DESIGNING AND DEVELOPING AN APP FOR A MIXED METHODS RESEARCH DESIGN APPROACH

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We present the story of how we designed and developed an application that provides expert consultation in mixed methods research—the *Mixed Methods Research Design App*. We provide a description of the key design decisions, the design failures, the related revisions made during the process of designing the app, and the contribution to the design knowledge. We used methodologies consistent with the design and development of an expert system, modified for areas specific to an app, such as user interface design. Being user-centered was the main rationale for our major design decisions. The app has three main sections that help users understand and use domain knowledge in their research project. One design failure was that users felt the app looked overwhelmed. The follow-up refinements included adding more pages to simplify the visual impression of each page, changing the overall navigation structure, and adding more contents to engage users. We conclude that the factors that influenced our design decisions are the end users' experience, domain expert's opinion, technology resources, domain knowledge representation, and general interface design principles.

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INTRODUCTION

Mixed methods research is an innovative approach that includes several different types of designs. In recent years, the number of people who want to learn the mixed methods research approach has increased rapidly (Clark, 2010). However, there are challenges for students who wish to learn and adopt it. Learning mixed methods has been heavily reliant on volumes of text-based books, in-class lectures, and project-based learning. Learners do not have enough time and resources to practice and master a core set of skills and content elements within a mixed methods domain on their own. Some mixed methods learners who do not have adequate prior knowledge (e.g., experience with qualitative and quantitative research methods) may feel insecure about their research design abilities when learning the mixed

methods research approach, and they may feel overwhelmed by the breadth and depth of the mixed methods course content (Brown, 2014). Inadequate prior knowledge may make students feel incapable of asking the instructors or the consultants the right questions to learn what they do not know, or they may be unable to explore certain research topics in depth when doing the coursework. All these issues may jeopardize students' meaningful learning of mixed methods and eventually impair their ability to conduct rigorous scholarly research. Mixed methods learners need a learning tool that functions as an expert support system.

The Objectives of the Mixed Methods App

We teach in a context where students need to learn the mixed methods research design approach in order to design a rigorous research project. To meet the needs of the learners, we decided to design and develop an app that provides a learning environment for users and enables effective consultation with issues related to the mixed methods research design approach. *App* is a short name for application. The significant benefits of apps include ease of use and learning, portability, accessibility, location awareness, and low price (Nayebi, Desharnais, & Abran, 2012). Because of these factors, apps have been increasingly used as a means for students to rapidly locate knowledge and make decisions in ways that were not previously possible.

The Mixed Methods app is designed to guide users through the cognitive learning process in an orderly manner. The app provides decision support tools and in-context information resources to support users' mixed methods learning. With the help of the app, users will be able to make informed decisions on whether to use the mixed methods research design approach and what type of mixed methods research design they should use for their study. They will also be able to add scholarly features to their research project.

The focus of the app design is to reduce the complexity of mixed methods knowledge. It streamlines the learners' cognitive learning and decision-making processes and only delivers core knowledge and a set of skills based on students' research purposes, needs, or interests.

Target Users of the Mixed Methods App

The target users of the mixed methods app are students and scholars around the world who want to learn how to use mixed methods to conduct rigorous research. They may have received some types of training in mixed methods (such as in-class lectures, online videos, studio, and textbook reading) and are interested in using advanced tools such as an app to improve their research skills. We believe the users who will benefit the most from the app will be those who lack previous training in quantitative or qualitative research methods, who do not understand a type of mixed methods design thoroughly, and who want to have a hands-on

experience in conducting a mixed methods study. These mixed methods learners need adequate support from experts for individualized training and guidance.

Resources for the App Design and Development

The resources we used to design and develop the Mixed Methods app included a domain expert, a knowledge engineer, and a software tool.

The mixed methods domain expert is Dr. John W. Creswell, a globally renowned leader in mixed methods who has more than forty years of experience in teaching and developing research methods and is working as a research consultant. Dr. Creswell is the co-founder of the *Journal of Mixed Methods* and author of many books focusing on research design, including ones on designing and conducting mixed methods research. He has taught both at the University of Nebraska-Lincoln (UNL) and at University of Michigan. He founded the Office of Qualitative and Mixed Method Research (OQMMR) at UNL, which provides support for students and faculty conducting mixed methods studies. Dr. Creswell established the app logical rules (i.e., if-then rules) as the solutions to the common questions students are likely to encounter when learning mixed methods. This process is similar to the knowledge acquisition process when designing an expert system (Annaiahshetty & Prasad, 2013).

The knowledge engineer is Dr. Shuhong Luo, who designed and developed the app interface to represent the domain knowledge and the logical rules developed by Dr. Creswell. Dr. Luo was a doctoral student studying instructional technology at UNL when she designed the app. Before Dr. Creswell became involved in the mixed methods app development process, Dr. Luo developed several beta versions of the mixed methods app based on the content from the mixed methods textbooks. These beta versions helped Dr. Creswell understand how to deliver the domain knowledge with the available resources. To identify and meet the needs of the mixed methods learners, Dr. Luo actively participated in the app usability testing and revision process as both a designer and an end user.

The software tool used to develop the mixed methods app interface is *Appery* (<http://appery.io/>), a cloud-based platform that offers the app development environment with visual development tools and the power of JavaScript. Appery provides various components, from pictures to text to videos that help define the functionalities and interface of an app. The components include the input controls (e.g., buttons, text fields, checkboxes, radio buttons, drop-down lists, toggles, and date field); the navigational components (e.g., slider, search field, and icons); the informational components (e.g., tooltips, icons, pops, and panels), and the containers. Appery allows the app to be tested in an online mobile simulator through a test link or a quick response (QR) code.

FIGURE 1. The welcome page of the mixed methods app.

FIGURE 2. The dialogue box that will appear after users tap the "start" button on the welcome page.

THE PROCESS OF DESIGNING AND DEVELOPING THE MIXED METHODS APP

Origin of the Design

The function of the Mixed Methods app is similar to an expert system, so we adopted methodologies to design and develop an expert system, modified for areas specific to an app, such as user interface design. We reviewed the literature on expert system design and the principles for designing and developing a useful and easy-to-use app that satisfies users. We used the findings from the literature as a guide to design and develop the Mixed Methods Research Design app.

Based on Brown's (2014) suggestion, we reduced educational content to core knowledge in the app. The educational

content includes "where to go from here" resources and focuses on the student's research process. We gave learners choices to direct their own learning based on their research purposes, needs, interests, and previous research experiences. In this learning environment, students are expected to be more likely to establish levels of mastery and confidence in using the mixed methods research design approach (Brown, 2014).

Key Design Decisions

App overview

The app aims to guide users to understand and use the mixed methods research design approach in their research project. The app starts with what users already know or what they want to know about the mixed methods research design approach. Figure 1 shows the welcome screen of the app. The interface has two major buttons: "Start" and "If you know which mixed methods design you need, check it out directly."

If users are not aware of their prior knowledge or do not know what they want to learn, they can click the "Start" button. The app will

ask users three main questions as indicated in Figure 2. Each main question will lead users to a section that addresses a general or specific area in using the mixed methods research design approach. As the app users move from one section to the next, the importance of each section and the requirement of the users' mixed methods competence level increase.

If users are more interested in knowing the different types of mixed methods design, they can click another button that says "If you know which mixed methods design you need, check it out directly." Types of the mixed methods research design approach are displayed in Figure 3.

FIGURE 3. The dialogue box that will appear after users tap “If you know which mixed methods design you need, check it out directly.” button on the welcome page.

Three main sections

We designed the app to have three main sections after the initial welcome screen. Each section is similar to a learner’s real-time consultation process with a mixed methods expert, Dr. Creswell. The app provides a series of questions and choices as a decision tree for learners to follow.

Section 1—Helps users answer the main question, “Is mixed methods the best method for my study?” This section is intended for users who do not know whether they need to choose a mixed methods study. The app asks the users questions about their topic and the intent of their study, their access to the research data, and their plan on whether to combine the two databases (qualitative and quantitative) for a rigorous research design. After users input their answers (yes/ no) to the questions, the app provides the mixed methods expert’s suggestions to the users. The app will continue to ask other follow-up questions to lead the users’ cognitive thinking process further until the users answer the main question of the section. At the end, a transition question, “What is your primary reason for combining the two databases?” links the users to the next section to further explore what types of mixed methods research design they could use.

Section 2—Helps users answer the main question, “Which mixed methods design should I use?” This section is intended

for users who decide to use mixed methods for their research but are not sure which type of mixed methods design they should use. Continuing with the transition question from section 1, the app will ask users at the beginning of Section 2, “How would you treat the data based on your primary reason for combining the two databases?” (see Figure 4) Each question has different choices that lead users to different suggestions from the domain expert. Based on the users’ previous answers, the app asks a new question to facilitate the users’ decision-making process. After the users answer the main question for section 2, the app will ask the users another transition question, “What mixed methods features can you add to enhance the rigor of your project?” This will lead users to Section 3.

Section 3—Helps users answer the main question, “What mixed methods features can I add to enhance the rigor of my project?” This section is intended for users who want to make their research project more scholarly and rigorous. In this section, the app will give users doable and practical advices at the stages of planning the study, collecting the data, analyzing the data, and writing and disseminating the report.

Section 3 also provides a summary template, which allows users to reflect on their recent decisions made with the app. By simply filling in the blanks, users will have a rigorous mixed methods research purpose statement that they can

FIGURE 4. An example of a dialogue box that will appear after the users transition to Section 2.

immediately use for their mixed methods research paper. Users can copy this purpose statement or take a snapshot of it for future use. At the end of this section, the app provides links to other mixed methods learning resources for students to maximize their learning.

Wizard format

A wizard format is an effective way to deliver the knowledge from an expert to a novice and tends to be fast and easy to use (Tidwell, 2011). It breaks down complex tasks into several steps, which feel familiar to users and make them comfortable (Toxboe, 2014). When users are forced to follow a set of predefined steps, they are more likely to focus on the important aspects of a process (Toxboe, 2014). The wizard format creates a path that directs the users to interact with the app and complete tasks in a suggested order (Tidwell, 2011).

Guided by the findings from the literature, we chose the wizard format as the app navigation structure pattern to deliver the domain knowledge (see Figures 5 and 6). In the app, the wizard is displayed as a series of dialogue boxes of questions and answers following the if-then rule designed by the domain expert. The app does not display the expert's suggestions for the question until the users select an answer to the question. Users are able to follow the decision-making processes to carry out a mixed methods dissertation or project in a step-by-step manner. Learners, especially those who are trained as consumers of research and do not know how to conduct a mixed methods study, will be able to identify their individual project and research design type to improve the quality of their project.

Domain expert's questions to learners

We believe the learners will engage in the domain knowledge learning process when we encourage them to think from their own perspective and reflect on their own research projects. This strategy might be especially helpful for those who are at the beginning of any research project and find

it difficult to engage in mixed methods learning. Therefore, this app uses the language "I" or "my" instead of "you" or "your" in the three main questions. For example, "Is mixed methods the best method for my study?"

Domain expert's suggestions to learners

We believe better decisions will be made when people have enough alternative choices. External cognitive aids and informative feedback during the decision-making process will

help learners to absorb and understand the new knowledge, manage their large amount of previous knowledge, and gain more insight into decision-making on how to control available information (Bruning, Schraw, & Ronning, 1999). Therefore, the Mixed Methods app presents a series of choices and established domain expert's suggestions as possible answers from which users can choose. The domain expert's suggestions are to educate learners to have a clear understanding of the domain knowledge, as well as allow learners to justify when to use mixed methods in their research proposals. Rogers (2003) indicated that the why-and-how knowledge may help learners adopt an innovation. Hence, the domain expert's suggestions focus on why and how to use mixed methods, regardless of learners' prior experience with mixed methods.

Offering a sense of control to users will likely help them feel engaged and have confidence in the app; otherwise, users will feel frustrated and nervous (Marinilli, 2002). When designing the app, we were particularly cautious about relieving users' anxiety of being trapped in an unrecoverable mistake. The app gives users the freedom to navigate back to the beginning and make alternative choices. We did not set up any default answers so that users will have the largest degree of autonomy when making decisions. Users can also freely navigate among sections. They can choose to go to the next section after they complete the current section. They can also select a button from a navigation bar at the bottom of each page, which helps them to know where they are within one of the three sections. Users can always go to the home page or go back to the previous page no matter where they are.

Offering a reward system can increase learners' engagement and make the learning meaningful (Alanne, 2016). With the reward system, users may feel relaxed and finish their tasks efficiently. Less anxiety when interacting with the app can decrease the users' cognitive load and improve their learning (Marinilli, 2002). Therefore, we designed the app to display a

FIGURE 5. Original Mixed Methods app flowchart.

FIGURE 6. Revised Mixed Methods app flowchart.

pop up “congratulations” message when users accomplish the entire task at the end of each section.

Simplicity

The app design follows the rule of being simple. To fully engage learners, the app does not display all domain knowledge at once. Instead, it starts with the question about which learners are most concerned with, or what they already know. The knowledge introduced in the beginning is simple and relevant to users’ prior knowledge. After users make choices, the app only displays the needed function and information. The content is kept within one longer page rather than multiple shorter pages. Each page only displays one open- or close-ended question with a clear and concise label. We used collapse-expand and content chunking techniques (Vukovic, 2014) to organize the large amount of content into smaller visual chunks and hide the non-essential details until users request them. Because users have a limited capacity to retain items in short-term memory, usually seven, plus or minus two (Bruning et al., 1999), the number of the choices responding to the expert’s suggestions was limited to less than seven, plus or minus two. All the information presented on the app page is obtainable within three clicks.

Consistency

In order for users not to commit cognitive resources to learn a new user interface and domain-specific terminologies, we followed the rule of consistency when designing the app. All of the standard terminology (e.g., “explanatory sequential design”) and abbreviations used in the mixed methods app are consistent across app pages and with other training materials on mixed methods, such as the series of mixed methods books written by Dr. Creswell.

Theme color

Color can bring psychological changes to the users at the moment when users look at the screen. Cool colors represent the night, water, and nature. They are often more subdued than warm colors. They express feelings of calmness and relaxation and of being reserved (Chapman, 2010). Therefore, we use cool colors (e.g., green and its variations) in this app.

In conclusion, we followed the user-centered design principle to design the app with the intention to engage learners, facilitate learners’ understanding of the domain knowledge, decrease learners’ cognitive load, and increase their learning efficiency (Bruning et al., 1999).

DESIGN FAILURES AND REVISIONS

After we had developed the app prototype, we invited several volunteer end users to conduct multiple cognitive

walk-throughs and provide feedback. The volunteer end users included students that were taking an entry-level research course—including mixed methods—and faculty members in higher education. The cognitive walk-through was to check the app’s (a) ease of use (user friendliness); (b) completeness (its ability to elicit all of the information needed during the mixed methods consultation process); and (c) consistency of design style, elimination of redundancies, grammar, and logic. The most popular and challenging feedback was that users felt the app looked overwhelmed. We made some changes based on this feedback.

Simplifying the App Interface

We received few constructive suggestions on how to redesign the app interface. We assumed that looking overwhelmed might be because there are too many text narratives displayed within three pages—a technology resource constraint. Appery changed their service level after November 2015 and was able to support more than three pages. Because of this change, we were able to add more pages and separate answers for different questions into different pages. This change reduced the text in each page. The challenge for this change was to keep the font and color consistent across all pages.

Changing the Navigation Structure

We changed the overall navigation structure to accommodate for the learning needs of different users—what users already know or what they want to know (see Figure 6). In the first welcome page, we increased option buttons from one to two, based on whether users know where to begin. We addressed the modified navigation structure under the “app overview” section.

Adding Content to Engage Users

To further address the users’ feedback, we analyzed the characteristics of the end users who provided the comments. We concluded that those who were not engaged in the app content were more likely to feel that the app looked overwhelmed. Few of them did not have a research topic yet, and most of them did not have strong motivations to learn the rigorous research design or to write for publication. On the other hand, a faculty user at a university who had research experience did not feel the same way. We assumed that when users do not have a research topic in their minds or do not want to learn domain-specific knowledge, they are usually less likely to engage with the full content of the app.

To engage users and improve their understanding of the domain knowledge, we made some changes. For those who had never heard of the domain knowledge, we included an introduction video at the beginning of the app (see Figure 7). The video aims to help users gain a general understanding

What is Mixed Methods Research?

John W. Creswell
University of Nebraska-Lincoln
Spring, 2013

FIGURE 7. Introduction video at the beginning of the App.

of what the mixed methods research design approach is and help users answer the expert's questions afterward.

We assumed that with a research topic in mind, users will be able to choose and understand the educational content provided by the app. Accordingly, we added, "Do you have a topic for your study yet?" as the first sub-question of Section 1 to prompt users to have a research topic when using the app.

We also observed that most users are only familiar with qualitative and quantitative research methods. They either do not know or have some misconceptions about the mixed methods research design approach. To better assist this type of end users, we added, "Do you want to both relate variables and to explore an issue?"; "Do you have access to quantitative data?"; and "Do you have access to qualitative data?" after the first sub-question in Section 1.

Users' Experience after the Design Refinement

To understand users' experience after we refined the app, we interviewed several end users and sent out an anonymous usability survey. The end users did not complain about the app looking overwhelmed anymore; instead, they appreciated that the changes helped them identify the types of mixed methods research design easier. However, this end-user group was different from the initial group. We may need more usability testing from larger samples with a diverse background to improve the user satisfaction.

CONTRIBUTION TO DESIGN KNOWLEDGE

In the process of designing and redesigning the Mixed Methods app, we had to deal with the full complexity of factors that influence design decisions, such as the end users' experiences, domain expert's opinion, technology resources, domain knowledge representation, and interface design principles.

Factors That Influenced our Design Decisions

End users' experience

When designing the app, we needed to fully listen to the end users' voices and deeply understand their needs and learning goals. Interviews and anonymous surveys sent to users are common ways to solicit users' experience and feedback. It was important for us to ask users the right questions to allow them to fully express their concerns. Challenges in understanding the users' experience may arise when the response rate of the survey is low or when the complaints are not associated with constructive suggestions. We had to be very careful in interpreting what users truly needed and collaborate with available technology resources to make necessary design changes.

Domain expert's opinion

The domain expert, Dr. John Creswell, has many years of teaching experience in mixed methods. He understands what learners need to know and in what order to deliver the

different levels of knowledge. The questions to the users in the app are from Dr. Creswell's rich teaching and consulting experience. The original outline (Figure 5) was from Dr. Creswell's training workshop in Harvard University College of Public Health. Based on the domain expert's opinion, we were able to design the appropriate app's structure and content for knowledge delivery.

Technology resources

The availability of technology resources is a major factor that influenced our design decisions. We designed this mixed methods app based on the plans Appery offered. We initially designed the app using three limited pages at the free level, which led to a large amount of text within a single page. We were able to redesign the app after Appery changed its platform plan to allow for multiple pages.

We believe designers need to understand and examine the full complexity of integrating technology resources into the design decision-making process, before incorporating the domain knowledge. In this design case, Dr. Creswell reviewed several beta versions of the app Dr. Luo had designed and developed. The purpose of the review was to understand the availability of the technology resources (e.g., in what way the available software tools support the delivery of the domain knowledge), and the scope of app developing skills the knowledge engineer (Dr. Luo) could offer. Based on these understandings, Dr. Creswell integrated his rich experience in the domain knowledge and designed the app's information architecture accordingly.

Domain knowledge representation

One of the most challenging design processes we faced was to make sure the app accurately represents the domain expert's knowledge. This process is essential in determining the success of an expert system (Annaiahshetty & Prasad, 2013). To make sure the app well represents the domain knowledge, the domain expert, Dr. Creswell, worked on this knowledge acquisition process in person.

Interface design principles

The general interface design principles (e.g., simplicity and consistency) are applied in the app to increase the scannability, legibility, and readability of the user interface and reduce the visual complexity (U.S. Department of Health and Human Services, 2014). Applying these general design principles helped the app to communicate the educational ideas to users effectively. Users are also able to use their short-term memory as much as possible when they interact with the app. When the user's memory load is lighter, this allows for a faster and more accurate interaction (Errey, Ginns, & Pitts, 2006; Marinilli, 2002).

SUMMARY

This paper provides an overview of the Mixed Methods app design and development process, the key design decisions, the design failures, and the follow-up refinement. We designed the app based on our thorough understanding of the target users' needs. We adopted the methodology of designing an expert system when designing the app. We utilized available technological resources, ensured the app represents the domain knowledge accurately, and applied the general interface design principles. We listened to the users' complaints and interpreted their needs, based on which we made app refinement plans.

MOVING FORWARD

We could add more advanced features to the app, such as animation that demonstrates the thinking process of re-search design, a database that stores users' personal data and generates an individualized research purpose statement for each user, and some exemplars of different types of mixed methods studies. We plan to get more feedback from end users with diverse backgrounds to improve the features and usability of the app. We will proceed in an iterative cycle of analysis, design, development, and implementation, of both the mixed methods content and user interface, until the end users achieve their highest levels of satisfaction.

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