projects can inform the development of design patterns, they provide no assistance to developers wishing to understand which technologies to use, or how best to combine these technologies into an optimal learning support system.

CONCEPTUAL FRAMEWORK

The ubiquitous nature of mobile technologies, and the identified potential for location-based technologies, in particular, to revolutionise the nature and quality of learning within cultural institutions, warrants the development of an information system design theory (ISDT). A failure to understand the theoretical underpinnings that support the use of such technology can lead to sub-optimal design solutions, wasted investment, poor user experience, and in the worst case scenario, a case of type 2 error where organisations reject perfectly good technologies for the wrong reasons.

Walls et al. (1992) define a design theory as "a prescriptive theory based on theoretical underpinnings which says how a design process can be carried out in a way which is both effective and feasible" (p.37). Gregor (2002) adds that in this way, design theories differ from explanatory and predictive theories that dominate the natural and social sciences as these theories are concerned with questions of how and why, rather than what.

Walls et al. (1992, 2004) articulate seven principles that characterise and distinguish design theory from other types of theory development. In particular, they assert that while design theories provide some prescription as to what needs to be done to address some goal, care needs to be exercised to avoid presenting such prescriptions as explanatory, predictive or normative. In this regard, design theories are bounded by kernel theories that provide both the scope for design, and prescribe the expectations regarding the performance of the artefact being designed.

To guide the development of a design theory for location-based education, we draw on the work of Gregor and Jones (2007) who identify eight requirements for an ISDT (see Table 1). These requirements synthesize and extend the prior work of Dublin (1978) and Walls et al. (1992), to emphasize the importance of creating design theories that are adaptable (mutable) and applicable in the real-world (instantiated).

In a critical review of ISDT in practice, Walls et al. (2004) observed that the majority of design-based research undertaken in information systems tends to be concerned with describing the features and requirements of particular artefacts, and that rarely is design theory used to generate new insights into the process of design. Jones et al. (2003) add that more attention needs to be given to the development of ISDTs that are grounded in the real-world as such systems need to adapt to changing technological and environmental demands. In summary, future research on ISDT needs to prioritise (i) more advanced applications of ISDT that identify systematic methods for bringing theoretical rigour to the design of artefacts and processes; (ii) the development of theory to guide the design and deployment of ISDTs; and (iii) the real-world instantiation of ISDTs to demonstrate their practical and theoretical value. With this background in mind, we identify three significant contributions associated with our research.

Contribution 1: ISDT for location-based educational services

To date, the integration of location-based technologies into educational services has been largely atheoretical. Even when the educator has a good understanding of the pedagogical needs of the learner, there is little theory to guide the selection and use of specific location-based technology to assist in the provision of educational services. Consequently, the technology and pedagogy develop in parallel streams, with technologists striving for ever more impressive, feature rich software and hardware artefacts; and educationalists sampling from such offerings in an effort to improve learning outcomes, with neither knowing if any particular technology offering represents the best solution to a particular learning need.

Table 1. Requirements for an ISDT

Component	Description
Purpose and scope	What is the system for, the set of meta-requirements or goals that specify the type of artefact to which the theory applies. Defines the scope and boundaries of the theory.
Constructs	Representations of the entities of interest in the theory.
Principle of form and function	The abstract blueprint or architecture that describes an IS artefact, either product or process.
Artefact mutability	The changes in state of the artefact anticipated in the theory, that is, what degree of artefact change is encompassed by the theory.
Testable propositions	Truth statements about the design theory.
Justificatory knowledge	The underlying knowledge or theory from the natural, social or design sciences that gives a basis and explanation for the design (kernel theories).
Principles of implementation	A description of processes for implementing the theory (either product or process) in specific contexts.
Expository instantiation	A physical implementation of the artefact that can assist in representing the theory both as an expository device and for purposes of testing.

A key feature of the ISDT approach is that it can provide guidance to all stakeholders on how best to address this challenge. The development of an ISDT also responds to what call the "theory donut" of design, where theory seems to surround every aspect of the design process, yet there appears to be very little theoretical guidance for the process of good design. Theory is drawn upon to inform the requirements analysis and to evaluate the usability of the resulting design solution, but the creative process associated with creating the actual design is viewed as a "black box." The development of an ISDT for location-based educational services is critical to our understanding of how best to design optimal, technologically-enhanced learning environments. This project is the first to address this important theoretical gap.

Contribution 2: Method for optimal product and process designs

The myriad of location-based technology options, different learning styles and user needs, varying physical environments, and the resource-based advantages of different educational services require the identification of rigorous methods to capture the needs of different stakeholders, and then translate these needs into optimal (or near-optimal) design solutions. Building on pattern-based design principles, this project will pioneer a new service design method for specifying design elements that are informed by different stakeholder needs, and then propose context-specific design solutions that will bring together the best combination of design elements for different users of a given educational service.

The proposed service design method addresses the call by Fincher (2002) for IS design to draw on pattern design principles to capture, codify and build theory about the design process. In the pattern-based design approach, this process is akin to the development of a pattern language—where choices are made about which design elements (patterns) should be combined to create a design solution. However, the pattern development process will often identify numerous design options (attributes) for a given design element (pattern), and to date there has been little guidance to designers and theoreticians alike on which patterns or attributes should be used address a particular design need.

This research makes a valuable contribution to the challenge of organising pattern languages by pioneering the use of an advanced combinatorial methodology—discrete choice analysis (DCA). DCA is an approach that allows users to conceptualize individual choices as a process of decision states. The method requires respondents to compare alternative choice options and make a decision that involves trade-offs between the components of these options. The result of this process is a 'choice outcome' that can be deconstructed based on the marginal utility for each of the 'options' available within the choice task conditional upon the underlying experimental design. Recent advances in experimental design theory and DCA modelling has resulted in extremely efficient models that minimize the cognitive demands on respondents while obtaining robust estimates of preference that are extremely accurate at predicting future behaviour (Louviere et al., 2000). Stated simply, the use of DCA will

enable us to better understand the relative importance of particular patterns and attributes, as well as the inter-relationships between them.

In this project we will employ a novel combination of DCA-related methods. Rather than relying on the traditional first-choice only DCA methods to investigate preferences, we will utilize an exploded ranked order model that treats each subsequent choice in a particular choice task as if it were the first choice out of a set of alternatives from which the options already selected have been eliminated. This extension will enable us to capture more information on pattern preferences, which in turn will enable us to make more accurate prescriptions for the organisation of pattern languages. Further, the utilization of latent class modelling will enable us to examine the extent to which group-level differences account for preference variation. That is, we will be able to further decompose the aggregate level findings (from the DCA) to identify a range of different pattern languages that reflect the preferences of difference sub-groups within the user population. This innovative combination of advanced combinatorial methods will add substantial rigour to the process of pattern language development, and could potentially revolutionize the way in which design process decisions are made.

Contribution 3: Real world instantiation

Gregor and Jones (2007) make the argument that the instantiation of design theory helps to demonstrate the practical value of good design, providing a useful tool for theory representation and exposition. In this project, we will instantiate the ISDT for location-based educational services within the school-based educational programs of two prominent national cultural institutions—the National Portrait Gallery and Questacon (the National Science Centre) These institutions were selected because they (i) represent two very different cultural products, (ii) use a mix of structured and unstructured learning approaches, (iii) attract a wide cross-section of school groups from different parts of Australia; and (iv) collectively service around 90% of all school groups visiting Canberra. The choice of the cultural sector is also significant as this market places strong emphasis on principles of good design, and has been quick to see the value of location-based technologies for enhancing the quality of the visitor experience.

The particular instantiation will focus on the development of a location-sensitive educational tool(s) that will provide scope for students to access additional information that is relevant to their learning needs, and to support interaction with peers through social networking tools and augmented reality. The resulting tools will be based on the pattern language(s) identified in contribution 2. These pattern language(s) will be developed in response to different educational service scenarios that are informed by pedagogical lines of enquiry (e.g., historian, artist, scientist, citizen and curator). The actual scenarios will reflect the different roles of the student, with location-sensitive technologies used to provide prompts and interactions, with students invited to find and comment on different aspects of the exhibition from one of the identified perspectives. This represents a significant advance on the current state of play in the use of such technologies in the sector.

In addition to the technology component, the instantiation will also involve design of the service context for education. That is, consideration will be given to non-technical aspects such as the quality of educational and service experience. Through a range of device, exhibit and peer-based interactions, a comprehensive log of user interactions and evaluations will be generated. Students will be able to access and contribute text, images, audio and/or video material as they progress through the cultural institutions. These interactions will be recorded as traces of meaning and engagement. This will allow two key outcomes. First, students will be encouraged to co-create value by consuming and producing exhibit-related content that others can use and reuse. Second, a web of student-generated data and visualisations of the learning environment will be produced. This web of material will be used to frame post-visit sessions co-facilitated by the researchers and the school group's teacher to understand and reflect on the temporal and spatial aspects of learning. Importantly, these within- and post-visit processes will provide a valuable source of data for evaluating the educational contributions of the location-based design solutions.

METHODOLOGY

To develop the ISDT for location-based educational services in the cultural sector, our project will utilise an action-based research approach. Action research is a reflective process of progressive problem solving led by individuals working with others to improve the way they address issues and solve problems (Lewin, 1958, Sein et al., 2011). According to prior design theorists (e.g., Jones et al. 2003, Walls et al. 2004), this approach is particularly well suited to design science projects, where it will serve as an iterative tool for developing location-based education artefacts and processes. In keeping with the action-based research approach, our project adds an additional component to Gregor and Jones' (2007) eight components of an ISDT. The additional component, labelled "evaluation," reflects the need to assess how well the instantiated design meets the expectations of users through some formal evaluation process. This assessment will provide valuable feedback and guidance for improving the product and process designs. Together, these nine components populate three separate stages,

each of which is aligned to the contributions identified earlier. These stages and components are represented graphically in Figure 1.
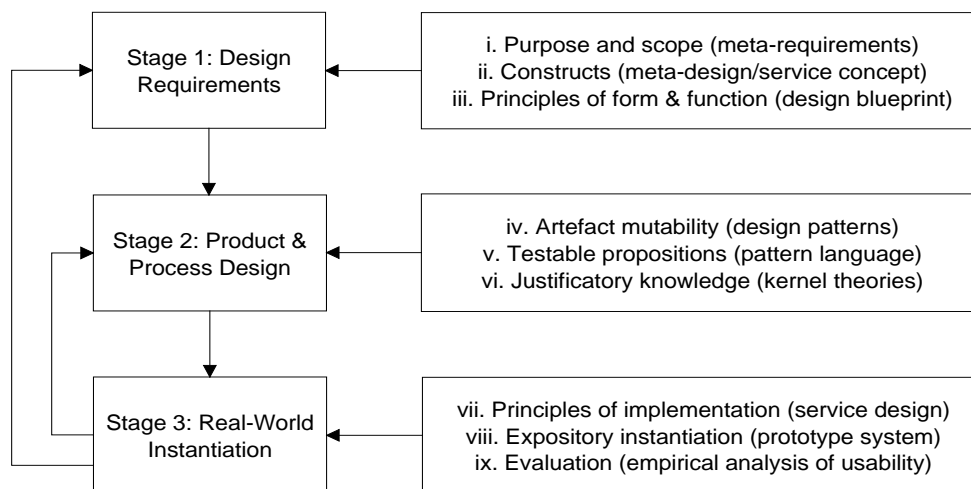
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│                 │        │  i. Purpose and scope (meta-requirements)    │
│ Stage 1: Design │◄───────│  ii. Constructs (meta-design/service concept)│
│  Requirements   │        │  iii. Principles of form & function          │
│                 │        │       (design blueprint)                     │
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│                 │        │  iv. Artefact mutability (design patterns)   │
│ Stage 2: Product│◄───────│  v. Testable propositions (pattern language) │
│ & Process Design│        │  vi. Justificatory knowledge (kernel         │
│                 │        │       theories)                              │
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│                 │        │  vii. Principles of implementation           │
│ Stage 3: Real-  │◄───────│        (service design)                      │
│ World           │        │  viii. Expository instantiation (prototype   │
│ Instantiation   │        │         system)                             │
│                 │        │  ix. Evaluation (empirical analysis of       │
│                 │        │       usability)                             │
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Figure 1: Methodological Stages and Components

Stage 1: Design requirements (aligned with Contribution 1)

i. Purpose and scope (meta-requirements)

To establish the meta-requirements for the ISDT, two pilot studies undertaken in early 2011. The first was undertaken to ascertain how experiential preferences, service quality, personal values and learning outcomes influence satisfaction and loyalty of visitors at two national cultural institutions located in Canberra, Australia. This study quantified the nature of visitor expectations and highlighted the important role that learning outcomes play in building quality perceptions and repeat visitation. The second study was an evaluation of the preferences and impact of school visitation to Canberra. The second study highlights, amongst other things, the importance of flexible informal learning as a driver of visitation to Canberra's cultural institutions each year for an excursion.

Taken together, these studies highlighted that while the cultural institutions provided a positive visitor experience, there was, nevertheless, an opportunity to improve and customise cognitive-based learning experiences through the use of emergent technologies. Importantly, the frameworks developed as part of these studies have now been incorporated into a longitudinal visitor evaluation program that will provide a useful tool for evaluating the impact of the resulting location-based educational interventions. This evaluation program provides real-time feedback to management and frontline staff via an interactive web-based dashboard that is populated automatically by onsite data collection terminals.

ii. Constructs (meta-design/service concept)

From the pilot work, we were able to develop a conceptual framework that identifies the interaction between a range of key constructs that impact on the quality and efficacy of a cultural institution's visitor and educational services (see Figure 2). The model reveals that satisfaction (and subsequently, attitudinal loyalty) with visitor and educational services is influenced by learning outcomes being met, and by the quality service interactions with key support staff. Learning outcomes were also strongly influenced by service quality, which in turn, was sensitive to the nature of the visitor's experiential preferences and their personal values. While a details explication of the model is outside the scope of this paper, it is noteworthy that both the measure and structural models have now been validated with more than 10,000 responses across three cultural institutions as part of the longitudinal visitor evaluation program.

Though this work on the broader service concept provides a useful starting point, we will also need to identify constructs specific to the design of a location-based educational tool. This work will require an extensive review of the literature on mobile device and network technologies, and the development of a typology of design features and associated functionality.
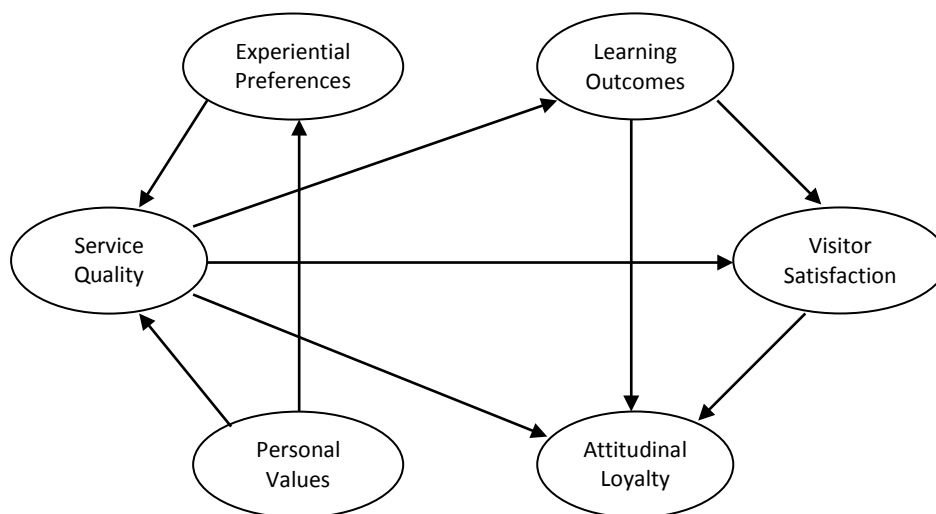
Figure 2: Conceptual model of visitor and educational services

iii. Principles of form/function (service blueprints and scenarios)

Walk through audits and key informant interviews will guide the development of the initial service blueprints and scenarios. The blueprints will provide an overview of "ideal" educational services for the different pedagogical lines of enquiry (e.g., historian, artist, scientist, citizen and curator) that students can take when visiting a cultural institution. Walk through audits of leading cultural attractions in North America, United Kingdom and Australia will be undertaken to better understand existing use of technology within context. These audits will be used to understand the nature and process of educational service delivery in cultural institutions. Interviews will also be conducted with technology and educational service personnel across a broad range of cultural institutions in Australia and Overseas. The goal of these interviews will be to understand the role that location-based technologies can play in supporting learning, and to capture intelligence on how location-based technologies are currently being used by the sector. The resulting blueprints will inform the scenarios that will provide the context for the pattern language development in task v, and will provide guidance on the theory development aspects of the research.

Stage 2: Product and process design (aligned with Contribution 2)

iv. Artefact mutability (design patterns)

The typology of features and functionality, and the blueprint developed in Stage 1, will be used to guide the development of design patterns. Using the pattern template developed by Alexander (1979), and the "common ground patterns for HCI interface design" proposed by Tidwell (1998) as a starting point, this task will focus on translating the design requirements identified in Stage 1 into a pattern collection. Each pattern will include a short, descriptive title followed by examples of the application of the pattern, a description of the context in which the pattern would be applied, an overview of the various forces impacting on the pattern use, and the proposed solution. In line with the work of Tidwell (1998), our patterns will also include a free text field in which random comments regarding the pattern and its application can be recorded.

As an extension to the original pattern template, and based on the recommendations of Dearden and Finlay (2006), our patterns will also include specific information regarding context. The resulting pattern collection will be presented to a group of practitioners to examine the face validity of the resulting patterns, and ensure the accuracy and relevance of the content by seeking the critical input of a range of persons with experience in the delivery of educational services in cultural institutions.

v. Testable propositions (pattern language)

A significant and novel contribution of the present study is the use of DCA methods to inform the creation of pattern languages. The creation of the pattern language will be done in four distinct steps. The first step in the

pattern language creation process will be to translate the patterns into design elements that can be incorporated into a choice experiment. The design elements will reflect the specific pattern options (e.g., a pattern may be identified relating to the need for access to social networking sites, where a design element would relate to particular sites such as Facebook, Twitter, Foursquare etc.) The presence or absence of a particular design element within a choice task will be controlled via an underlying experimental design derived from first principles using the optimal design theory (Street and Burgess, 2007).

The second step is to identify an efficient resolution five design (i.e., a design for main effects and all two-way interactions) such that each respondent is presented with a manageable number of choice tasks. Each task will require respondents to select from among three options, the design solution they believe is best or worst suited to a particular educational service scenario (see task iii). A comic artist will be employed to support the development of the scenarios (story boards), with approximately 100 school teachers from across Australia with experience leading a school excursion participating in the experiment.

The third step will analyse the resulting data using a conditional logit model (McFadden, 1973). The conditional logit model is a regression-type model that was developed as part of McFadden's Nobel Prize winning research. It extends the multinomial logit model to estimate parameters based upon an underlying experimental design. As we are using a exploded ranked order model, we will also need to weight each choice according to the Luce and Suppes (1965) weighting theorem. The resulting analysis will provides a sound basis for a pattern language, where the importance of each pattern is established along with the strength of the relationships between patterns. In this research, we will also seek to pioneer a nomenclature for presenting pattern languages based on a combination of concept mapping and density mapping. The resulting map will represent patterns as circles, where the size of the circles will reflect the importance of the pattern, and the proximity of one circle to another will reflect the strength of the inter-pattern relationships.

The final step is to examine how contextual factors such as demographics, institutional type, experiential preferences and personal values influence the organisation of pattern languages. To do this we will need to introduce additional information into our model and estimate a latent class (finite mixture) model over the original conditional logit model. In doing so, we attempt to capture some of the unexplained variance in the pattern preferences at the aggregate level by segmenting the respondents into groups. The result of this analysis is the identification of different pattern languages for sub-groups of users with similar preference structures. Ultimately, this will provide the basis for designing a range of location-based services that are catered to the preferences and needs of different user segments within the school education market.

The resulting pattern language(s) will be presented to same group of practitioners that participated in Task iv, to gain valuable feedback on the face validity of the pattern language(s).

vi. Justificatory knowledge (kernel theories)

A multi-disciplinary design team will be involved in the identification of relevant kernel theories to explain the resulting design solutions. This work will involve a series of workshops modelled on the living laboratory approach developed at MIT. There will be four workshops involving key staff from the participating institutions education teams. The goal of this task will be to elicit and ascribe meaning and theoretical understanding to the resulting design solutions.

Stage 3: Real-world instantiation (aligned with Contribution 3)

vii. Principles of implementation (service design)

The findings of Stage 2 will inform the revision of service blueprints. These blueprints will detail how the different location-based technologies will be used to support educational services for the different educational service contexts (scenarios). Importantly, the blueprints will also provide guidance on and changes that will be required to existing service delivery processes for the partner organisations, and articulation of staff training needs, as well as any additions or modifications to infrastructure (including the location of key location-based hardware).

viii. Expository instantiation (prototype system)

The selection of the hardware and the development of the supporting software for the prototyping will then be undertaken in conjunction with the support of a mobile application developer. The goal will be to develop an application that will incorporate the desired features and support the educational service delivery. The final decision on the hardware and platform will be made after Stage 2, when more information on the type and nature of the location-based service is known.

ix. Evaluation (empirical analysis of useability)

The final task in Stage 3 will involve a qualitative evaluation of the prototype system. This evaluation will include fieldwork to be conducted according to the critical ethnographic tradition, and will focus on uncovering the implicit values expressed by participants, and the unacknowledged biases that may result from such implicit values (Thomas, 2003). Traditional ethnography tends to emphasize the researchers role in controlling interactions in the field and in reporting their findings in a disengaged way. Critical ethnography, on the other hand, examines the assumptions behind actions, and postulates that a researcher can ask questions. It attempts to free researchers from ideologies that detract from informed reportage.

The purpose of the ethnographic fieldwork is to observe and uncover the user experience associated with the proposed location-based educational services. The fieldwork will take place over four weeks, and will involve 20 school groups at each of the partner institutions. Each school group will participate in a briefing at the beginning of their visit, and a debrief discussion at the end of their visit. The transcribed observation and group interview data will be analysed to identify important themes, and to inform and refine the future use of location-based technologies in support educational services.

CONCLUSION

Creating technology enhanced learning experiences will be critical to the way we educate and engage with future generations. This research-in-progress paper proposes an approach that will develop a stronger theoretical basis for understanding how location-based technologies can enhance learning outcomes of school students visiting two of Australia's leading cultural institutions. Understanding the factors that lead to highly creative and innovative ideas and concepts, as well as the conditions that lead to effective use of emergent technologies is critical for any organisation that aspires to be innovative. This program of research will work with Australian cultural institutions, the government, and the wider community to achieve this aim.

REFERENCES

Alexander, C. (1979) *The timeless way of building*, Oxford University Press.

Anderson, D. (1995) Gradgrind driving Queen Mab's chariot: What museums have (and have not) learnt from adult education. In *Museums and the Education of Adults,* ed. A. Chadwick and A. Stannett, 11–33. Leicester, UK: National Institute of Adult Continuing Education.

Anderson, P. and Blackwood, A. (2004) Mobile and PDA technologies and their future use in education, JISC Technology and Standards Watch, http://www.jisc.ac.uk/media/documents/techwatch/acf11b0.pdf

Benford, S. (2005) Future Location-Based Experiences, JISC Technology and Standards Watch, http://www.jisc.ac.uk/uploaded_documents/jisctsw_05_01.pdf.

Brown, P. and Jones, G. (2001) *Context aware retrieval.* Personal and Ubiquitous Computing, 5 (1). New York, NY: Springer, pp. 253-263.

Dearden, A. and Finlay, J. (2006) Pattern languages in HCI: A critical review, *Human Computer Interaction*, 21(1), 49-102.

Dribin, N. and Rickhoff, A. (2010) Media and the Museum: A Response to Learning Science in Informal Environments, *Curator,* 53 (4), 221–228.

Dubin, R. (1978) *Theory Building* (Rev. ed.), Free Press, London.

Falk, J. and Dierking, L. (1995) Introduction: A case for conducting long-term learning research in museums. In *Public Institutions for Personal Learning: Establishing a Research Agenda,* ed. J. H. Falk and L. D. Dierking, 9–14. Washington D. C.: American Association of Museums, Technical Information Service.

Fincher, S. (2002) Patterns for HCI and cognitive dimensions: Two halves of the same story?, *Annual Workshop of the Psychology of Programming Interest Group, June, Brunel University.*

Gregor, S. (2006) The Nature of Theory in Information Systems, *Managing Information Systems Quarterly,*

Gregor, S. and Jones, D. (2007) The Anatomy of Design Theory, *Journal of the Association for Information Systems*, 8(5), 312-335.

Kahr-Højland, A (2010) EGO-TRAP: A Mobile Augmented Reality Tool for Science Learning in a Semi-formal Setting, Curator, 53(4), 501-509.

Hooper-Greenhill, E. (1995) A museum educator's perspective. In *Museums and the Education of Adults,* ed.

A. Chadwick and A. Stannett, 49–64. Leicester, UK: National Institute of Adult Continuing Education.

IEEE (2002). *802.15.1: Part 15.1: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)*. IEEE Standards [online]. Institute of Electrical and Electronics Engineers Inc. Available online at: http://standards.ieee.org/getieee802/download/802.15.1-2002_sectionone.pdf.

Jones, D., Gregor, S. and Lynch, T. (2003) An Information Systems Design Theory for Web-Based Education, *Computers and Advanced Technology in Education,* 30 June-3 July, Rhodes, Greece.

Kress, G. and Pachler, N. (2007) Thinking About the "M" in M-Learning. In N. Prachler (Ed.), *Mobile Learning: Towards a Research Agenda,* WLE Institute for Education, London.

Lewin, K. (1958). *Group Decision and Social Change*. New York: Holt, Rinehart and Winston

Louviere, J., Hensher, D. and Swait, J. (2000) Stated choice methods: Analysis and applications, Cambridge University Press,

Luce, R. D. and P. Suppes (1965) "Preference, Utility, and Subjective Probability". In Luce, Bush and Galanter (Eds.) *Handbook of Psychology IIl, Wiley, New York.*

McFadden, D. (1973) Conditional logit analysis of qualitative choice models, In Zarembka (Ed.) *Frontiers of Econometrics*, Academic Press, New York.

OECD (2010) *The Nature of Learning: Using Research to Inspire Practice,* OECD Publishing, Paris.

Packer, J. and Ballantyne, R. (2002) Motivational Factors and the Visitor Experience: A Comparison of Three Sites*, Curator,* 45(3), 183-198*.*

Parry, R. (2005) Digital heritage and the rise of theory in museum computing, *Museum Management and Curatorship*, Volume 20, Issue 4, December 2005, 333-348.

Pujol, L. (2011) Integrating ICT in exhibitions, *Journal of Museum Management and Curatorship*, 26(1), 63-79.

Roussos, G. 2002. *Location Sensing Technologies and Applications*, JISC Technology and Standards Watch, http://www.jisc.ac.uk/index.cfm?name=techwatch_report_0208

Sein, M., Henfridsson, O., Purao, S., Rossi, M. and Lindgren, R. (2011) Action Design Research, *Management Information Systems Quarterly,* 35(1), 37-56.

Street, D. and Burgess, L. (2007) The construction of optimal stated choice experiments: theory and methods, Wiley and Sons, Sydney.

Thomas, J. (2003). Musings on critical ethnography, meanings, and symbolic violence. In R.P. Clair (Ed.), *Expressions of Ethnography*. Albany, NY: SUNY Press, pp. 45

Tidwell, J. (1998) Interaction design patterns, *Conference on Pattern Languages of Programming,* 3 August, Illinois.

Walls, J. G., Widmeyer, G. R., and El Sawy, O. A. (1992) Building an Information System Design Theory for Vigilant EIS, *Information Systems Research*, 3(1), 36-59.

Walls, J., Widmeyer, G. And El Sawy, O (2004) Assessing Information System Design Theory in Perspective: How Useful was our 1992 Initial Rendition, *Journal of Information Technology Theory and Application,* 6(2), 43-58.

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