Developing a DBR Model for Designing Authentic Healthcare Solutions: Mobile and Wearable Technologies

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This concise paper outlines the initial stages of a project involving a transdisciplinary team of educational researchers, practitioners, student designers, and the Auckland Hospital Design Lab in the design of innovative technology enhanced solutions to enhance patient and health care practitioner experiences. We outline the methodological design of the collaborative Design Based Research (DBR) approach. Using DBR, the project explores real world problems in health care with a team of student designers evaluating the application of mobile and wearable technologies to these problems. The goal of the project is the development of design principles for innovative learning environments that facilitate student-determined learning in real world scenarios.

Keywords: Design-Based Research, Authentic Learning, Heutagogy, Collaborative Assessment Design.

Introduction

Mobile and wearable technologies in healthcare have been identified as a significant research context driven by the almost ubiquitous ownership of mobile devices, and the predicted growth of social acceptance of wearable technologies (Rich & Miah, 2017). This is a real world context with problems that Universities can contribute towards authentic solutions. Initial explorations of the design of higher education courses in smart healthcare engineering indicate "positive impact on the learning process as well as a positive learning experience" (Rodić-Trmčić, Labus, Barać, Popović, & Radenković, 2018, p. 484) for students. This has led to establishing collaboration between hospital teams and university design teams to develop authentic health care solutions.

An example of the design problems that hospitals are ill-equipped to deal with is the identification of patients with restricted extremities. Restricted extremities refers to the restriction of access to upper limb(s) for drawing blood, obtaining intra-venous (IV) access or blood pressure (BP) monitoring. For example, patients with lymphoedema / AV fistula / thrombosis. Existing practice is to use a variety of colour coded wristbands, bracelets, compression sleeves and marking skin with either an indelible or surgical skin pen; each of these come with its own limitations and unanticipated adverse complications. Colour coding in particular presents a series of risks due to the lack of consistency in colours used to communicate specific clinical information across the different services in the hospital. Hence, the Health Quality & Safety Commission (HQSC) does not recommend the use of coloured wrist bands for any type of alert. An innovative solution providing an instant and effective visual alert is required to eliminate oversight of patients with restricted extremities in an environment that is over crowded with alerts of various shapes and forms. The end design solution should allow clinical staff to work and respond appropriately for these patients, providing better care and confidence for both patients and clinical staff.

The authors argue that Design Based Research is one approach to meeting the demands of these healthcare real world problems and designing authentic learning environments in higher education. Academics collaborating with students as designers in real world learning is a key element of educational design research (McKenney & Reeves, 2018), that is founded upon the principles of Design Based Research. Educational Design Research and Design Based Research are often used synonymously. These are the critical influences behind our project.

An Ecology of Wearable Technologies in Health Care

The project encompasses the exploration of several forms of visual (custom bands and watch faces), database-driven, multi-sensory input (such as voice, for example Siri) and feedback (visual, audio, proximity-based, and haptic) and biometric data (heart-rate sensing, fall detection, and ECG). Recent research validates the correlation between basic biometric data tracking and user/patient cognitive experiences (Aguayo et al., 2018).
Wearable technologies such as smart watches provide the basis for a customisable and unobtrusive approach to sharing patient information to a health care professional, via either the practitioners wearable device or their hand-held mobile device. A custom application will allow the health care practitioner to manage the notification data held upon a patient's wearable device, and choose appropriate options to be activated on a patient's wearable

device. This could include interactive patient notifications for; medications, directions, reminders, and alternative accessibility interaction from the patient via voice commands (for example Siri), and motion detection (for example the Apple Watch's built in fall detection). At a simple level, visual cues from the wearable device can take the form of custom designed and 3D printed colour-coded straps, and custom designed watch faces with select functionality for patient feedback and information. However, the use of wearable technologies opens up a wide variety of deeper and more flexible tracking of patient data. Some of the potential applications of wearable technologies in a health care context identified in an initial brainstorm include:

- Colour coded watch bands can easily identify the area of the patient's needs.
- Patients can be monitored either within the hospital or outside of the hospital thus reducing the needs of beds in hospital.
- If the patient has fallen over a wearable device can raise an automated alarm either within the hospital or away from the hospital.
- Blood pressure can be monitored automatically and sent to a nurse or central position.
- Notifications can be sent to the patient advising them of scheduled times for; medicating taking, exercise, appointments, location, navigation through unknown or unremembered environments (for example dementia or alzhiemers' patients).
- Family and friends can communicate with patients easily.

Research Questions

The problem of identifying restricted extremity patients is the first of many real world healthcare practice problems that the Hospital Design Lab have ear-marked for collaborative design with the University. As well as meeting the initial requirements of restricted mobility patients, the project aims to explore the wider potential of wearable and mobile technologies to enhance health care practice and the patient experience. The research questions underpinning the project are:

1. In what scenarios can wearable and mobile technologies most effectively enhance health care practice and the patient experience?
2. What are the design principles that can guide the development of authentic mobile learning collaborative student projects?

Methodology

The principal investigators (an academic advisor and an academic lecturer) bring a critical lens to the project team, and act as mentors and project managers to the student team. Through the Scholarship Of Technology Enhanced Learning (SOTEL) the project explores critical practitioner reflection on the design and implementation of technology enhanced learning environments founded upon learning theory. The project uses heutagogy (Hase & Kenyon, 2007) as a framework for designing learning environments that are student-centred and focused upon building student creativity, problem-solving, and life-long learning capabilities. Heutagogy builds upon the principles of constructivism (students build knowledge based upon prior experience), social constructivism (learning is a social process through which students build upon and extend their learning via learning from experts or more expert peers), and the importance of authentic problem based learning (real world projects), Heutagogy (a learning theory that focuses upon developing student capacity to navigate the unknown (Blaschke & Hase, 2015)) provides a theoretical framework for designing wearable and immersive learning environments that can impact student learning in a deeper way than traditional teacher-directed pedagogies. Heutagogy reframes teaching and learning as a collaborative endeavour between teachers or more experienced peers and learners, where learning is facilitated rather than mediated through teacher-directed content. The principles of heutagogy map closely to the core affordances of design based research (Blaschke & Hase, 2015), and provide initial principles for the design of authentic learning environments to facilitate student-determined learning that builds student capacity to problem solve and develop practical solutions to real world problems. Heutagogy can also be applied to patients' experiences. In this sense the project aims to empower patients through self-led action, within the ethical and safe practice limitations of the Health sector.

Design based research provides a structured, four-phase iterative framework (McKenney & Reeves, 2012) for designing interactive wearable and immersive reality (XR) learning environments for health education (Cochrane, Cook, et al., 2017). The four phases of the project are:

Phase 1: Analysis and exploration - Identification of the healthcare practice problem and the critical issues surrounding the application and design of authentic interactive wearable and XR learning environments, and exploration of supporting literature to identify initial design principles to address these issues.

Phase 2: Design and construction - Prototyping of the design of an interactive wearable and XR learning environment and healthcare practice intervention informed by the identified design principles.

Phase 3: Evaluation and reflection - Evaluation of the prototype interactive wearable and XR healthcare practice design through user feedback (Clinicians and volunteer patients), and refinement of the design principles.

Phase 2-3 Loop: Iterative redesign and re-evaluation of the prototype interactive wearable and XR healthcare intervention.

Phase 4: Theory building - Development of transferable design principles and dissemination of findings.

The project participants (outlined in the project team details table 1) comprise a collaborative transdisciplinary team of researchers, practitioners, student development team and the Auckland Hospital Design Lab. The project builds upon prior research in the application of mobile technologies for enhancing health care education (Aguayo, Cochrane, & Narayan, 2017; Aguayo et al., 2018; Cochrane, Cook, et al., 2017), particularly within the domains of critical care (Paramedicine) (Cochrane, Stretton, et al., 2018), nursing (Cochrane, Aiello, et al., 2018; Cochrane, Stretton, et al., 2017), and physiotherapy (Cochrane, Stretton, et al., 2018; Stretton, Cochrane, & Narayan, 2018). The project also builds upon prior research on the redesign of the visual design curriculum facilitating authentic student learning experiences through XR technologies (Sinfield, 2018; Sinfield & Cochrane, 2018).

Table 1: Project team details

Team Member	***Organisation***	***Role in research project***
Auckland Hospital Design Lab Manager	Auckland Hospital Design Lab	Overall project management
Auckland Hospital Clinical Staff	Auckland Hospital	Owners of the design intervention problem
Academic Advisor	Auckland University of Technology, Centre for Learning And Teaching	Principal investigator, educational technologist and student supervisor
Academic Lecturer	Auckland University of Technology, Art and Design	Co-Principal Investigator and academic/student supervisor
Research Fellow	Auckland University of Technology, App Lab	Coordinator of App Lab immersive reality application development team
Student 1	Auckland University of Technology, Art and Design	Student team leader
Student 2	Auckland University of Technology, Art and Design	Visual Design
Student 3	Auckland University of Technology, Colab	App Developer
Student 4	Auckland University of Technology, Art and Design	Prototyping Design

Establishing the Research and Design Team

The principle investigators have collaborated on several innovative curriculum design projects enhancing studio-based learning environments with mobile and immersive reality technologies (Sinfield & Cochrane, 2018). This led to the identification of health practice problems as real world design scenarios for student teams, and brokering of a potential design partnership between the University and the Auckland Hospital Design Lab. The project will be initially kick-started with the establishment of a team of 4 students funded by the University through 10-week 2019-2020 summer student scholarships. The recruitment of the initial student design team involves collaboration with several design-based departments across the University, including Visual Design, Colab, and Computer

Science. Managing these diverse relationships and providing appropriate access to working spaces and computers relies upon a model established by the Centre for Learning And Teaching (Frielick, Klein, & Probert, 2013). The key milestones in establishing the project are outlined in Table 2.

Table 2: Project timeline and milestones

Project Milestones	Project Timeline
Initial meeting of principle investigators and the Hospital Design Lab manager	February 2019
Scoping of a project MOU	July 2019
Fortnightly brainstorm/planning meetings of principle investigators and Hospital Design Lab manager	July 2019
Selection of first design problem	August 2019
Recruitment of student design team	Second Semester 2019
Initial project scoping and design team formation	10-week Summer 2019-2020 Student Scholarships
Analysis of first design problem	First Semester 2020
Prototyping of potential design solution	Mid First Semester 2020
Stake-holder evaluation	Second Semester 2020
Redesign of design solution and re-evaluation	Mid Second Semester 2020
Dissemination of first project outcomes	End of Second Semester 2020

As outlined in Table 2 the initial timeline for the setup stage of the project has taken significantly longer than anticipated. The process of building trust between the University research and project management team and the Hospital Design Lab team was complicated by prior experiences that the authors were initially unaware of. Rebuilding trust between the teams has been a critical step in the project. The next stage of the project involves the recruitment of the student team that will hopefully establish a longitudinal design team as students move from under-graduate to post graduate studies and potentially take the project as the basis of PhD research. Selection of a cross-disciplinary student team requires collaboration between several University Departments and academics, and negotiating roles, responsibilities, funding, and benefits to all. The availability of summer student scholarships from our Centre for Learning And Teaching for the University team to fund the initial scoping and prototyping of test design briefs has also been a key step to build confidence between the University and the Hospital design teams, to effectively kick-start the implementation of the project.

Conclusions

In this concise paper we have outlined a Design Based Research methodology for approaching real world problems as authentic learning environments for collaborative design teams that encompass real world stakeholders, academics as advisors and mentors, and students as designers. A significant first stage of the project establishment has been the building of trust between the principle investigator team and the key stakeholders of the real world problems – the Hospital Design Lab. Building this level of trust provides the foundation upon which the project will grow into a sustainable model of real world learning experiences for our students.

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