Purdue Journal of Service-Learning and International Engagement

Smart Health Monitoring System: A Human-Centered Design

Dolzodmaa Davaasuren
Purdue University, ddavaasu@purdue.edu

Jordy Timothy
Purdue University, jtimothy@purdue.edu

Askar Zhapbassov
Purdue University, azhapbas@purdue.edu

Tahmeed Rafee
Purdue University, trafee@purdue.edu

Prim Boonwisut
Purdue University, pboonwis@purdue.edu

See next page for additional authors

Follow this and additional works at: https://docs.lib.purdue.edu/pjsl

Part of the Medicine and Health Sciences Commons

Recommended Citation

Smart Health Monitoring System: A Human-Centered Design

Authors

Dolzodmaa Davaasuren, Jordy Timothy, Askar Zhapbassov, Tahmeed Rafee, Prim Boonwisut, and Raymond Tanudaja
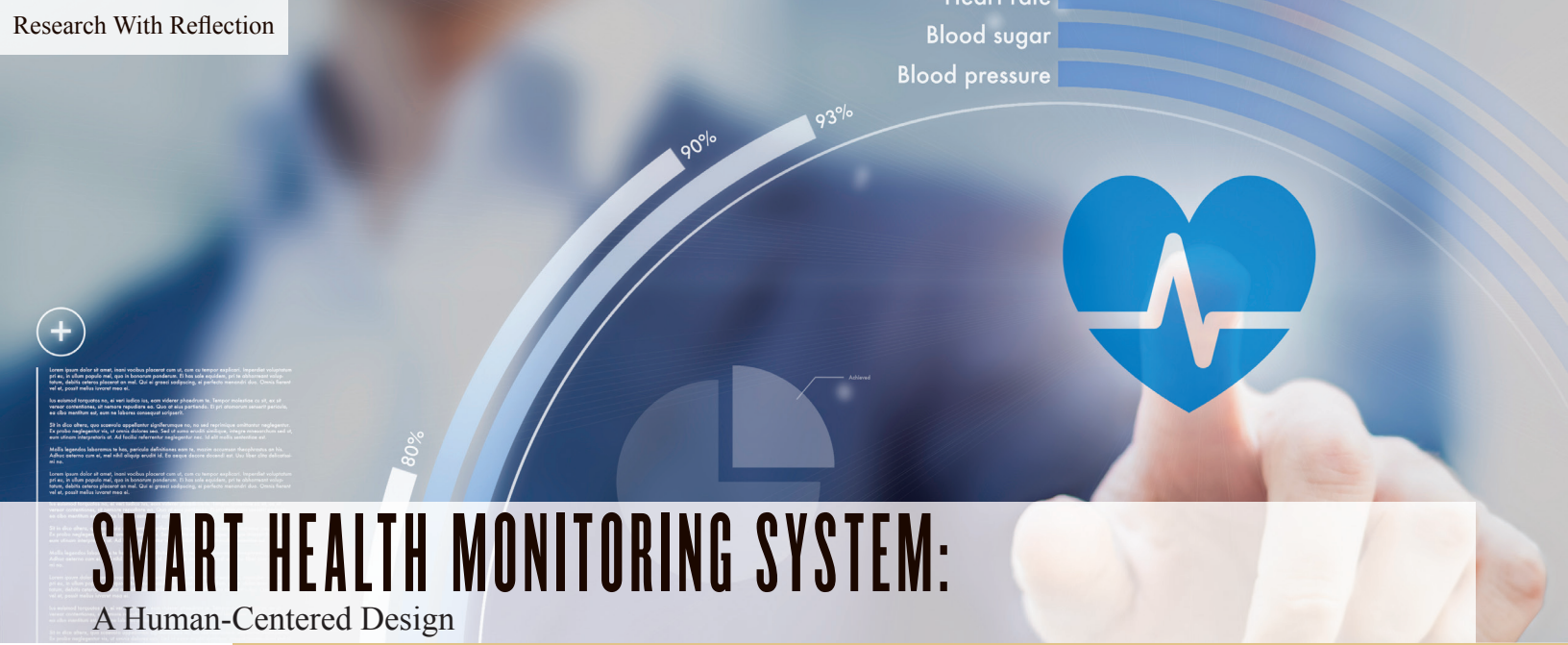
SMART HEALTH MONITORING SYSTEM:
A Human-Centered Design

Dolzodmaa Davaasuren, Jordy Timothy, Askar Zhapbassov, Tahmeed Rafee, Prim Boonwisut, and Raymond Tanudjaja, College of Engineering
Contributors: Raymond Gerry Susilo and Dennis Karunia, College of Engineering

Dolzodmaa Davaasuren, Jordy Timothy, Askar Zhapbassov, Tahmeed Rafee, Prim Boonwisut, and Raymond Tanudjaja are fourth-year students in industrial engineering at Purdue University. They all share a common interest in the health care industry. In this article they describe how they developed a health monitoring device prototype within the course titled Work Analysis and Design II (IE 486).

INTRODUCTION

Work Analysis and Design II is a required course for students enrolled in industrial engineering at Purdue University. In this class, we worked as a team of six students to develop a health monitoring device prototype, in collaboration with two students enrolled in the course titled Job Design (IE 556). We also incorporated concepts learned in Integrated Production Systems I (IE 383), which is about improving the system of an industry.

In a hospitalized patient, achieving full recovery can depend on the patient's health care providers. According to the book *Keeping Patients Safe*, nursing actions such as the ongoing monitoring of patient health status have been shown to be directly related to better patient recovery (Page, 2004). When there are not enough health care providers to monitor patient health status, the hospital may divert the patient to other doctors or restrict patient admissions, placing the patient's health at risk. In the United States, there is a discrepancy between the supply of and demand for certified nurses. This nursing shortage is predicted to increase,

as the country's population is expected to grow by 18% between 2000 and 2020 (Page, 2004).

Our team is addressing this problem by suggesting the development of a new health monitoring device in the form of a wristwatch that measures certain health parameters. The device continuously sends the health data to the doctor via wireless transmission, allowing practitioners to monitor vital parameters that could arise unexpectedly. The device also improves communications between the patient and his or her doctor. Our proposed device is a smart design because it is a self-monitoring, self-measuring system that is user-centered. This device could help alleviate some of the tasks that nurses complete when checking in or checking out a patient, thereby reducing the length of patient health care check-ups. The device may also assist in reducing the number of visits. The prototypes relate specifically to the service provided; they are computer app designs for the doctor to monitor the patient's health condition and a smartphone app for the patient to track his or her own health conditions.

METHODOLOGY

At the start of the project, we had to decide whether our health monitoring device should be a wearable or an under-the-skin device. We decided to go with wearable based on feedback from peers that it would be easier for patients to use the device. The majority of our project work revolved around the project concept and user interface aspects of the device. The interface prototypes were developed using Balsamiq tools for wireframing and developing basic functions of the intended interface.

We approached the project by brainstorming ideas on the design of the interfaces of the device and the software for the doctor. Each team member designed prototypes on their own. We then rated the three best prototypes and further analyzed them using cluster analysis, Statistical Package for the Social Sciences (SPSS), and analytical hierarchy process (AHP) methods. Each method analyzed distinct components of the prototype.

After some initial brainstorming, our team then performed hierarchical task analysis (HTA) to identify key functions our solution needs to perform. We divided the process into primary tasks such as "monitoring patients' health" (for doctors) and "track your own health" (for patients). After that, smaller tasks were brainstormed and added to the picture. Examples include transferring data into a database, providing a warning signal, and notifying a doctor if the patient's health is at risk.

Tasks Description

Tasks are different for the patient and the doctor. General tasks in designing the interface for the doctors include: (1) login page (user information is saved in the server), (2) navigation of the tabs (patient search, doctor's profile, patient data), (3) doctor's profile page, (4) patient search page, (5) each patient's data page with history and current data, and (6) diagnosis page. For patients, these general tasks include: (1) device installation on the patient, (2) pain interface with general health status, (3) alert system, and (4) message from the doctor.

Structural Equation Modeling Analysis

The main purpose for conducting structural equation modeling (SEM) is to evaluate the correlation between latent variables (usability, aesthetics, etc.) and the variables we were able to measure. That way, we can determine which factor most contributes to the usability and interface design.
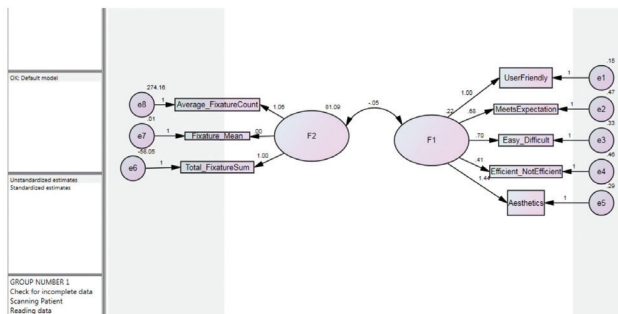

Figure 1. SEM for patients in SPSS.

In this SEM model for patients' interface design (Figure 1), F1 is the user interface and F2 is usability. We can see from the SEM that there is a relationship from the prediction between Average_FixationCount and User Interface, with the maximum coefficient (1.06), followed by Total FixationSum (1.0) and Aesthetics along with Usability as maximum (1.44). This implies that the participants (patients) rate the usability of the app higher when pages are high on aesthetics. In other words, when the pages on the patients' user interface look pleasing, users rate the patients' interface high on usability.

SEM for Doctors

Again, latent variables, F1, are called User Interface and F2 is the Usability of the app (Figure 2). We can see from the SEM that there is a relationship from the prediction between Average_FixationCount and User Interface with the maximum coefficient (2.03), followed by Total_FixationSum (1.0). This implies that the pages are complex, difficult to understand, or have too much
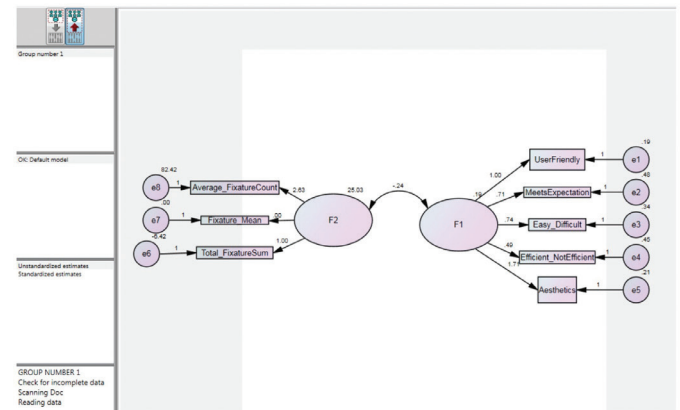

Figure 2. SEM for doctors in SPSS.

information. However, since the targeted user is a doctor, we presumed that he or she would need all of the information in the prototype. The prediction between Aesthetics and Usability is maximum (1.71). This implies that the participants rate the usability of the app higher if they feel that the pages are high on aesthetics. In other words, the pages on the doctors' user interface are pleasing to the eye, which is why the users score the doctors' interface high on usability.

AHP Analysis

We performed an AHP analysis for our three prototypes: prototype 1, prototype 2, and prototype 3. We ranked the prototypes based on tester feedback and decided on the criteria that both the testers and we believed to be the

	A	B	C	D	E
1			Scores for Alternatives		
2	Criteria	Weights	Prototype 1	Prototype 2	Prototype 3
3	Complexity	0.390	0.633	0.260	0.106
4	Usability	0.390	0.685	0.136	0.179
5	Creativity	0.134	0.429	0.429	0.143
6	Choice of visuals	0.087	0.455	0.091	0.455
7					
8	Weighted Ratings		0.611	0.220	0.170
9					
10	B3:B6 represent the weights for each of the criteria				
11	C3:C6 represent Prototype 1's weights for each criterion				
12	D3:D6 represent Prototype 2's weights for each criterion				
13	E3:E6 represent Prototype 3's weights for each criterion				

Figure 3. AHP analysis results.

most important. The final results of our AHP analysis are shown in Figure 3.

RESULTS

Cluster Analysis

Cluster analysis was executed for three of our prototypes. The purpose of this analysis was to evaluate how each prototype captures eye fixations of the testers. First, we obtained the eye-tracking data from the Discovery Learning Research Center (DLRC) at Purdue. We then analyzed the eye fixation through the gaze plot, heat map, and cluster map. Using this method, we determined whether potential users were attracted to the main focus on each slide of the prototypes.

Analyzing the cluster result from eye-tracking data, we derived that each prototype achieved the goal. The testers focused on the important aspects, such as information on health parameters or direction tabs, instead of blank spaces of the prototype. There are some outliers on the second prototype where the tester actually focused on blank spaces. Each cluster shows the percentage share of the testers who have their eyes fixated in that particular area.

The heat map (Figure 4) shows that participants are interested in almost all segments of the page—the profile picture, the short bio, the date, and the various tabs available on the left-hand side.

For our subjective evaluation of our final prototype, we created five Likert scale questions, which are listed in Appendix A. The participants used for this evaluation were students enrolled in the spring 2016 IE 486 class. Questions related to the usability, visible appearance, and usefulness of our prototype. As seen in the pie chart (Figure 5), feedback was positive. Based on the

eye-tracking testing experiment, a total of 69% of the participants were highly satisfied with our prototype.

After considering the results from all these analyses, we devised the final prototype (see Figure 6).

IMPACT

Our team targeted organizations such as hospitals and clinics for use of this system. Our team goal was to design a prototype for this new smart service system. Our future goal involves testing our device at hospitals or clinics and obtaining feedback from users in order to improve access to, the efficiency, and the safety of the
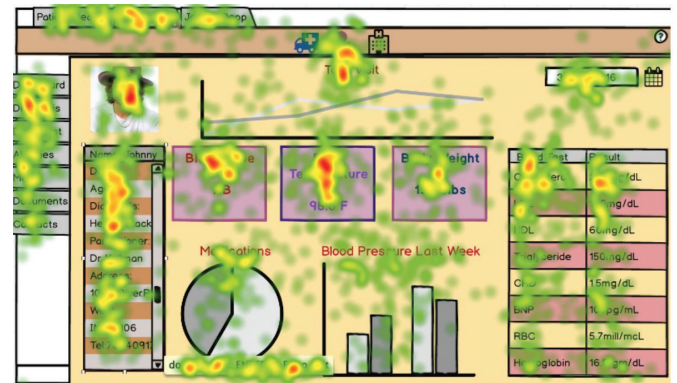

Figure 4. Heat map result of prototype 1 using Tobii eye tracking software.

device. Interested organizations may request assistance from our team to implement the smart service system and to ensure that it gathers information properly and is safe, user friendly, and accessible. From the questionnaire, we obtained feedback that showed that most users were satisfied with the system. Our system was designed to optimize operations within a hospital or clinic setting by allowing patients to monitor their own health to prevent serious complications or conditions and save valuable time. Doctors can also easily track patients' health through the device. It is our goal that hospitals
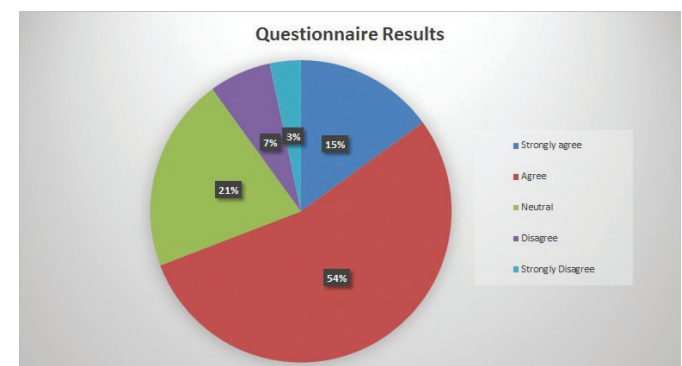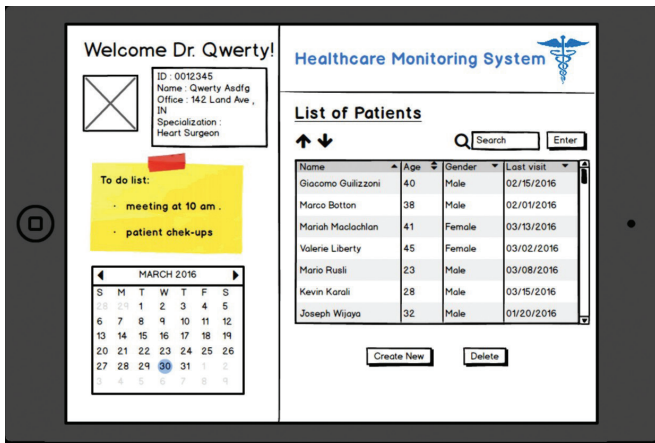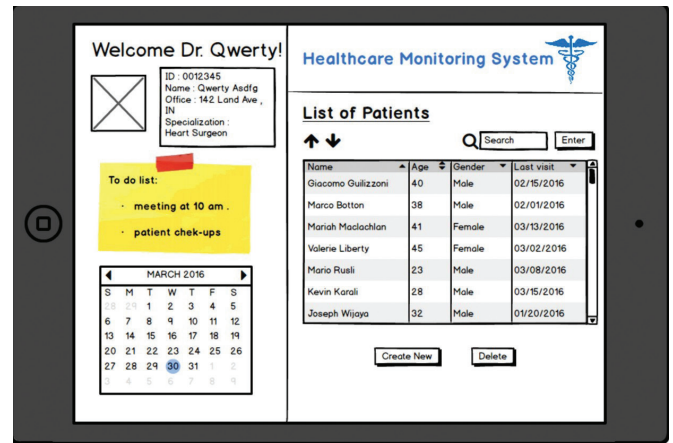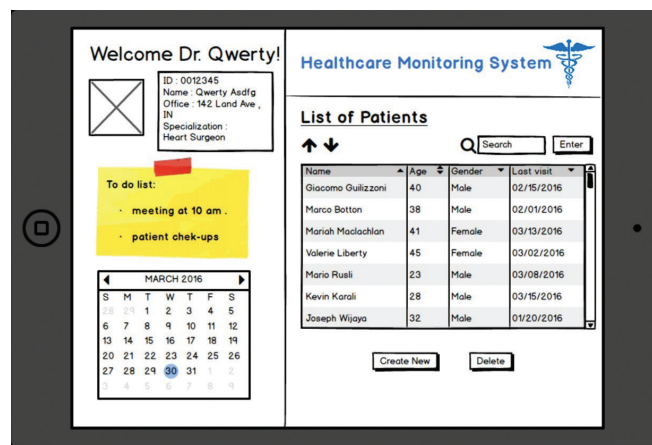

Figure 5. Questionnaire results.

Figure 6. Final prototype: (a) login page, (b) personal profile page for the doctor, and (c) patient information page shown in Balsamiq.

will require less skilled nursing care, resulting in monetary savings for the hospital. In the short term, our plan is to discuss piloting the device within the Purdue University Student Hospital (PUSH), with a long-term goal of applying it in other health care systems.

This project encompasses both service and system learning. Our learning process was insightful and required incorporation of new methodologies, literature, and theories. The overall theme of our project ("smart system") is highly correlated with our plan of study as industrial engineers in which we are expected to be able to merge technical and service aspects with user experiences. This project gave us an opportunity to perform multiple analyses from different points of view.

From the technical field, we incorporated new, ongoing research about under-the-skin and wearable tracking devices. Our team merged this technology with a service industry. We learned how to effectively choose a topic of

interest by using the AHP rating system, creating a software mock-up using the Balsamiq platform, analyzing tester behavior using cluster analysis, and evaluating the system using an SEM model. Our team prepared for the project by conducting multiple literature reviews before finalizing our topic. Initially, we had multiple areas of interest. After discussions, we focused on the health care industry and our common interest in health monitoring devices. Reflecting back, we would have conducted more extensive literature reviews in each area of interest before deciding on a topic.

There were some challenges throughout the project. For instance, we were not able to acquire the test data from the testing center within our proposed time frame due to a lack of participants to test our prototypes. This hindered our progress in terms of analysis. However, we overcame this problem once we obtained the data by working extra hours to meet our deadlines. We also found it challenging to interpret the eye-tracking data.

However, our advisors from IE 556 were there to help us analyze the data and provide insightful recommendations to assist us in completing the project.

CONCLUSION AND RECOMMENDATION

In conclusion, our team designed a self-monitoring health device that tracks important health parameters including blood pressure and body temperature. The wearable device is designed for use by health care professionals and their patients when the patients are away from their providers and health care facilities.

In the future, we plan to contact local hospitals in regard to pilot testing and feedback. Based on this feedback and subsequent improvements to design and functionality, we would like to launch our device in the marketplace. Our long-term goal is to incorporate this technology into a phone application, which would reduce cost by eliminating the need for the production of a wearable device.

We believe our device could have a positive impact on doctors' and patients' ability to effectively perform their roles. Working on this project has helped us, as engineering students, realize the importance of health care technology in improving people's lives. We all agree that a career focused on improving the efficiency of the health care system would be very interesting.

ACKNOWLEDGMENTS

REFERENCE

Page, A. (Ed.). *Keeping patients safe: Transforming the work environment of nurses.* Washington, DC: The National Academic Press. Retrieved from http://www.nap.edu/read/10851/chapter/1

SUGGESTED SOURCE

Weisfeld, V., & Lustig, T. A. (2015). *The future of home health care: Workshop summary.* Washington, DC: The National Academic Press. Retrieved from http://www.nap.edu/read/21662/chapter/1

Davaasuren, D., Timothy, J., Zhapbassov, A., Rafee, T., Boonwisut, P., & Tanudjaja, R. (2016). Smart health monitoring system: A human-centered design. *Purdue Journal of Service-Learning and Engagement, 3,* 55–59. http://dx.doi.org/10.5703/1288284316176

APPENDIX A

Questionnaire

Rating Scale for Questions 1–6: => Strongly Agree => Agree => Neutral=> Disagree => Strongly Disagree

1. Our prototype is user friendly and easy to use.
2. Our prototype does everything it is expected to do.
3. Our prototype will make the process of hospital check-in easier.
4. Our prototype will allow doctors to monitor patients' health effectively.
5. Our prototype interface is aesthetically pleasing.
6. The font of the interface is well-readable.

Rating Scale for Questions 7–9: = >1(Worst) =>2 =>3 =>4 =>5(Best)

7. How would you evaluate prototype 1?
8. How would you evaluate prototype 2?
9. How would you evaluate prototype 3?

Rating Scale for Question 10: =>1(Never) =>2 =>3 =>4 =>5(Very Likely)

10. If you were a medical practitioner how likely would you be willing to use our system?