ISSN: 2473-3857
v3 n4481

Teaching Case

Practicing the Concept of Fit in a Human-Computer Interaction Classroom Through Paper Prototyping

Michael J. Scialdone
Michael.Scialdone@fredonia.edu
Computer & Information Sciences
State University of New York Fredonia
Fredonia, NY 14063, USA

Amy J. Connolly
conno3aj@jmu.edu
Computer Information Systems & Business Analytics
James Madison University
Harrisonburg, VA 22807, USA

Abstract

In computing degree programs, human-computer interaction (if offered) is often an elective. Even in industry, interface design can be easily overlooked, sometimes causing dire consequences. Due to the need for and difficulty in teaching this interdisciplinary topic, we present a few examples of paper prototyping helpful for teaching students about the concept of "fit". These exercises are easily implemented in any computing classroom without extensive training or preparation. They are interesting, challenging, and fun for students. This case study provides background for the teacher, specific instructions to prepare for, set up and teach the exercises, and examples of student work. These active learning exercises are flexible for technical and non-technical computing majors and suitable for computing courses at any level.

Keywords: Human-Computer Interaction, paper prototyping, fit, usability, active learning

1. INTRODUCTION

A useable computing interface can make all the difference when it comes to life or death, as this example vignette illustrates. Meet Dale, a 62-year old woman entering an urgent care center. To reduce wait times, the city's busiest urgent care implemented new kiosks to help automate check-in. Upon entering, Dale taps the big "CLICK HERE TO CHECK IN" button on the screen. The screen requests common medical data: name, insurance carrier, social security number, emergency contact, and so on. The list seems to go on forever. Dale struggles for a moment, looking for a physical keyboard, before realizing, "Oh, it's like an iPad!" She taps on the first field, and a digital keyboard raises up from the bottom. Although left-handed, she types with her right hand, which now feels shaky. An intense pain in her left shoulder is making her feel anxious. She taps the "NEXT" button, but a message flashes across the screen: "Error! Insurance ID is a required field!" It seems to lock up. She curses aloud to an empty room. She can't recall the numbers and her wallet is lightyears away, forgotten in the car. She pokes her finger on the "NEXT" button feverishly, but nothing happens. She feels upset, defeated, and now, scared. The room begins to swim. She sees spots and hears loud talking. Maybe someone is coming to help. "Just another panic attack," she thinks, as her heart fails. A real person could have helped her. Instead she has collapsed to the floor

ISSN: 2473-3857
v3 n4481

in front of the poorly designed interface on a kiosk in an empty waiting room.

This vignette is a facetious scenario in which the designers of the user-interface for the kiosk did not appropriately consider the range of potential users' physical, cognitive, and affective states. Given society's recent penchant for over-automation, this scenario is not unimaginable.

Automation forces us to interact with computing technology daily for mundane and extraordinary tasks. Dale's example is important for computing students to understand when designing software, especially as it relates to the interface; the point where the human interacts with the machine. It demonstrates that while the kiosk was useful because it automated check-in at the urgent care center, its lack of usability lead to harmful and unintended consequences.

In the following paper, we present a teaching case in which the aforementioned scenario could produce different outcomes. The case focuses on a prototyping exercise in an introductory, undergraduate Human-Computer Interaction (HCI) course. We begin with a brief background about the scope and coverage of HCI, the concept of fit as a key construct of usability, and an overview of paper prototyping. We then detail the exercise as applied in an introductory HCI class including instructions, materials needed, and points for discussion. Next, we provide a discussion that contextualizes our application of, and experience with, the exercise to help other teaching professionals adopt or adapt this exercise to their needs. Finally, we conclude with a summary of this work.

2. BACKGROUND

To orient the reader on how we employed paper prototyping as a classroom exercise, we present an overview of the concepts the activity was designed to reinforce (fit within HCI), and some applications of paper prototyping.

Human-Computer Interaction and Fit

The field of HCI is "concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" (Hewett, Baecker, Card, Carey, Gasen, Mantei, Perlman, Strong, & Verplank, [1992] as cited by Zhang, Benbasat, Carey, Davis, Galletta, & Strong, 2002, p. 335). The goal of the field, in practice, "is achieving high usability for users of computer-based systems" (Hartson, 1998, p. 103). By usability, we mean the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11, 1998).

HCI draws from "computer science, psychology, management information systems, information science, and human factors engineering" (Carey, Galletta, Kim, Ten'eni, & Wildemuth, 2004, p. 357). Different fields both contribute to and derive emphases from it. In our exercise, HCI is positioned as a sub-field of IS, and the focus is on "the ways that humans interact with technologies for various purposes" (Zhang & Li, 2005, p. 228). This view maintains that there are two core components: humans and technology. The driving force is to understand phenomena based on how one or more aspects of humans interact with technology for one or more tasks within a given context. Interaction is investigated in terms of both the design and use (and/or impact) of an information system (Zhang & Li, 2004, 2005). Furthermore, the "human" is <u>first</u> in the title as research and development focuses on "concern about humans, not in a sense that would interest a pure psychologist, but in the ways that humans interact with technologies for various purposes" (Zhang, Li, Scialdone, & Carey, 2009, p.56).

Human factors may range on multiple dimensions including, but not limited to: demographics, physical or motor abilities, cognitive issues, or affective and motivational aspects. Technology, meanwhile, is loosely defined as a researcher may investigate diverse characteristics based on hardware, software, procedures, data, information, applications, or knowledge (Zhang & Li, 2005). Given this emphasis on the human, HCI instruction must necessarily facilitate students' experience with "methods and skills to understand current users, to investigate non-use, and to imagine future users" (Churchill, Bowser, & Preece, 2016, p.70). That is, understanding how human abilities and limitations impact interface usability allows us to create "better, more successful" technologies (Cooper, Reimann, Cronin, & Noessel, 2014, p. xxiii).

One approach is focusing on the concept of fit: the extent to which a computing technology's characteristics, given a task or set thereof, promotes efficient and effective human performance and well-being. It is best conceptualized on three separate but related dimensions: physical fit, cognitive fit, and affective fit (Te'eni, Carey, & Zhang 2006).

ISSN: 2473-3857
v3 n4481

The notion of physical fit is analogous to the more-familiar concept of ergonomics and, to some extent, accessibility. It is an accounting of the abilities and limitations of our human physiology and how the designed input/output mechanics of computing devices may maximize productivity while minimizing physical effort (Te'eni et al., 2006).

Meanwhile, cognitive fit assumes that when the design and output of a user interface matches a user's mental model and skill level, then the user can accomplish a corresponding task effectively. In other words, "when the problem representation and the task both emphasize the same type of information" (Vessey & Galletta, 1991, p. 67). Finally, affective fit is the extent to which positive affect (or another desired affective state) can be influenced by the design of a user interface (Avital & Te'eni, 2009).

Paper Prototyping

Prototypes tend to be early iterations of a project in-process, representing a preliminary model. In software design, prototypes can be used to receive user feedback and save money because "it's 100 times cheaper to make a change before any code has been written than it is to wait until after the implementation is complete" (Nielsen, 2003, para. 6).

Paper prototyping, also known as low-fidelity prototyping (Rettig, 1994), or throwaway prototyping (Vijayan & Raju, 2011), is not new. IBM popularized it during the 1980s as a technique for software developing and designing processes. Since then, the design community has accepted this as a useful approach to creating user interfaces (UIs). In its simplest form, paper prototyping is "building prototypes on paper and testing them with real users" (Schultz, 2008, p. 21). Although such prototypes may seem crude, research shows they produce similarly critical feedback in terms of quantity and quality when compared to computer-based prototypes (Sefelin, Tscheligi, & Giller, 2003).

While Schultz (2008) notes paper prototypes are arguably less useful for coding a workable product, our goal was not to teach students prototyping mastery via paper. Although this may be a beneficial skill, our exercise was designed for students to reflect on physical, cognitive, and affective fit (and related concepts), and then apply these to UI design, regardless of their technical programming skills.

3. A PAPER-PROTOTYPING EXERCISE

In this section, we present instructions for the paper-prototyping exercise as developed in an introductory HCI undergraduate course. These are general enough to be adapted by other instructors, but specific enough to describe how they were used in the classroom.

Overview of Exercise

This activity required students to reflect on the physical, mental, and emotional abilities and limitations of potential users; corresponding to the notions of physical, cognitive, and affective fits, respectively. They were charged with designing an urgent care kiosk like the one described in our opening example.

This problem was chosen because it is feasible that anyone coming into a medical facility may have a physical injury or limitation that would impact data entry. Some examples of dimensions that one might consider for physical fit include accommodations for impairments or limitations related to: hearing, motor skills, arm reach/length, muscular strength (in hands or arms), and visual ability (including clarity, light sensing, and color sensing) (Te'eni et al., 2006).

Similarly, a given medical condition or disability could impact one's mental processes while checking in, making it harder to understand, process, and input data. Two key dimensions to be considered here are that of attention and memory. Factors to be mindful of include: how an interface might present choices using structuring, color, spatial, and/or temporal cures; divided attention among tasks using multiple windows; and reminders to the user of where in the check-in process they were prior to an interruption (Te'eni et al., 2006). These are particularly important dimensions to account for as "the basic cognitive functions most affected by age are attention and memory" (Glisky, 2007, p.4), while 21.5% of emergency room visits are from adults 45-64, while 15.4% come from those 65 and over (National Center for Health Statistics, 2014).

Finally, since urgent care centers handle medical emergencies, users are likely to be anxious or emotional, and therefore more error-prone. Accommodations that should be considered are to make actions easy to undo, navigation through the check-in process easier, and following best-practices for error messages as to not exacerbate any user frustration. Examples of guidelines for errors is to avoid terms like bad, invalid, or fatal; audio and visual warnings, avoiding all uppercase text, precise messages (quick and easy to read),

 ISSN: 2473-3857
v3 n4481

and context-sensitive (as opposed to general) help for a given action (Shneiderman, 1998).

Exercise Directions

Students are introduced to paper prototyping through a YouTube video (Yun, 2007) in which a completed email software prototype is "tested" by one person, while another manipulates the paper to demonstrate interaction. Next, students are advised they will be designing an interface for a different device with paper. They're told they have 45 minutes to complete the prototype individually. After 45 minutes, they will find a partner and test their prototype for 2-3 minutes. Then, they would be allowed to make any desired revisions. They could then test with a second student, and revise one more time before demonstrating their prototype to the instructor. Inspired by Snyder's (2001) guidelines, the rules are reviewed as follows:

- Once everyone finished their prototypes, the students pair up
- One student plays "the computer" and one "the user" and then switch roles
- While in the "computer" role, a student presents his or her prototype to the "user"
- The "user" clicks (or taps) on paper objects using their fingers and the "computer" manipulates the paper materials accordingly to simulate the behavior of their interface
- The "user" simulates inputting character text however they want (pretending to type, voice, selecting an option, etc.)
- The "computer" cannot speak or give any explanation about how to use the prototype as their role is simply to simulate the interface functionality
- After both students play the role of "computer" and "user," they can make revisions before finding a new partner and again pair up into their roles
- Each student must play "computer" and "user" at least two times each with other students to ensure their design is seen by multiple people
- Each student must play "computer" to the instructor of the course with their final design to ensure the instructor has an opportunity to see each prototype (in a large class, this step may be optional or have students submit a video of their prototype, like the video presentation cited above)

After reviewing these rules, students receive the problem via a slide projected at the front of the room as displayed in Figure 1. A digital timer is also displayed for time management.

The problem reads as follows:

You're designing self-check-in kiosks for an Urgent Care waiting room. When patients arrive, they can check in and receive an estimated appointment time.

Figure 1: Prototyping in Progress

The prototype must allow (but is not limited to) the following inputs:

- Name, phone, and residential address
- Emergency contact details
- Insurance details (including billing address)
- Existing medical conditions and medications taken

The prototype must provide (but is not limited to) the following output:

- Estimated wait time
- Name of the health care professional the patient will see

While students are given loose rules about which materials to use, they are encouraged to use card stock to represent any "main" screens as this material forms a sturdy base to work on.

Exercise Materials

For 16 students, the following materials (samples depicted in Figure 2) were more than sufficient for two iterations:

- 11x17 in cardstock paper (x50 sheets)
- 8.5x11 in printer paper (x50 sheets)
- 3x5 in notepad paper (x100)
- Sticky notes (x50 small, x50 large)
- Index cards (x100)
- Various-sized sticky labels (x100)
- No. 2 pencils with erasers (x20)
- Extra erasers (x20)
- Colored pencils (x2 packs of 72)

ISSN: 2473-3857
v3 n4481

- Scotch tape (x4 rolls)
- Glue (x4 sticks)
- Paper clips (x2 packages of 50)
- Binder clips (x2 packages of 20)
- Scissors (x1 per 4 students)

Figure 2: Paper Prototype Materials

Points for In-Class Discussion

Following the exercise, students are asked to reflect on what they learned. These questions assist students in making connections between prototyping and the elements of fit covered in class. Students are first asked, *which factors influenced your initial prototype? That is, why did you design your prototype the way that you did?* This question encourages students to think about how they did (or did not) apply fit to the design and functionality of their prototype.

The second question is, *did you learn anything of value from the "usability tests," either on your prototype or by exploring a peer's prototype?* This works to demonstrate to students that good design does not occur in a vacuum. It also highlights the role of feedback in designing UIs.

The third question asks to *describe any modifications that went into your revised prototype and specifically why you made any changes that you did*. This reinforces the ideas presented in the first and second questions and emphasizes the notion that fit may be improved through iterative design and evaluation.

Next, students are asked, *does anything come to mind now for a third prototype that you did not consider in your previous iterations?* Here, the students were must consider and reflect on features and functionalities that they did not have the opportunity to design due to time constraints, material constraints, or any other limitation(s).

Finally, students are asked, *what, if anything, did you learn from this activity?* This is intended to help them step back and reflect on a whole as to the degree to which they found meaning in the practice of prototyping, design, and evaluation.

4. DISCUSSION

This section presents an overview of our experience to provide the reader with detail about how this exercise worked in practice, and to gauge which computing class(es) this exercise may be appropriate for. To begin, we discuss the context of the class in which the exercise was developed, and explain why we repeated it later in the semester. Then we provide some tips learned from our experience.

Overview of an HCI Introductory Course

This exercise was developed for an elective HCI course (with no prerequisites) taught by one of the authors at a state university in the northeastern United States. This course is housed in a Computer and Information Science program that offers Computer Science (CS) and Computer Information Systems (CIS) degrees. Accordingly, the course had a range of students with varying levels of technical skill.

During the first few weeks, the course focused on fundamental concepts like usability, affordances, and constraints. An affordance is "the design aspect of an object which suggests how the object should be used; a visual clue to its function and use" (Chamberlin, 2010, p.169; citing Norman [1988]), while constraints are the "limitations of the actions possible perceived from object's appearance" (Norman, 1988). After these ideas were introduced and students had a small vocabulary of HCI terms, the first paper prototyping round took place.

In the fourth week, we explicitly defined and discussed fit. As the course progressed, nearly every topic was linked to one or more types of fit. For example, in discussing the design of icons as affordances, we considered their placement and visibility on screen (physical fit), the types of symbols or signs intended to give them meaning (cognitive fit), and the color/shape of the icons (affective fit). When learning about dialog boxes,

 ISSN: 2473-3857
v3 n4481

we noted including non-annoying audible alerts (physical and affective fit), avoiding technical language (cognitive fit), and not blaming the user for an error (affective fit). In-class and take-home activities were designed to give students experience reflecting on, and applying, concepts related to these three aspects of fit.

During the last 4 weeks of class, students learned a range of evaluation techniques to determine and articulate the extent to which a UI matched each facet of fit. It was during this period that we completed a second iteration of paper prototyping.

In both rounds, students were given the same directions and materials. This initial iteration was useful to: (1) get a sense as to what students' existing mind-frames were when it came to designing a usable interface; (2) let them begin to apply the basic concepts they just learned about; and (3) provide them with a first round of prototyping experience. For the second, they could: (1) reflect on and integrate what they'd learned over the term (particularly about fit); (2) practice their prototyping skills; (3) and to do both without having to consider a new contextual domain.

Prototyping Iterations

As noted above, the first incarnation was shortly after learning basic concepts (usability, affordances, constraints, etc.) and vocabulary, but prior to delving into specifics about physical, cognitive, or affective fit. Accordingly, it served well as an orienting exercise and first attempt at reflecting on designing components of a UI.

Appendices A and B provide an example of one student's first and second prototypes respectively, complete with short, descriptive annotations. This example was chosen because it was relatively representative of what the instructor observed.

Iteration 1 (Start of the Semester)

As expected, the first version of most prototypes (such as depicted in Appendix A) did not consider context much in respect to the potential physical, mental, or emotional states of the user (similar to Dale's example our introduction). For example, despite having an injury or condition that could impact the user's mobility, data largely had to be inputted through a touch-based interface (such as digital keyboard) or traditional keyboard and mouse (as seen in Figures A3-A6).

Affordances, as clues to UI functionality (and hence a measure of cognitive fit), were somewhat evidenced in initial prototypes. For instance, in Appendix A, the student used buttons to indicate items which could be pressed. Also, color was used to show the path forward in the check-in process (such as the "start" button in Figure A1, the "next" button in Figures A3-A6 and A8, and the "finish" button in Figure A9. However, additional visual cues were not clear elsewhere. For example, in Figure A3 and A4, required data fields (such as last name) were not distinguished from optional data fields (such as middle initial).

Given that individuals in an urgent care center are likely anxious, they are more prone to mistakes, frustration, and a sense of urgency to complete the task. While the example in Appendix A allows the user to cancel or step back, the user only has the options of signing-in as a new or returning patient (Figure A2). The user is presented with forms in a way that compels them to provide all mandatory and optional data, which lengthens the task time. Furthermore, there is no option for immediate attention, which could only add to emotional discomfort.

Iteration 2 (End of the Semester)

This iteration occurred during the second-to-last week of class after covering design and evaluation methods and the various aspects of fit. Generally, students took the context of the situation more into account than in the first iteration. Appendix B demonstrates a sample prototype from the same student whose example was used in Appendix A.

One significant change was presenting the user with a third login option (Figure B2): providing some information later to expedite check-in. This is presumably meant to reduce anxiety by hastening the process. Similarly, as illustrated in Figure B6, there is a large button to call for immediate assistance.

Another point of noted improvement over the previous iteration is facilitated-input for some data. As depicted in Figure B9, dialog boxes to select country and state assist in entering address data, and Figure B10 directs the user to insert their insurance card into a physical slot to circumvent typing it in.

This example demonstrates increased attention to alleviating physical effort (such as facilitated data entry) and some affective concerns (such as the expedited check-in and calling for help). However, it does not improve upon affordances.

ISSN: 2473-3857
v3 n4481

While most students' second prototypes included some degree of enhanced accommodation for fit; this example was standard in that few made holistic accommodations across the board.

Teaching Tips for Paper Prototyping

For those who wish to adapt the described prototyping exercise in their own classroom, this section provides some suggestions and insight gained from our experiences. We break these down into three themes: materials, instructor, and context.

Materials Suggested

The materials necessary (and quantity thereof) for paper prototyping are flexible, but should be chosen in consideration of the type of interface and the number of students in the course.

We suggest that anyone adopting or adapting this exercise inventory the materials that they plan to use. We found that sticky notes worked very well for large buttons or dialog boxes, as did having scissors readily available for students to customize the sizes and shapes of screen items. For items that not everyone would always need access to (such as scissors and tape), these were kept at the front of the room for students to share as needed.

We also included a huge supply of colored pencils as we expected that students would want to use color to help reinforce affordances and highlight certain items on their prototypes. We anticipated these needs in advance to ensure materials were sufficient for the context of the activity. However, a variation of this exercise could be applied to for example a mobile device, in which case students would need to work on a smaller scale. Therefore, the materials should be adapted as well.

Our rules were intentionally loose regarding which materials students should use and how, because we wanted their prototypes to emerge as organically as possible. For example, we did not tell students to use color in boxes or sticky notes for buttons. Rather, the exercise forced students to reflect and apply the concepts learned. Similarly, we did not want to stifle creativity by planting preconceptions as to which materials we expected students to use (or not). It was important that students' designs reflected their own impressions of what should go into designing a UI to address a problem at hand. The array of paper-related materials allowed them this freedom.

Role of Instructor

While this exercise was designed for a relatively small class-size (about 15), it could conceivably be scaled up to larger groups. However, the role of the instructor is key to success; so we ask the reader to consider a few points before deciding on how large a group to moderate.

From our experience, the students benefitted from instructor contact during the exercise. Points of praise motivated students (such as noting a screen, button, or dialog box that was exceptional). Gentle but critical encouragement was useful as well. For example, offering comments such as "you're not using any colored pencils," or "what does this mean," can serve as subtle prods to stimulate missed connections to course material.

Another important task for the instructor comes while students are role-playing "user" and "computer" while testing out their designs. Because the "computer" is representing and manipulating their own design, it is natural for them to want it to succeed. The instructor in our example described here observed that the "computer" often gave non-verbal cues to the "user" in the form of a sigh, glance, or gesture when the user was not performing as expected. This goes against the spirit of the exercise as students do not receiving genuine feedback from their peers. The instructor, therefore, should remind students during the testing periods of the rules and the role of the "computer". The instructor can also correct behavior that runs contrary.

Finally, the instructor's observations during the activity and in playing the role of a "user" are useful for debriefing at the end of the exercise. By engaging with students throughout the activity, the instructor can better identify missing themes. If a key construct is not being observed during the exercise, it provides a clue to the instructor that the construct needs to be clarified or refined. For example, following our first iteration, the instructor noted that one student did not have an expedited check-in process (such as a "press here for immediate attention" button). The instructor then reviewed the importance of context and the anticipated users of the interface.

The Context

By context, we refer to the notion that human-computer interactions do not occur in isolation. Computing hardware and software are designed toward supporting goals, which directly or indirectly carries assumptions about use. Our urgent-care scenario implies a chaotic,

ISSN: 2473-3857
v3 n4481

emergency environment, intentionally chosen as so that students would have a range of factors to account for in respect to fit. However, this is not the only such scenario that a paper prototyping exercise could be set in; nor is HCI the only course where such an exercise would be appropriate.

For example, in a mobile app development course, the focus might be more on other aspects of usability such as readability, learnability, or emphasizing visible affordances and constraints. As such, an instructor might adopt a scenario for students to prototype based on a smaller, less urgent task or goal (and hence, a smaller screen).

Similarly, in a Software Engineering course, instructors might use paper prototyping to help with teaching requirements engineering. In such a case, students could be broken up into groups of customer and engineers. The customer team could come up with an idea for an application and a requisite set of (visible) functional and non-functional requirements. The engineer team could then design a paper prototype to quickly gather feedback as to how closely their image of the software matches up with that of the customer. In this way, it could be demonstrated how prototypes assist in the customer-team communication process.

5. CONCLUSION

We began this paper with a scenario in which a poorly-designed UI design resulted in harm to the user. While few interactions with computing technologies might lead to such disaster, an extreme context like an urgent care facility can serve as a strong teaching case to highlight the human considerations for design.

Our exercise was intended for HCI students with and without technical computing savvy such as programming. This allowed them to practice skills and demonstrate concepts that are relevant to the concept of fit. However, we encourage other teaching professionals to explore the application of paper prototyping in a way that aligns with their instructional goals, whether it relates to usability or something else. We found that this exercise is especially engaging for students because it is an agile, non-technical, and hands-on approach to creating a UI that requires little (if any) prior experience. Furthermore, it requires only basic materials to implement.

Of note, the instructor handout which accompanies this paper includes a set of pre-requisite concepts, as well as suggested additional readings intended to help develop course material either prior to doing paper prototyping, or following it. These readings could also be of general use to any instructor who wants to supplement a course with some basic key concepts and theories related to HCI.

As nearly everyone uses (or will use) computing in their lives, and as computing has become nearly ubiquitous;, understanding users is paramount to designing and implementing effective and efficient interactions (Janicki, Cummings, & Healy, 2015). Paper prototyping is an accepted practice in industry (Schultz, 2008); in the classroom, it can serve as a powerful tool for driving home lessons related to how human beings interact with computing technologies.

6. REFERENCES

Avital, M., & Te'eni, D. (2009). From generative fit to generative capacity: exploring an emerging dimension of information systems design and task performance. *Information Systems Journal*, *19*(4), 345-367.

Carey, J., Galletta, D. F., Kim, Y., Te'eni, D., Wildemuth, B., & Zhang, P. (2004). The role of human computer interaction in management information systems curricula: A call to action. The Communications of the Association for Information Systems, 13(1), 62.

Chamberlain, P. (2010). Horses, Elephants and Camels. Challenges and Barriers to Interdisciplinary User-Centered Design Research. In *DS 60: Proceedings of DESIGN 2010, the 11th International Design Conference, Dubrovnik, Croatia*.

Churchill, E., Preece, J., & Bowser, A. (2014, April). Developing a living HCI curriculum to support a global community. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems* (pp. 135-138). Association for Computing Machinery.

Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). About face: the essentials of interaction design. John Wiley & Sons.

Glisky, E. L. (2007). Changes in cognitive function in human aging in *Riddle, D. R. (Ed.). (2007). Brain aging: models, methods, and mechanisms. CRC Press,* 3-20,

ISSN: 2473-3857
v3 n4481

Hartson, H. R. (1998). Human–computer interaction: Interdisciplinary roots and trends. *Journal of Systems and Software*, 43(2), 103-118.

Hewett, T., R. Baecker, S. Card, T. Carey, J. Gasen, M. Mantei, G. Perlman, G. Strong, and W. Verplank (1992) *ACM SIHCHI Curricula for Human-Computer Interaction*, New York, NY: Association for Computing Machinery.

ISO 9241-11 (1998). Guidance on Usability. Last accessed on July 13, 2017 at https://www.iso.org/standard/16883.html.

Janicki, T., Cummings, J., & Healy, R. J. (2015). Incorporating a Human-Computer Interaction Course into Software Development Curriculums. *Information Systems Education Journal*, 13(3), 81.

National Center for Health Statistics. (2014). National Hospital Ambulatory Medical Care Survey: 2014 Emergency Department Summary Tables. *Centers for Disease Control and Prevention*. Last accessed on September 8, 2017 at https://www.cdc.gov/nchs/data/nhamcs/web_tables/2014_ed_web_tables.pdf.

Nielsen, J. (2003). Paper prototyping: Getting user data before you code. Last Reviewed on July 12, 2017 from https://www.nngroup.com/articles/paper-prototyping/

Norman, D. A. (1988). *The psychology of everyday things*. Basic books. Chicago

Rettig, M. (1994). Prototyping for tiny fingers. *Communications of the ACM*, 37(4), 21-27.

Shneiderman, B. (1998) *Designing the User Inter- face: Strategies for Effective Human-Computer Interaction* (3rd ed.). Reading, MA: Addison- Wesley.

Schultz, L. (2008) Using Low-Fidelity Prototyping to Teach the Basics of Interface Design. Proceedings of Information Systems Education Conference.

Sefelin, R., Tscheligi, M., & Giller, V. (2003, April). Paper prototyping-what is it good for? a comparison of paper-and computer-based low-fidelity prototyping. In CHI'03 extended abstracts on Human factors in computing systems (pp. 778-779). ACM.

Snyder, Carolyn (2001). Paper prototyping: Sure, it's low-tech, but this usability testing method can help you sidestep problems before you write your code. URL: dwmaster.raleigh.ibm.com/dwcontent/developerworks/library/library-html/us-paper/index.html (accessed: 6/29/2004).

Te'eni, D., Carey, J. M., & Zhang, P. (2005). *Human-computer interaction: Developing effective organizational information systems*. John Wiley & Sons.

Vessey, I., & Galletta, D. (1991). Cognitive fit: An empirical study of information acquisition. *Information systems research*, (1), 63-84.

Vijayan, J., & Raju, G. (2011). A new approach to requirements elicitation using paper prototype. *International Journal of Advanced Science and Technology*, *28*, 9-16.

Yun, Channy (2007). Hanmail Paper Prototype (video). Last accessed on July 14, 2017 at https://www.youtube.com/watch?v=GrV2SZuRPv0.

Zhang, P., Benbasat, I., Carey, J., Davis, F., Galletta, D., & Strong, D. (2002). Human-computer interaction research in the MIS discipline. *Former Departments, Centers, Institutes and Projects*, 40.

Zhang, P., & Li, N. (2004). An assessment of human–computer interaction research in management information systems: topics and methods. *Computers in Human Behavior*, *20*(2), 125-147.

Zhang, P., & Li, N. (2005). The intellectual development of human-computer interaction research: A critical assessment of the MIS literature (1990-2002). *Journal of the Association for Information Systems*, *6*(11), 9.

Zhang, P., Li, N., Scialdone, M., & Carey, J. (2009). The intellectual advancement of human-computer interaction research: A critical assessment of the MIS literature (1990-2008). *AIS Transactions on Human-Computer Interaction*, *1*(3), 55-107.

ISSN: 2473-3857
v3 n4481

7. APPENDICES

Appendix A: Example of 1st Prototyping Round

Figure A1
Start Screen. The only option is to press "start."

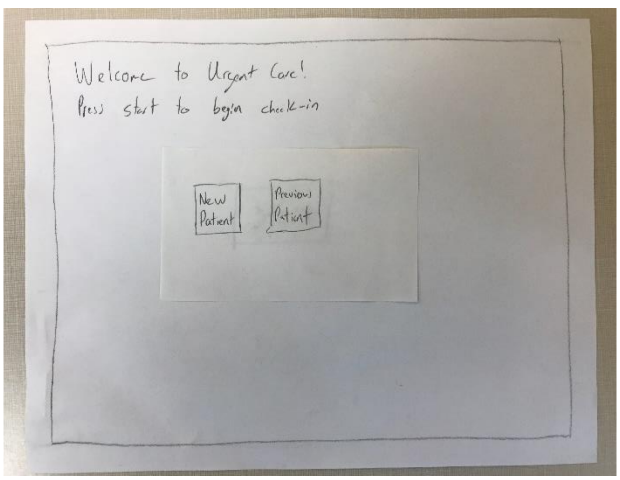

Figure A2
Patient can choose two options: "New Patient" or "Previous Patient". The first takes the patient to the screen depicted on Figure A4, while the second takes the patient to the screen depicted on Figure A3.

Figure B3
Existing patients can enter in name and pressing "next" will take patient to the screen depicted on Figure A7.

http://iscap.info

ISSN: 2473-3857
v3 n4481

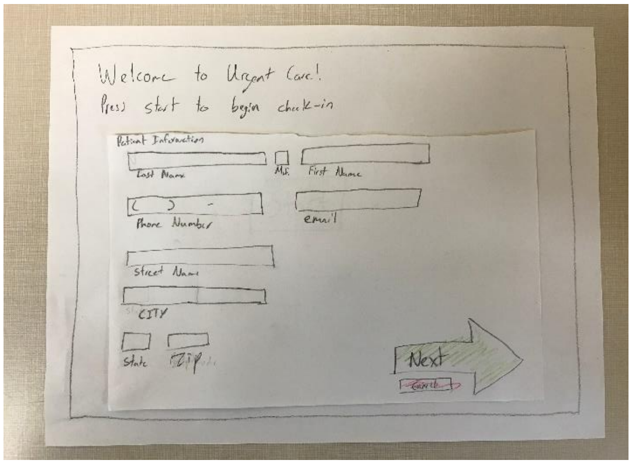

Figure A4
Sample input screen 1 for new patient

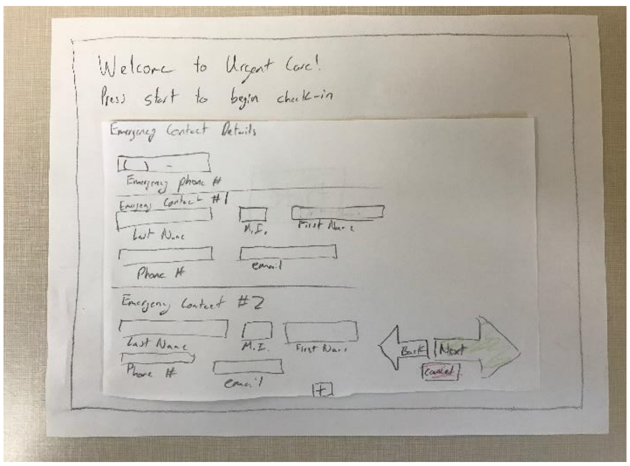

Figure A5
Sample input screen 2 for new patient

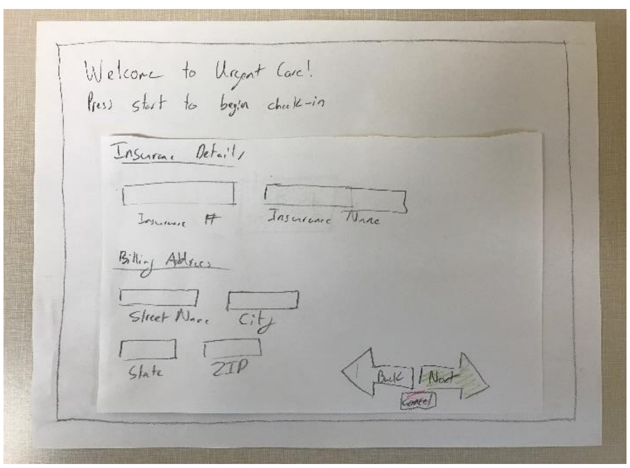

Figure A6
Sample input screen 3 for new patient

ISSN: 2473-3857
v3 n4481

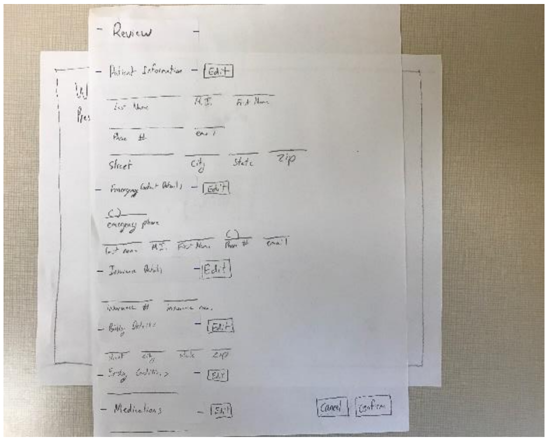

Figure A7
Review screen for new and previous patients. Pressing the "confirm" button will take patients to the screen depicted in Figure A9.

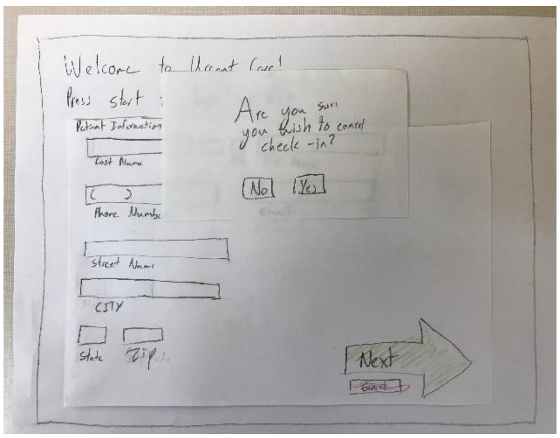

Figure A8
Pressing the "cancel" option at any point in the process will show a pop-up dialog box such as this, allowing the patient to exit the process.

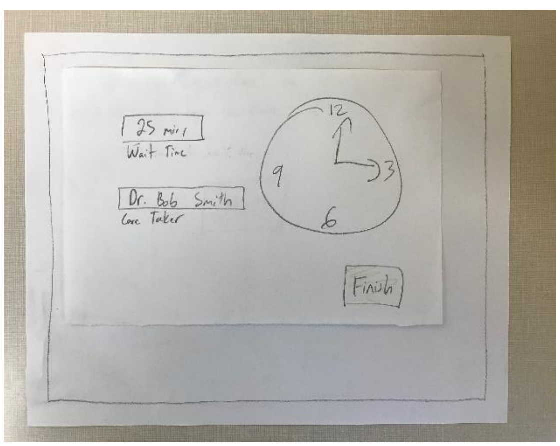

Figure A9
The end of the check-in process, showing the patient the wait time, time of appointment, and care taker. Pressing the "finish" option will take the patient back to the first screen depicted in Figure A1.

ISSN: 2473-3857
v3 n4481

Appendix B: Example of 2nd Prototyping Round

Figure B1
Start screen where the only option to press is "begin"

Figure B2
Three options are presented to the user after pressing "begin." They can login as a returning patient, in which case they would then be brought to the screen depicted in Figure B3. They can login as a new patient in which case they would then be brought to the screen depicted in Figure B8. Or, the patient can login with an expedited process to minimize self-input, in which case they would be brought to the screen depicted in Figure B6.

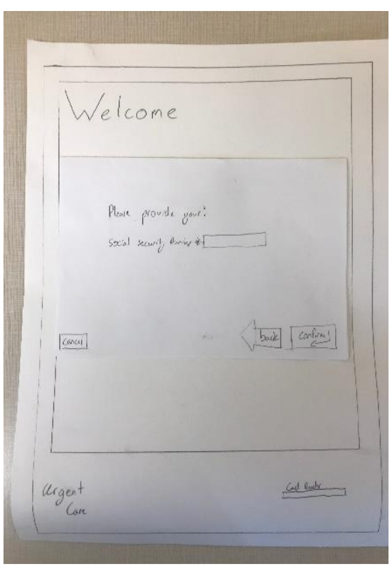

Figure B3
This screen allows the user to login as an existing patient by entering their Social Security Number. If the number is recognized by the patient database, the user will move on to the next screen shown in Figure B4. If not, the user will be brought to the screen depicted in Figure B5

ISSN: 2473-3857
v3 n4481

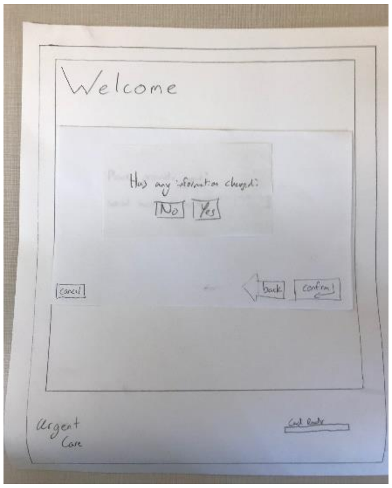

Figure B4
This screen allows an existing user whose Social Security Number is recognized by the patient database to choose to update their records or not. Choosing "no" will take the user to the appointment-confirmation screen depicted in Figure B11, while choosing "yes" will take the user to the screen depicted in Figure B8. But rather than the blank boxes in the input process shown in Figure B8, they would already be filled out with the most recent patient data.

Figure B5
This screen informs the user that they are not in the existing patient database. Pressing "okay" will take the user back to the screen depicted in Figure B2 with the three login options.

Figure B6
This abbreviated login form allows the user to input basic name data, or to request help immediately. Confirming the name data will send the user to the screen depicted in Figure B7.

ISSN: 2473-3857
v3 n4481

Figure B7
The user has the option in this screen to input emergency contact data. Pressing "confirm" will take the user to the insurance input screen depicted in Figure B10.

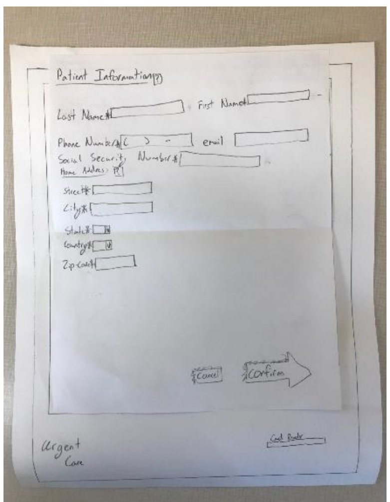

Figure B8
For new patients, this form will be blank, while for existing patients, it will contain their most recent data. Pressing confirm will take the user to screen depicted in Figure B9, while pressing cancel will take the user back to the previous screen they were on.

Figure B9
This figure shows input for the patient's billing address. Of note, there are additional dialog boxes that are displayed to simplify entering in the user's resident state. They dialog boxes were also used in other screens in this appendix whenever an address needed to be inputted. Pressing "confirm" will take the user to the insurance input screen depicted in Figure B10.

 ISSN: 2473-3857
v3 n4481

Figure B10
The patient has two options here. One is to enter in the data manually, while the other is to insert their insurance card into the slot depicted at the bottom right of the display. In either case, the user would then press the “confirm” button to move on to the appointment confirmation screen depicted in Figure B11.

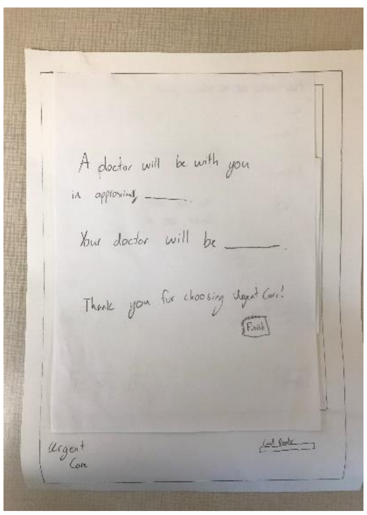

Figure B11
Appointment confirmation screen with output of wait time and care provider.

