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A Randomized Trial Comparing Classical Participatory Design to VandAID, an Interactive Crowdsourcing Platform

K.R. Dufendach,

Cincinnati Children's Hospital Medical Center

S. Koch,

Karolinska Institutet

K.M. Unertl, and

Vanderbilt University Medical Center

C.U. Lehmann

Vanderbilt University Medical Center

Abstract

Background—Early involvement of stakeholders in the design of medical software is particularly important due to the need to incorporate complex knowledge and actions associated with clinical work. Standard user-centered design methods include focus groups and participatory design sessions with individual stakeholders, which generally limit user involvement to a small number of individuals due to the significant time investments from designers and end users.

Objectives—The goal of this project was to reduce the effort for end users to participate in co-design of a software user interface by developing an interactive web-based crowdsourcing platform.

Methods—In a randomized trial, we compared a new web-based crowdsourcing platform to standard participatory design sessions. We developed an interactive, modular platform that allows responsive remote customization and design feedback on a visual user interface based on user preferences. The responsive canvas is a dynamic HTML template that responds in real time to user preference selections. Upon completion, the design team can view the user's interface creations through an administrator portal and download the structured selections through a REDCap interface.

Results—We have created a software platform that allows users to customize a user interface and see the results of that customization in real time, receiving immediate feedback on the impact of their design choices. Neonatal clinicians used the new platform to successfully design and

Corresponding Author: Kevin R. Dufendach, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, MLC 7024, Cincinnati, OH 45229-3026, kevin.dufendach@cchmc.org, Phone: 513.636.7018, Mobile: 616.481.5089, Fax: 513.636.2056.

Human Subject Protection

This study was approved by the investigational review board of Vanderbilt University Medical Center (study ID 160124) and followed procedures in compliance with the ethical standards of the responsible committee on human experimentation and with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects.

customize a neonatal handoff tool. They received no specific instruction and yet were able to use the software easily and reported high usability.

Conclusions—VandAID, a new web-based crowdsourcing platform, can involve multiple users in user-centered design simultaneously and provides means of obtaining design feedback remotely. The software can provide design feedback at any stage in the design process, but it will be of greatest utility for specifying user requirements and evaluating iterative designs with multiple options.

Keywords

computers; informatics; human factors and engineering; human-computer interface

Introduction

One of the goals of the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act was to improve the safety of medical care through the investment in electronic health record systems. However, safety results vary significantly between specific systems and locations.[1] E-iatrogenesis — the unintended negative consequences of implementing health information technology — had been described as early as 2007.[2] If not implemented carefully, unintended consequences of automation can contribute to medical errors.[3] By applying human factors principles into the design of medical software alerts, Russ et al. demonstrated improved usability and decreased prescribing errors in a simulated crossover trial.[4]

Despite advances in existing technology, clinician dissatisfaction with Electronic Health Records (EHR) increased from 24% in 2010 to 39% in 2012.[5] A significant proportion of end user dissatisfaction in healthcare systems is attributable to poorly designed interfaces unresponsive to user workflows and needs. Change management knowledge mandates that end users must be included in the design process and that “workflow and information needs of end users must be studied and analyzed, and the effect of the new intervention must be modeled on workflow, new work demands, interruption of other tasks, and local culture and conditions.”[6] Development of health information technology software requires establishment of common ground between design and the clinical work that needs to be performed.[7] Medical software design requires input from real users, who “alone have the relevant knowledge and understanding of the actions, and the consequences, of their work.” [7]

User-centered software design seeks to involve end users throughout the design process to create a product that better matches the user’s expectations and experience. Developing software based on the user’s needs and requirements (for example, by including all data elements required by a user to complete a task on the screen), allows the software to better match the end user’s optimal workflow as opposed to forcing users to change their behavior to accommodate the product’s design (like having to interrupt the task and search for the required information elsewhere only to come back to complete the task).[8]

Current EHR certification requirements from the Office of the National Coordinator for Health Information Technology require EHR vendors to attest to implementing user-centered design practices in the creation of their software products.[9] However, a study examining the user-centered design processes of eleven EHR vendors from February to August 2013 found a wide range of user-centered design practices ranging from full in-depth contextual analysis to simply providing methods of receiving requests and feedback from users.[10] Despite variance from robust to basic user-centered design strategies, all EHR software designers indicated that they felt user-centered design to be important and wished they had more resources to pursue it further. Yet, a recent examination of usability practices of 50 top electronic health record vendors found that fewer than half used the recommended 15 participants in usability testing, and only 8 of those used at least 15 individuals with a clinical background.[11]

Basic user-centered design employs interviews and surveys, but these techniques can prove inadequate, as most users neither know their own requirements nor can they articulate them in ways computable to the design team.[7; 12] Involving users in cooperative design or guided user-driven innovation allows end users to become a source of innovation in the design process, but such methods have limitations due to the time and expertise demanded on both designers and end users, alike. Due to these demands, end user involvement is often limited to just a small number of stakeholders, which may not encapsulate the complexity in healthcare information technology systems, which often involve multiple stakeholders in varying contexts of use.[13]

Objectives

The goal of this project was to reduce the effort for end users to participate in co-design of a software user interface by developing an interactive web-based crowdsourcing platform.

Methods

We developed VandAID (Vanderbilt Active Interface Design), an interactive web-based platform that allows responsive remote customization and feedback of a visual user interface (Figure 1). Users can express their preferences in the software's dynamic canvas, where the user interface is built and modified by the user. This canvas responds to settings and preferences from a toolbox available to users.

The platform is written as a single page application using hypertext markup language (HTML) and JavaScript with the AngularJS 1.5.x framework.[14] AngularJS facilitates data binding between HTML elements and settings stored in the JavaScript data model.

Canvas

With the creation of any user interface, a design team must decide which data elements to display and how to present them in regards to color, font, location on the screen, and other design choices. With VandAID, the dynamic canvas allows the design team to test different display options by letting the users select the ones that best match their expectations and

workflow. The canvas responds dynamically to the selections and preferences made by users, giving them direct feedback on the results of their decisions.

The dynamic canvas itself is an HTML document that leverages the power and customizability of HTML 5 and JavaScript. Any graphics, formatting, and even scripts that can be included in a web page can be built directly into the dynamic canvas. This makes this platform ideal for designing custom HTML-based software, such as might be done in creating a SMART (Substitutable Medical Apps, Reusable Technologies) on FHIR (Fast Healthcare Interoperability Resource) application that can be embedded into an EHR.[15–17]

Preferences Pane

The preferences pane provides a toolbox from which the user builds the application by first selecting which elements should appear on the canvas and then setting specific element option fields, such as whether out of range values should be bold or how numerical data should be displayed (Figure 2). The option fields are based on standard survey questions such as multiple choice, checkbox, yes-no, text, and other options. The toolbox supports advanced survey options like branching logic, which allows irrelevant options to be hidden until needed.

The canvas responds to the user's selections and preferences by accessing the values of the preference fields through interfacing with a JavaScript field manager. Although any JavaScript can be used to access the field values, this platform is optimized to use AngularJS directives that allow direct manipulation of the HTML document object model (DOM) based on the values of fields.

Integration with REDCap

By representing each design option as a standard survey field, the VandAID platform is able to interface directly with the powerful REDCap survey and database software.[18] Using the secure REDCap API, the platform can import data collection instrument fields directly into the software for use in the preferences pane and then save each user's selections as a unique submission in the project. REDCap can also be used to create automated email invitations to users. This can allow anonymous feedback submission on the interface being designed as well as end user voting on preferred interface settings. The REDCap integration also provides designers with a secure, centralized location to store user submissions and to export the raw data for statistical analyses.

Evaluation Interface—In addition to performing statistical analyses on the raw data, administrators from the design team can also use the evaluation interface to view each individual submission. This view is built directly into the VandAID platform itself and allows designers to jump between the various submissions to see the design product from each end user.

Comparison of Classical Participatory Design with the VandAID Platform—We compared the new VandAID platform to classical participatory design (PD) through a

parallel randomized controlled trial of neonatal intensive care clinicians. Our initial test case for this platform seeks to establish the list and formatting necessary to create an effective neonatal patient list for use in a handoff between neonatal clinicians.

Eligible neonatal clinicians for the study included all neonatal attendings, fellows, and nurse practitioners at Vanderbilt University Medical Center, excepting the two individuals who participated in creation of the VandAID software platform itself. We invited all eligible clinicians to provide feedback on a neonatal handoff tool. Of those who expressed interest, two from each professional group were randomly selected, using R software, to participate in one-on-one PD sessions.[19] Invitations and reminders were sent using REDCap.

One-on-one PD sessions were conducted directly by the first author. Participants were given the opportunity to design a neonatal handoff tool using pens, paper, sticky notes, scissors, and other materials. They were also given a prompt of pre-enumerated potential items, which were the same items available to the VandAID group. Each session was video recorded and then transcribed for further evaluation. All creations were collected by the design team at the conclusion of the session.

All remaining clinicians were sent email invitations with an individualized link to provide design feedback on a neonatal handoff tool using the VandAID software. The VandAID version allowed users to weigh the benefits of adding more information with the space required to present that information. VandAID additionally allowed users to customize the presentation of the data, such as by indicating whether out of range labs should appear in bold and if new labs should appear in italics.

Following each PD or VandAID session, users provided feedback on the usability of the specific user-centered design method by completing a standardized system usability scale survey.[20; 21]

Results

We successfully created a software platform that allows users to customize a user interface and see the results of that customization in real time, receiving immediate feedback on the impact of their choices. We invited all 67 eligible neonatal clinicians to participate in the randomized trial. Of these, 42 expressed interest and were randomized. All 6 randomized to PD completed the sessions, and 29 used the VandAID platform to design and customize a neonatal handoff tool (Figure 3).

Several similarities existed between the items selected with VandAID and the PD sessions (Figure 4). All individuals requested a to-do list. The patient name was forced to be included with the VandAID software, although users could choose how it should appear. Nearly all requested the patient's location, age and weight information, ventilation settings, and a medication list. No individual requested detailed vital signs. Of note, only 63% of individuals selected the medical record number to appear, which could be considered an important safety concern.

When contrasting the PD sessions with the VandAID designs, we observed differences between the two groups in the items included. Only one of the PD users included the care team name, and only one included a plan by system, both of which were included in over half of the VandAID software designs in which it could be selected as an option. PD participants also generally did not comment on item formatting, such as bold or italicized data, although one individual did volunteer that they would like to have resuscitation status bold if not “full code.” Most PD participants also required prompting from the facilitator specify how laboratory values should appear, whether in a table or in a stick figure diagram. Many VandAID participants left additional free text comments with additional ideas and options not presented in the specific example, some of which had also been enumerated in PD sessions.

Time spent creating a handoff design was significantly shorter for VandAID users with a mean of 9.6 minutes per user (median 9, 95% confidence interval 7.4–11.8 minutes) compared with the PD sessions, which lasted a mean of 26.3 minutes (median 27.5, 95% confidence interval 20.3–32.3 minutes). Results of the system usability scale survey for VandAID users gave a mean of 84.3 (95% CI 80.2–88.4), which places it in the 96th percentile for usability with this standardized survey. For comparison, the PD sessions achieved a mean 75.4 (75th percentile), but also had a very large confidence interval (95% CI 52.3–98.5).[20; 21] Other than a short prompt at the top of the canvas pointing them to the left-sided toolbox and the save and submit button, users received no instruction on using the tool itself, and at no time did any of the clinicians contact a research team member to request additional instruction on using the tool.

Source Code

The source code for this initial use case project is available at <https://github.com/KevinDufendach/vandaaid-nicuhandoff>.

Conclusions

This study compared two user-centered design methods to help design a neonatal handoff tool, classical one-on-one PD sessions and VandAID, a new web-based crowdsourcing platform. Both methods provided important information, and they proved complementary to each other. VandAID prompted users with examples of possible data elements, which may have allowed users to better weigh the value of displaying certain elements. Compared to the PD session, the use of the VandAID tool was significantly faster and less onerous to providers and researchers while yielding similar results.

Part of the success of the initial use of VandAID may be attributable to the fact that the lead designer of the software (KRD) is a neonatologist and thus a domain subject expert, leading to user-driven innovation. Identification of items for the toolbox and design of the example items was enhanced by having the expertise of an informatics-trained user. Lacking such a dual perspective would likely have required earlier PD sessions or other user-centered techniques.

Our new design platform provides a means of crowdsourcing electronic health record design from multiple users remotely and asynchronously. The versatility of the interactive canvas means that interface designers can use this process at multiple steps throughout the design cycle as the product moves from rough sketches to high fidelity prototypes and ultimately to a fully functional release candidate. An initial canvas may have little more than plain text or hand drawings, while a design in its later stages may be a fully functional SMART on FHIR application that draws data from a live EHR. Using REDCap functionalities, this tool could be used to incorporate input from much larger groups, including external sites.

Involving stakeholders at the start of the design process has been shown to improve end user satisfaction and efficiency by matching the final product to the user's workflow. This new design platform adds another low-cost tool that can complement other user-centered design methods and facilitate involvement of multiple users throughout the design process.

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References

1. Metzger J, Welebob E, Bates DW, Lipsitz S, Classen DC. Mixed results in the safety performance of computerized physician order entry. *Health Aff Proj Hope*. 2010 Apr; 29(4):655–663.
2. Weiner JP, Kfuri T, Chan K, Fowles JB. e-Iatrogenesis: the most critical unintended consequence of CPOE and other HIT. *J Am Med Inform Assoc JAMIA*. 2007 Jun; 14(3):387–388. discussion 389. [PubMed: 17329719]
3. Graham, J., Dizikes, C. Baby's death spotlights safety risks linked to computerized systems. *Los Angeles Times*. 2011. <http://www.latimes.com/ct-met-technology-errors-20110627-story.html>. Accessed 2016-4-15.
4. Russ AL, Zillich AJ, Melton BL, Russell SA, Chen S, Spina JR, Weiner M, Johnson EG, Daggy JK, McManus MS, Hawsey JM, Puleo AG, Doebling BN, Saleem JJ. Applying human factors principles to alert design increases efficiency and reduces prescribing errors in a scenario-based simulation. *J Am Med Inform Assoc JAMIA*. 2014 Oct; 21(e2):e287–296. [PubMed: 24668841]
5. Survey of Clinicians: User satisfaction with electronic health records has decreased since 2010. 2013. <https://www.acponline.org/acp-newsroom/survey-of-clinicians-user-satisfaction-with-electronic-health-records-has-decreased-since-2010?hp=>. Accessed 2016-4-15.
6. Lehmann, CU., Unertl, KM., Rioth, MJ., Lorenzi, NM. Change Management for the Successful Adoption of Clinical Information Systems. In: Finnell, JT., Dixon, BE., editors. *Clinical Informatics Study Guide*. Springer International Publishing; 2016. p. 435-456. http://link.springer.com/chapter/10.1007/978-3-319-22753-5_18. Accessed 2016-6-15.
7. Scandurra I, Hägglund M, Koch S. From user needs to system specifications: multi-disciplinary thematic seminars as a collaborative design method for development of health information systems. *J Biomed Inform*. 2008 Aug; 41(4):557–569. [PubMed: 18394969]
8. McCoy AB, Waitman LR, Gadd CS, Danciu I, Smith JP, Lewis JB, Schildcrout JS, Peterson JF. A computerized provider order entry intervention for medication safety during acute kidney injury: a quality improvement report. *Am J Kidney Dis Off J Natl Kidney Found*. 2010 Nov; 56(5):832–841.
9. HealthcareUsability. *ONC Meaningful Use and Usability Testing*. 2013. <http://www.healthcareusability.com/article/onc-meaningful-use-and-usability-testing>. Accessed 2016-6-15.

10. Ratwani RM, Fairbanks RJ, Hettinger AZ, Benda NC. Electronic health record usability: analysis of the user-centered design processes of eleven electronic health record vendors. *J Am Med Inform Assoc JAMIA*. 2015 Nov; 22(6):1179–1182. [PubMed: 26049532]
11. Ratwani RM, Benda NC, Hettinger AZ, Fairbanks RJ. Electronic Health Record Vendor Adherence to Usability Certification Requirements and Testing Standards. *JAMA*. 2015 Sep; 314(10):1070–1071. [PubMed: 26348757]
12. Beyer HR, Holtzblatt K. Apprenticing with the Customer. *Commun ACM*. 1995 May; 38(5):45–52.
13. Andre K, Christian N. Participatory Design, User Involvement and Health IT Evaluation. *Stud Health Technol Inform*. 2016:139–151.
14. AngularJS — Superheroic JavaScript MVW Framework. [date unknown]; <https://angularjs.org/>. Accessed 2016-6-15.
15. Something New and Powerful: SMART on FHIR®. SMART Health IT. 2014. <http://smarthealthit.org/smart-on-fhir/>. Accessed 2016-6-15.
16. Mandel JC, Kreda DA, Mandl KD, Kohane IS, Ramoni RB. SMART on FHIR: a standards-based, interoperable apps platform for electronic health records. *J Am Med Inform Assoc JAMIA*. 2016 Sep; 23(5):899–908. [PubMed: 26911829]
17. Summary - FHIR v1.0.2. 2015. <http://hl7.org/fhir/summary.html>. Accessed 2017-1-5.
18. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009 Apr; 42(2):377–381. [PubMed: 18929686]
19. R: The R Project for Statistical Computing [date unknown]. <https://www.r-project.org/>. Accessed 2016-7-19.
20. Assistant Secretary for Public Affairs. System Usability Scale (SUS). 2013. <http://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html>. Accessed 2016-6-15
21. Sauro, J. A practical guide to the system usability scale: background, benchmarks & best practices. 2011.

Figure 1. VandAID interface. On the left-hand, the user selects content and formatting design decisions from the toolbox. On the right the user experiences the results of all selections in real time on the dynamic canvas.

Figure 2. Responsiveness of the VandAID interface. By changing ventilation display setting from a table (panel A) to a diagram (panel B), the canvas updates itself dynamically to reflect the change.

Figure 3.
Randomized trial flow diagram

Figure 4.

Percentage of individuals who selected each item on the handoff list, per clinical role. PD participant data are illustrated with the lighter bars, while data from VandAID participants are shown with dark bars.