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IEA 2021 Patient Safety Design Competition

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Abstract. This paper reports on the Patient Safety Research and Application Competition that was held in conjunction with the 2021 International Ergonomics Association Conference. The objectives of this competition were to: (1) Formulate research problem statements and innovative solutions to improve patient safety through the application of human factors/ergonomics (HF/E) to the healthcare system, (2) Showcase how the HF/E approach to this topic can lead to a useful, usable, and satisfying user experience while simultaneously improving outcomes relating to both functional and non-functional requirements, and (3) Provide an effective way of engaging students and early career researchers in IEA activities and initiatives. After reviewing the patient safety topics that motivated the design competition, we then report on the work carried out by the two finalists in the competition, and discuss lessons learned. We propose the continued use of design competitions in the future to motivate and showcase ergonomic problem-solving design by students and early career researchers and practitioners.

Keywords: Human Factors, Ergonomics, Patient Safety, Clinical Deterioration, Educating Designers, Design Competition.

1 Introduction

1.1 Design Competitions

In recent decades considerable effort has been put into developing new methods for educating designers and creating innovative design technologies that can improve the way we live and work while respecting the world around us. As a design-oriented discipline, human factors and ergonomics needs to promote innovative design and to

incorporate best practices from other design-oriented disciplines. Design competitions of various types have come to be recognized as an important part of modern design pedagogy. Design of racing cars has been successful in motivating mechanical engineering students to learn about, and experience, design since 1981, when SAE International developed and managed the first Formula SAE student competition [1]. [2] discussed how to integrate this type of design competition within the design curriculum. Capstone design courses provide another kind of competition, having been part of the engineering curriculum for 40 years. Thus, design competitions of various kinds are a fixture of the engineering curriculum. They provide a way for students to put their knowledge into practice before they graduate [3] and typically have a competitive aspect, with prizes and recognitions for the best performing teams.

1.2 Design Competitions in Human Factors and Ergonomics

The Stanley Caplan User Centered Design Award is an annual award from the Product Design Technical Group of the Human Factors and Ergonomics Society (https://sites.google.com/corehf.com/ucd-award/). This annual award emphasizes innovative and user-centered approaches to Human Factors and Industrial Design, but is not specifically student, or early-career, focused. Design competitions have sometimes been run at the ACM SIGCHI Conference (usually referred to as "CHI") often with a focus on students (e.g., [4]). The CHI design competition has also been explicitly linked to student design projects (e.g., [5]). [6] described the use of design competitions as a pedagogical tool. In view of the advantages of design competitions noted above, we decided to run a design competition for the IEA 2021 conference.

2 Design Competition Topic: Clinical Deterioration Examples

Although design competitions have been used in other venues, they have not been a feature of IEA conferences. We sought to address this deficit by creating a design competition that focused on an urgent problem of relevance to the IEA community. The objective of the competition was to encourage students and Early Career Researcher (ECR) teams to collaboratively use their knowledge/skills in human factors and ergonomics to design a solution to prevent clinical deterioration. Failure to prevent avoidable clinical deterioration leads to the loss of many lives and is a major threat to patient safety in healthcare systems. Safety leaders such as Healthcare Insurance Reciprocal of Canada (HIROC), the Canadian Patient Safety Institute (CPSI), the Canadian Foundation for Healthcare Improvement (CFHI), and the International Society for Quality in Health Care (ISQua) have all called for action on the patient safety issue of failure to recognize, or appreciate and act upon, patient status changes or deterioration. Clinical deterioration is a key contributor to mortality and is among the top patient safety concerns globally. The failure to recognize, monitor, interpret and respond to clinical deterioration is a systemic patient safety concern (e.g. failure to monitor/interpret/respond to abnormal fetal status; failure to appreciate and respond to a deteriorating condition). The design challenge asked:

1) How can good ergonomic design and innovative solutions contribute to reducing avoidable harm and subsequent mortality, through early recognition

and intervention for clinical deterioration, and increase quality of life for patients and their family caregivers?

2) How can we design innovative and ergonomically informed environments, tools, fixtures, devices, methods and applications that will improve early recognition and intervention for clinically deteriorating patients and improve patient safety?

There were two tracks for this design competition; Track One covered solutions relating to workplace design, industrial ergonomics, and occupational health, and Track Two covered HCI/UX (human-computer interaction/user experience) solutions. The competition was advertised through IEA, HIROC, and HFIG networks and social media channels. Professors were emailed with courseware examples and other resources to encourage implementation in their classes, as a class project.

2.1 Clinical Deterioration Examples

The following clinical deterioration example topics were provided (Table 1), although the design competition teams were free to choose other related topics. We prepared a one-hour training video with an associated slide deck to explain the concept of clinical deterioration. We also provided a short textual description of each of the topics (excerpts from two of these summaries, for falls and for mismanagement of neonatal resuscitation, are shown below), and we held online question and answer sections with experts, for those contestants who wanted it.

Patient Falls. Injuries caused by falls frequently result in significant disabilities with loss of independence and associated costs. Safety is fostered by both fall prevention and by reducing the severity of injury should a fall occur.

Mismanagement of Neonatal Resuscitation. Post-delivery neonatal resuscitation has become a significant liability exposure for hospitals, perinatal practitioners and the resuscitation teams, particularly in cases where the infant sustained neurological injury not arising from the management of pregnancy, labour or birth.

Table 1. List of suggested clinical deterioration topics.

Sample Events
Failure to Monitor, Interpret or Respond to Atypical and Abnormal Fetal Health Surveillance (FHS) Patterns
Failure to Appreciate Status Changes/Deteriorating Patients
Death by suicide while under care/Suicide Attempts
Failure to Identify/Manage Neonatal Hyperbilirubinemia
Failure to Identify/Manage Neonatal Hypoglycemia
Delayed Decision to Delivery Time for Caesarean Sections
Patient Falls
Mismanagement of Neonatal Resuscitation
Failure to Communicate/Respond to Critical Test Results
Inadequate Triage Assessment/Reassessment
Failure to Communicate Fetal Health Status
Failure to Identify/Manage Postpartum Hemorrhages and Hemorrhagic Shock

3 Design Competition Finalists

We selected two teams to be finalists and present their work at a special session of the IEA conference. As described below, one team proposed an ergonomic redesign within an oncology department, and the other team addressed mental health issues for women who have recently given birth.

3.1 Redesigning Procedures in an Oncology Department

The first team carried out an ergonomics study in the Oncology Department at Trillium Health Partners Hospital in Mississauga, Ontario. Their goal was to reduce the risk of clinical deterioration by improving the wellbeing of nurses and the operational performance of the department. The team conducted informal interviews with nurses, as well as collecting both quantitative and qualitative observation data about the current situation. Based on the results of this observation they decided to focus on the tasks of 1) transferring patients from beds to gurneys and vice versa; 2) retrieving items from the supply closet. The team focused on novel designs that could reduce physical load and mental strain while performing the tasks. Due to the ongoing COVID-19 crisis, it was not possible to evaluate the designs in the hospital setting. Thus the team proposed further work to demonstrate the extent to which the designs can improve nurse well-being and lead to better system performance. Two examples of the work performed are shown below.

1. A redesign of the patient transfer cloth would be implemented in order to ensure the posture used during patient transfers is an upright reach and pull rather than a bent-forward reach and pull. Implementing the change would result in a reduction in joint shear experienced by the 5th percentile female from 368N to 325N, representing an 11.7% reduction in joint shear as can be seen in Fig. 1 below.

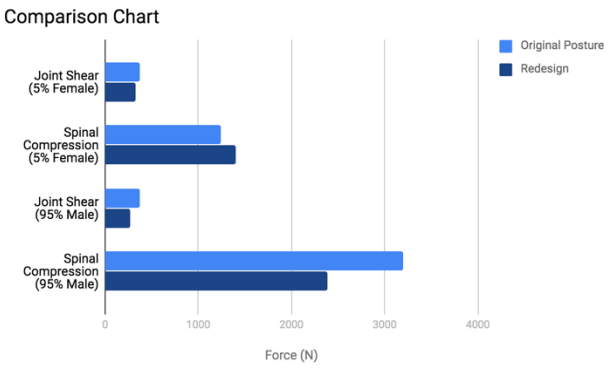

Fig. 1. Force Comparison on Human Body for Work Postures

2. To improve item retrieval, each supply room can be equipped with a Tablet for around $250 Cdn each at the time of writing. The tablets should have at least a 5-year

lifetime and should be mounted on the wall with the charger in each supply room. An Excel file on the tablet would have multiple excel tabs that are coloured-coded, matching corresponding coloured sections of the storage cabinet, making it very easy to locate items.

3.2 A Postpartum Mental Health Tool

The second team focused on the issue of postpartum mental health. Approximately 85% of new mothers experience negative changes in their mood during the postpartum period, which may manifest as various mental health conditions including postpartum depression (PPD) and postpartum blues [7]. In researching literature, personal blogs, and available solutions, it was found that most existing technological solutions provide a range of resources for monitoring infant health but are lacking in features that promote maternal well-being for the postpartum period [8]. The team designed a mobile application, called *Nura*, to provide new mothers with tools and resources, encouraging them to focus on their own well-being, as well as their infant's.

To effectively promote maternal mental health during the postpartum experience, the *Nura* App aims to focus on the three user experience goals of (1) **Streamlining the flow of information**, which will lessen information overload for users (which can often lead to misinformation and additional stress for young mothers) [9]; (2) **Customizability**, which will allow the users to make specific changes, such as notification times for appointments, to fit their individual needs; (3) **System driven personalization** which will offer mothers a unique user experience based on data they provide while registering, throughout their use of the App.

In order to achieve these goals, the *Nura* team carried out a user-centered design process, starting with the objective to understand and empathize with the user. The team interviewed two potential users (mothers with young children) to gain additional perspective to aid in the formation of requirements and user personas. Based on the interviews and supplemental research of the e-health space, 6 technical and non-technical requirements were developed, as well as 2 personas to drive the design. After creating scenarios and use-cases, the team decided to re-frame the product from a "psychological" or "mental wellbeing" platform to a self-care application due to mothers feeling uncomfortable interacting with a "mental wellness" app. Next, the team created four low-fidelity prototypes, using a parallel design paradigm [10], leading to the example wireframes (one for each of the four prototypes) shown in Fig. 2.

Fig. 2. Four Independent Low-Fidelity Prototypes.

The low-fidelity prototype alternatives were then narrowed down to create two unique and distinct medium-fidelity prototypes, which were evaluated with a comparative usability test to determine which design better met the team's usability, utility, and satisfaction goals. The usability tests were conducted remotely with two young mothers (the target audience) and two students (usability experts). The quantitative and qualitative data collection methods used were a System Usability Scale, Usability-Satisfaction Scale, Think-Aloud Protocol and a User Questionnaire.

After conducting comparative usability tests on the two designs, the team created a high-fidelity prototype which integrated desirable aspects of the earlier prototypes, while improving upon or eliminating features that were deemed unsatisfactory.

A heuristic evaluation was then done on the high-fidelity prototype, providing the designers with an opportunity to identify shortcomings within the design based on established usability principles. The prototype was evaluated based on Jakob Nielsen's set of 10 usability heuristics [11]. Various issues and strongpoints were identified and rated according to severity, and reflective changes were made in the prototype based on the discoveries from the heuristic analysis (an example of which can be seen in Fig. 3, where "Select all that apply" was added to cue appropriate input).

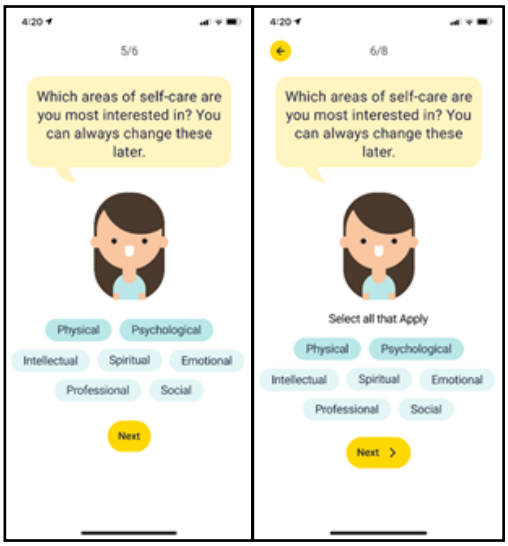

Fig. 3. Onboarding Form Before (left) and After (right) Heuristic Evaluation.

The next step in the development of the *Nura* app would be collaboration with subject-matter experts to determine how clinicians (primarily obstetricians) can best use the app to promote wellness of mothers postpartum.

4. Conclusions and Key Lessons

We faced a number of challenges in running the design competition, with the biggest challenge being the COVID-19 pandemic which was ongoing during the competition. Teams had difficulty carrying out the user research necessary for requirements analysis, and for user evaluation of design alternatives, although video conferencing was found to be a powerful tool to support the collaborative design work. Teams also had difficulty addressing the official topic of clinical deterioration, which was relatively unfamiliar to them, and typically picked topics of a more general nature that were likely easier for them to understand and get data on from secondary sources (which was not surprising given that their opportunities to collect data in hospitals were severely limited). Aside from the pandemic we also experienced problems in getting the design competition assigned as a project in university courses, which had been our preferred strategy for recruiting participants.

For many professors that we approached, the timing of the competition did not match the timing of their courses, particularly in different countries or in universities that had a quarter system vs. a semester system. Students and professors also had difficulties understanding, or perhaps warming to, the topic of clinical deterioration which was outside their general experience. Even when the design competition was assigned as a course project there were problems getting students to formally enter the design competition. For instance, in one course participation was voluntary, and as a

result only one out of 7 project teams for that class submitted their work to the design competition. In spite of these challenges we judge the design competition to be a success and we plan to keep running it in future years, and with a range of conferences, using iterative design to improve topic selection, communication with professors, and mentoring of teams. Our IEA 2021 design competition was a kind of "pop-up" competition which didn't have a history behind it and didn't have people planning to participate in advance of the competition launch. In future, having a regular design competition will encourage professors and students to plan ahead, and should lead to more adoptions of the design competition as a course project.

The sharing of good practice is essential for the principles of HFE to spread, and healthcare is just one of a number of important and highly relevant fields for design competitions to address. Having an annual competition, with accessible topics for university students, should increase uptake of the design competition within courses, not only increasing the size of the design competition but also enhancing its role as a pedagogical tool.

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