Cases on Educational Technology Planning, Design, and Implementation:

A Project Management Perspective

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Chapter 14
Agile Management of a Mobile Application Development Project for Surgeon Workflows

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EXECUTIVE SUMMARY

This case describes the agile management methods for an iPhone software development project. The overall objective was to design a smartphone solution that allowed surgeons access to dynamic Electronic Health Record (EHR) data to optimize their workflow. Three separate organizations distributed the responsibilities. Specifically, the lead organization, Cerner Corporation, collaborated with the University of Missouri Health Care and University of Missouri Information Experience Lab to create the technology. Project goals included increased surgeon satisfaction; improved task efficiency, as measured by time spent retrieving lab and vital sign data on morning rounds; dynamic data accessibility; and increased revenue from new product sales. To accomplish these goals, agile project management was utilized, applying iterative usability methods to create deliverables within a short development cycle. Each development cycle focused on user-centered design principles. Several challenges were encountered related to the user-centered design methods, usability data extraction, academic collaborations, and interface design choices.

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ORGANIZATIONAL BACKGROUND

Cerner Corporation is an international, publicly held healthcare information technology (IT) firm that provides software and services to hospitals and other medical organizations. The company has nearly 10,000 employees and more than 6,000 client organizations worldwide, with a net income of $306 million and revenues of $2.2 billion (2011). With the federal incentives to foster implementation of healthcare information technology (e.g. American Recovery and Reinvestment Act of 2009), Cerner has experienced healthy sales and growth in the past several years.

Cerner Corporation maintains large legacy systems previously developed using the waterfall method. The waterfall method outlines a linear process that includes requirements gathering, design, implementation, verification, and maintenance. However, these legacy systems were often developed for functionality rather than usability. Cerner has since transitioned to agile management methods and flexible software service infrastructures.

Based in Kansas City, Cerner is less than two hours away from the University of Missouri-Columbia (UMC), which hosts a full-scope university as well as professional campuses for medicine, nursing, law, and veterinary medicine. The University of Missouri and Cerner Corporation formed a not-for-profit technology collaborative entitled the Tiger Institute for Health Innovation, with the aim of developing a range of innovative new products and services that could benefit both organizations. Within the Tiger Institute, the research and development arm was called the Living Lab. The Living Lab promoted collaborations across the University of Missouri campus, including the physicians and other healthcare professionals from the School of Medicine. The partnership also included the University of Missouri Information Experience Lab, which is a user-centered design research group that blends traditional usability evaluation with human information behavior research. The School of Information Science & Learning Technologies (SISLT) department within the College of Education operates the Information Experience Lab.

SETTING THE STAGE

Across the US, hospitals and large healthcare organizations have been progressively adding sophistication to their use of health IT. By and large, the technical capacity for sharing health information across different Electronic Health Records (EHR) is in its infancy. Federal incentives have promoted the development of health information exchanges, but they are in the early developmental stages, often limited to data exchange within a single vendor, and limited to a highly constrained core data set and exportable/importable CCDA (Consolidated Clinical Document Architecture).

Since 2003, University of Missouri Health Care (UMHC) has been using at least some components of the Cerner product line. New functionality had been added stepwise over the years. Electronic availability of lab and imaging results were widely used among all physician groups. However, electronic clinical documentation by physicians was uneven, with family medicine and internal medicine among the early adopters. Some departments had special documentation needs (e.g. photographs, research protocol documentation, etc), which slowed the initial adoption of electronic clinical documentation. Physician satisfaction with the product line was low, because of concerns about system responsiveness, dependability, and learnability of the complex EHR. Other concerns expressed by the physician EHR users included: Slow responsiveness; poor dependability; large increases in time demands for daily record keeping; poor information display and general usability; and poor matching of features to user groups' workflow needs. As such, Cerner had begun vigorous efforts to improve dependability and responsiveness on a corporate level.

As the Living Lab team considered new opportunities, four domains were considered: Market opportunities, new technology capabilities, local UMHC needs, and product-line gaps not being addressed by the larger Cerner organization. In particular, a mobile application (app) aimed at the needs of surgeons seemed a good fit. Surgeons in particular were unlikely to carry personal laptops in their daily workflow of early morning rounds and surgical cases (planned and unplanned) throughout the day. Moreover, smartphone apps from a few EHR vendors were beginning to appear, so the competitive environment made it an ideal project for Cerner to undertake.

CASE DESCRIPTION

The analysis of the surgeon workflow found that this specialty needed access to dynamic data as they monitored patient status throughout the day. The members of the project team believed that the best solution was to develop an app that accessed patient data using a mobile device. This case illustrates the technology, evaluation methods, and management processes necessary for user focused solution that improved surgeon performance.

Technology Concerns

There were various technological concerns to consider throughout the project. First, the security and confidentiality of Protected Health Information (PHI) needed to be ensured, as specified in HIPAA (Health Information Portability and Accountability Act) regulations. These rules specify a series of administrative, physical, and technical safeguards to assure the confidentiality of electronic PHI. Second,

mobile devices are more at risk for being lost or stolen. The engineers managed those concerns by ensuring that no PHI data would reside on the phone itself after the authenticated session ended, and that transmitted data would be encrypted bi-directionally. Third, mobile devices have the limitation of small screen size, limited battery life, and smaller simplified keyboards. Authentication needed to be quick and convenient (complex passwords are harder to enter on a mobile device), but balanced with security that used 2-factor authentication.

Data gathering for user research also posed a problem. In previous studies, the Information Experience Lab had often conducted usability studies using software that gathered data on computer desktops. However, no commercial solution had been developed for mobile apps. This caused the Information Experience Lab to gather user feedback in new ways despite not having the ideal tools for data collection.

Technology Components

In order to successfully complete the project, the team members employed various Web 2.0 tools to coordinate efforts. Examples included DropBox, Evernote, Google Spreadsheets, uCern (Cerner communication portal), Google Calendar, and JIRA (development issue and project tracking software). This allowed the team to schedule meetings and access artifacts such as usability prototypes, user-feedback, and usability design research that aided the project. However, team members often improvised their use of technology to suit the needs of that task. For instance, an individual would capture an image from the white-boarding design session using Evernote, but the image was only available on his tablet. Other times the project required the members to share designs created from prototype software such as Balsamiq or Omnigraffle. The Cerner intranet allowed for secure communication and document sharing, but access became an issue as personnel were continually added or removed from the project. Although these tools were beneficial from a low-cost perspective, the scattered artifacts often made it difficult to assimilate all of the needed resources for later stages of the project.

Management and Organizational Concerns

Management and organizational considerations also posed challenges. This software development project was the first project undertaken by the newly formed Living Lab of the Tiger Institute. The governance of the organization was evolving, and the processes for vetting new project proposals was new for both Cerner and for the University of Missouri-Columbia participants. New projects were proposed to organizational oversight groups (first, a steering committee, and subsequently to the Board of Governors) in a 2-page charter document. Once approved, the project would

be extended for a 90-day period, with the presumption that it would be renewed and extended to the next project stage if milestones were being met. After each 90-day period, the initial charter document was amended as needed, with revised timeline milestones and success criteria. In the first year, the Living Lab Steering Committee was disbanded and the project team reported directly to the Board of Governors.

The scope and project management also posed some obstacles for the Information Experience Lab team. User-centered design suggests that users provide feedback at various stages of the software development life-cycle. In doing so, the project aims to develop a solution that better meets the needs of the users. However, planning was difficult because the Information Experience Lab team utilized a flexible personnel model by adding graduate students to various projects as needed. Although this avoided wasting personnel at downtimes of a project, this sometimes posed problems with knowledge transfer for more intensive projects.

Initiating the Project

The project consisted of members across three institutions: University of Missouri School of Medicine, University of Missouri School of Information Science & Learning Technologies (Information Experience Lab), and The Tiger Institute (a technology collaborative between the UMHC and Cerner Corporation). The Subject Matter Expert (SME) was a family medicine physician at the University of Missouri School of Medicine with over 30 years of clinical experience. The SME also had extensive experience working with integrating medical technology, such as Computerized Physician Order Entry (CPOE) and social media into his medical practice. The University of Missouri Information Experience Lab (i.e., faculty, staff, and graduate students) provided a theoretical and research-oriented approach to interaction design, along with iterative usability methods expertise. The Tiger Institute team provided Cerner-employed software engineering expertise and access to patient's electronic health record development databases. Each institution was autonomously managed, but used collaboration tools to communicate across groups. Lastly, the surgeons served as the primary stakeholder for which the project development was targeted (See Table 1).

Table 1. App development project team

Team	Role
Information Experience Lab	Usability evaluation methodology, Interaction Design expertise, Data collection
Subject Matter Expert	Medical subject matter expertise, User perspective, Usability expertise
Tiger Institute/Living Lab	Engineering, Application development

Rather than develop a solution based on preconceived notions of physicians' needs, the project management from each institution decided to place an emphasis on user-centered design. The team chose this approach because of its strengths in optimizing the user experience to support a workflow. The design approach also assists with determining an initial scope, avoiding faulty assumptions, and promoting buy-in amongst the stakeholders. As will be discussed, the project conducted iterative usability of the application using the following methodologies:

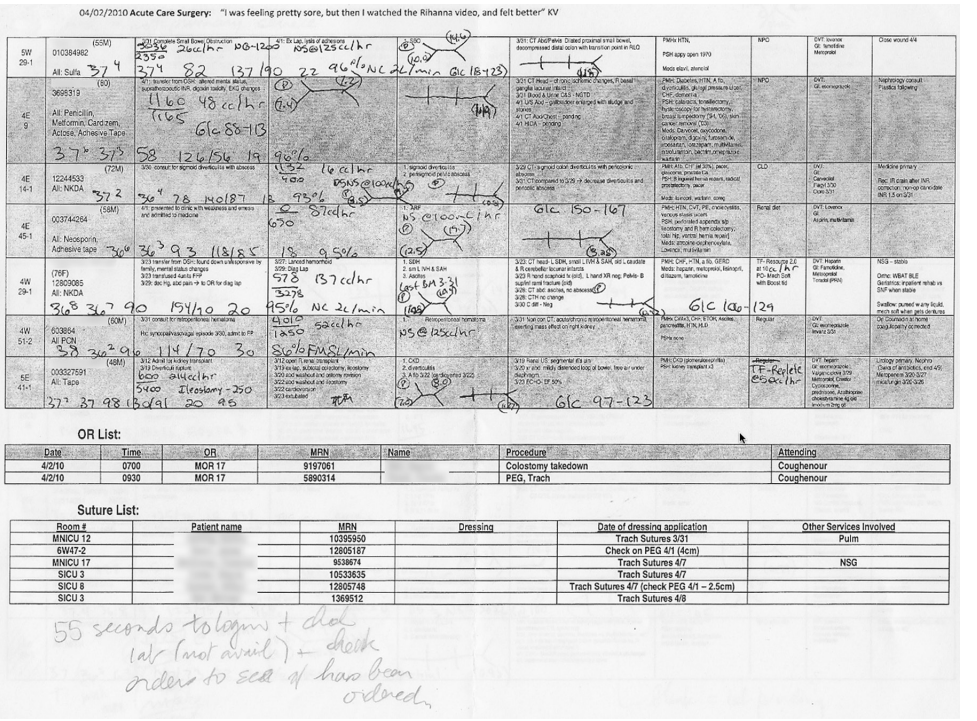
- Ethnographic observation
- Semi-structured interview focus group
- User scenarios
- Card sort
- Lo-fidelity prototype testing
- High-fidelity prototype testing

The Information Experience Lab team conducted an ethnographic study of the "rounding report" meeting at the initial stages of the project. The rounding report entailed all of the physicians and medical students convening in the morning to engage in knowledge transfer regarding patient care from the previous 24 hours. Faculty physicians facilitated the meeting and discussed patient care strategies for the upcoming day. The decision to observe the initial stages through ethnography was important for multiple reasons. The observation helped expose the project members to the workflow processes of the surgeons. As such, the team was able to identify the current technology solutions that were employed by users as they happened in practice and gaps that existed in the workflow. The project members were also able to understand the information needs that played a role in physician decision-making.

Within the hospital workflow system, the ethnographic observations revealed that the surgeons needed a lightweight mobile access to dynamic medical information. As a workaround, third year medical students (M3) would often come in two or more hours prior to the morning rounds (4:00 am) for the sole purpose of copying and pasting patient textual data from the Electronic Health Record (EHR) into a Microsoft Word document (Figure 1). The rounding report included information such as diagnoses, completed procedures, etc. Once the rounding report was created, the physicians would print out the document as a way to reference medical data and write task lists during patient rounds. Physicians would then check off task items throughout the day (Figure 2). However, this solution wasted personnel resources and failed to deliver the dynamic data needed to optimize the physicians' workflow.

Although a limited number of fixed PCs were available throughout the hospital, many physician specialties within the hospital did not have ready access to the dynamic data found within the EHR. The surgeon workflow in particular pre-

Figure 1. Paper rounding report with early AM lab and vital sign results



04/02/2010 **Acute Care Surgery:** "I was feeling pretty sore, but then I watched the Rihanna video, and felt better" KV

OR List:

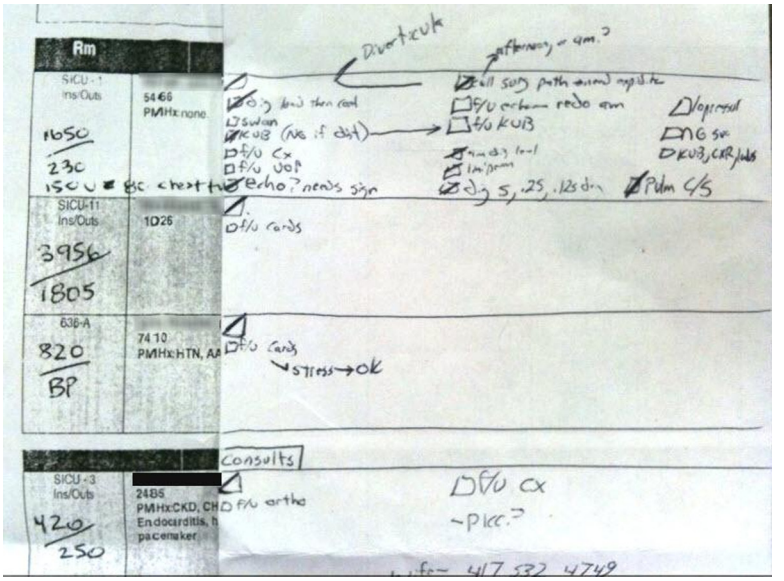
Date	Time	OR	MRN	Name	Procedure	Attending
4/2/10	0700	MOR 17	9197061		Colostomy takedown	Coughenour
4/2/10	0930	MOR 17	5890314		PEG, Trach	Coughenour

Suture List:

Room #	Patient name	MRN	Dressing	Date of dressing application	Other Services Involved
MNICU 12		10395950		Trach Sutures 3/31	Pulm
6W47-2		12805187		Check on PEG 4/1 (4cm)	
MNICU 17		9538674		Trach Sutures 4/7	NSG
SICU 3		10533635		Trach Sutures 4/7	
SICU 8		12805748		Trach Sutures 4/7 (check PEG 4/1 – 2.5cm)	
SICU 3		1369512		Trach Sutures 4/8	

55 seconds to login + click (air (not avail) + check orders to see if has been ordered

Figure 2. Completed tasks



cluded transportation of laptops and therefore required a solution that would fit within a surgeon's scrub suit pocket. Thus, the overall objective of the project was to design a smartphone solution for surgeons that allowed read-access to the EHR between patients, during rounds, on call, and off hours. The desired outcomes included increased surgeon satisfaction, improvement in time to complete workflow tasks, dynamic data accessibility, and revenue increases for Cerner.

Planning the Project

The project charter (2-4 pages) submission to the Tiger Institute Board of Governors outlined the various aspects needed to plan the project. The charter included the following elements:

1. **Project Name and Type:** R&D, pilot, first productive use of new product, or commercialization.
2. **Overview:** Create a cloud-based mobile solution for surgeons.
    a. **Scope:** Application functionality and user stories, deliverable goals.
    b. **Timeline:** 90 days, with start date specified.
    c. **List of Criteria for Success or Acceptance:** Increased surgeon satisfaction, shortened workflow time, and revenue from product sales.
3. **Outcome Assessment Factors:** Quality of care, clinician satisfaction, financial outcomes, development effort.
4. **Required Resources:** Personnel, hardware and software, and total investment required for this phase.

The project was re-evaluated every 90 to 180 days, depending on the promised deliverables and target dates. The decision to proceed to the next charter phase would depend on the outcome of the current phase and Board of Governors approval.

Based on the flexibility and skillset of the team members, an agile project management model was chosen as the best method to align with the iterative and incremental planning, designing, development, and management phases of the project activities. The Manifesto for Agile Software Development (2012) describes the following twelve basic principles of this methodology:

1. The highest priority is customer satisfaction through early and continuous delivery of meaningful and valuable software.
2. Welcome changing requirements regardless of timing in development in order to harness change for the customer's competitive advantage.
3. Frequently deliver working software within a couple of weeks to a couple of months, with a preference towards the shorter timescale.

4. Business personnel and developers must collaborate and cooperate daily throughout the project.
5. Projects can be successfully built around motivated individuals that are provided with a supportive environment and trust to complete the tasks.
6. Face-to-face communication is the most efficient and effective method of conveying information among members of development team.
7. The primary measure of progress is working software.
8. Agile processes promote sustainable development by maintaining a constant pace among the sponsors, developers, and users.
9. Agility can be heightened by continuous attention to technical excellence and good design.
10. Simplicity is essential for eliminating unnecessary work.
11. Self-organizing teams tend to create the best architectures, requirements, and designs.
12. At regular intervals, reflection is important for team members to modify their behavior to sustain and improve effectiveness.

An agile project management approach emphasizes flexibility for changes that emerge throughout the project. This is in contrast to the waterfall method that prescribes predictive planning and evaluation activities at the end of the product development life cycle. Continuous user feedback, flexible timelines, less required documentation, and rapid decisions concerning design and development efforts are appealing features for generating a quicker return on investment. By combining a user-centered design approach with an agile approach, the project life cycle deterred a developer-centric focus that may reflect functionality without usability.

For a traditional waterfall product development life cycle, there is a project manager to monitor activities, personnel, costs, risks, scope, etc. Following agile project management methodologies similar to Scrum, this project did not have a formal Project Manager. The SME served in an informal role as the Product Owner wherein he provided the customer perspective and helped to bridge the gap between the surgeons, usability team (Information Experience Lab), engineering team (Tiger Institute/Living Lab), and the stakeholder (Cerner Corporation). The engineering team entities had their own project facilitator to coordinate communication and activities internally and with the entire project team. As such, there was no formal Scrum Master to help prioritize tasks or to coach the agile process. However, the Product Owner and engineering team shared responsibilities to sustain a consistent agile process, which promoted teamwork and collaboration throughout the project life cycle.

Table 2. Project risk

Risk Category	Degree of Risk	Description
Scope	Medium	Subject to change due to user needs discovered during iterative feedback
Schedule	Low	90 day commitment of resources
Budget	Medium	Some experience with the process. Funding adequate and expected to be stable.
Project Linkage	Medium to high	Dependencies on Cerner for development of software services for mobile, in ongoing development.
Human Resources	Medium to high	Recent success in a similar project, but not formally trained in tools and techniques. Additional graduate students added as resource demands increased.
Senior Leadership Support	Low	Identified, committed, and enthusiastic.
Organizational Impact	Medium	Four organizations involved. Processes subject to change. Project participants somewhat inexperienced.
Technology	Medium	Mobile development and evaluation as an emerging technology for all the team members.

Based on the project initiatives and agile methodology, the team decided to meet weekly to discuss usability feedback and the subsequent stages of the project. Because of the anticipated time demands, the Information Experience Lab initially deployed 7 doctoral students to the project instead of the typical 4 students for tasks such as data collection and analysis. Two senior students were initially required to attend weekly meetings. This flexible approach allowed additional team members to be added as the project became more involved in the later data collection stages.

Risk management needed to address technology, budget, team members, and sponsorship. The technology risk was high given the challenges of the novel infrastructure and security services required for the mobile application. This was mitigated with a 90-day timeframe, which allowed all parties to end the participation at the end of that period without further resource commitment. The budget risk was moderate because the total project cost was $133,459. The budget was reassessed every 90 days before the next phase was approved. Team membership risk was small given the overall size of the group. The risk was slightly higher given that the graduate students were added to the project as resource demands increased. Because of the multiple entities involved, the risk was increased on that account (See Table 2).

Executing the Project

The initial ethnographic observation of the workflow helped to determine overarching problems of the surgeons' workflow. Based on the analysis, the project members

determined the current EHR desktop interface was cumbersome and data points were scattered throughout the system. In doing so, the interface failed to reflect a cohesive picture of the patient changes. Observation and interview data revealed that surgeons needed dynamic and mobile data to support their workflow. The team decided to move forward with a smartphone application that provided dynamic medical data.

Because user-centered design suggests that usability data is collected throughout the software development cycle, it was important for the project to employ various usability methods based on the needs of the given project stage. For instance, the initial stages included focus groups using semi-structured interviews to garner a broad understanding of the current problems of the user and discuss possible recommendations. The semi-structured was comprised of open-ended questions such as "Tell me about your workday", "How would you improve your workflow?" and "What information do you access and when?" The questions were constructed to allow for discussions and elaboration. As physicians began to discuss their workflow and frustrations, a broader awareness of the user needs became clear to the team. This was especially important given the uniqueness of the workflow and novelty of mobile application development.

Once the project team developed an initial sense of the project scope, the team felt it was valuable to formulate scenarios to contextualize the focus group data. Near the inception of the project, the subject matter expert (physician) documented various hypothetical scenarios on a notecard. These served as theoretical examples of how the technology could be employed by the user (Bodker, 2000; de Jong & Lentz, 2006). For instance, the team would often reference the "soccer field scenario" that hypothesized how a physician might use the app when s/he is randomly interrupted while away from the office by a nurse. The scenario-based approach helped to incite discussions such as basic information needs, access to additional technology, and security considerations. This helped to focus discussions and uncover unseen misconceptions and expectations of the technology. The scenarios also served as important references at both the initial stages and throughout the development stages of the user-centered design process.

At the later stages of development, the project sought to design features that met physician's information needs, but did not overwhelm the relatively small interface. The team once again thought it important to gather additional user data to guide the design. While the observations and semi-structured interview helped to conceptualize the overall goals of the project, these methods did not specify what was needed on an interface. Rather than assume what was important to the physician based on previous data, a card-sort solution provided a more reliable and low-cost user-centered methodology. A card sort provided user input in setting those priorities for inclusion. Technical considerations also impacted the prioritization of what to include. In previous research, card-sort had shown to be beneficial to determine the

information structures and specific interface requirements (Ahlers-Smichdt et al, 2011). In the current project, potential application features such as checking patient data, creating orders, or viewing schedule were given to physicians on a 3 x 5 index card. Physicians were asked to sort the features set in terms of "Need to Have", "Nice to Have" and "Not Important". The data was then imported into a spreadsheet so the project members could view the information needs and app features users deemed as most important for the mobile application. This also helped to resolve "scope creep" issues and focus project efforts based on quantifiable user requested features.

After user data was translated into product specifications, the next stage of the project required the team members to translate the user feedback into an interface design. As a way to minimize the initial investment in engineering, the team decided to employ low-fidelity and high-fidelity prototypes to facilitate the iterative nature of the project. This approach was selected for multiple reasons. In many projects, time is wasted at later stages of the development lifecycle because usability problems are only found after the product has been coded (Romano-Bergstrom, Olmsted-Hawala, Chen, & Murphy, 2011). In the current case, this would have also caused the developers to significantly reconstruct and recode many of the underlying elements of the application after each usability session. Because the interface was constantly in flux, it would have wasted personnel resources in terms of development.

The design process employed paper for the initial prototyping. This method was beneficial because it allowed a quick, efficient, and cost-effective means for the teams to conceptualize and redesign the interface (See Figure 3). Prototypes in the initial stages were especially important because the artifacts provided a concrete

Figure 3. Lo-fidelity paper prototype

visual as to how to translate elements of the EHR desktop into a handheld device and generate a common vision for the team.

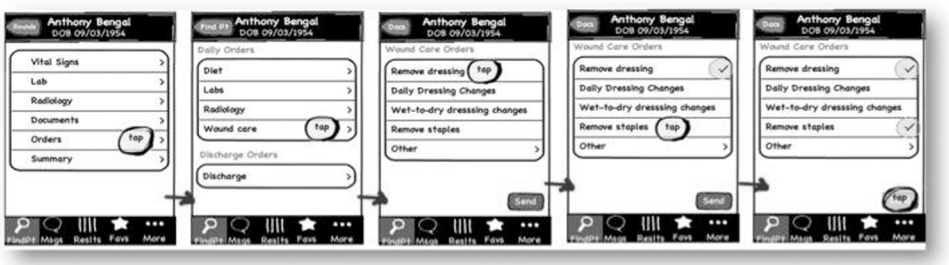
Prototypes became increasingly more complex as user data was extracted and translated into more advanced features of the interface. Later prototypes generated from Balsamiq Mockups and Omnigraffle were cost effective means that produced rich qualitative data from users throughout the project and served to document design decisions. As additional data was gathered, the project developed multiple lo-fidelity storyboards that helped the team to foresee a series of potential user interactions (Figure 4).

A revised prototype would often be developed one to two weeks after the initial usability feedback was received. Project meeting times also included design sessions where the team would draw interface ideas on a large whiteboard. It was only during the latter stages that we devoted significant engineering resources to the project. As the project progressed, the native iOS software developers' kit and Sencha Touch was used for development. High fidelity prototypes were then loaded on late model iPhones and iPod Touch devices by the engineering team for usability tests. This helped the usability team to gather more representative data about the user experience, while also allowing opportunities to iterate the design based on user-feedback.

After the lo-fidelity prototypes received user feedback, the engineering team developed a high-fidelity prototype that was loaded onto an iPhone. However, the user-centered design approach posed significant challenges for gathering data. In previous projects, the usability team from the Information Experience Lab employed Morae software to record a Windows desktop as users interacted with an interface. For the purposes of this project, the project developed various workarounds for the software to gather mobile device software. Specifically, a "mobile usability station" was conceived that consisted of an overhead Webcam and laptop that recorded a user's interaction with the prototype

Despite the benefits of prototyping, this stage of the process also posed some unforeseen issues due to informality of agile roles. The engineering teams and product

Figure 4. Storyboard prototype



owner were sharing the planning and coordination, but the lack of a formal project manager or Scrum Master to facilitate the agile process confounded some aspects of the project. As we adopted the prototype tools and other high resolutions, it was unclear which organization owned this aspect because the prototype software and design process was a novel activity for all parties. Because the Information Experience Lab had conducted needs analysis and usability evaluations for other projects, it was assumed by others that the resident graduate students would conduct the design work. However, the graduate students assumed the engineers would be responsible for the design because they would eventually code the app. This posed some confusion during the project execution because of the ambiguity about responsibilities and the rapid, iterative nature of the design process.

Monitoring and Controlling the Project

Usability reports served as a critical communication artifact from a project management perspective. Members from the Information Experience Lab would often be deployed to the hospital setting to gather user data for the latest prototype. Upon completion of the rapid user feedback, the Information Experience Lab team would assess the qualitative data for themes related to the design and share the reports using Dropbox and Google Docs. Given the iterative and agile project management methods, the team members met weekly as a way of monitoring the project. The meeting was primarily to determine changes to include in the interface for the later project stages of the development process. Each evaluation would often change the scope and direction of the project based upon user data. This iterative approach helped to promote efficiency by avoiding engineering rework at the end of the project.

These meetings were initially small with one physician, one engineer, and two doctoral students attending the meetings. Each institution was thus seen as representing one of three perspectives: Physician (SME), technical (engineer), usability (Information Experience Lab). A "level playing field" approach also allowed for open discussions as each team member's contribution was seen as an important input for that aspect of the design. Because each perspective was included at the outset of the project, the team members avoided viewing the project in disparate phases such as "engineering" or "usability", but instead embraced a holistic design approach that emphasized an atmosphere of mutual respect and understanding throughout each phase.

Closing the Project (Merging)

The merger of two app projects (Mobile Surgeon iPhone App in Columbia at the Tiger Institute Living Lab and the Physician Express iPhone App at the Kansas

City Cerner campus) constituted an end of the Mobile Surgeon project. Merger with another project was never in the original plan, and was not foreseen. The original goal had been to bring the smartphone app to market. However, the Cerner Kansas City campus DeviceWorks team (responsible for providing services and interfaces to a wide range of non-PC devices such as hand-held scanners and PDAs) was developing an iPhone app to test its new infrastructure for mobile devices. The overlap in functionality caused Cerner leadership to merge the two smartphone projects. This merger resulted in a new leadership structure and new work processes across the two geographic locations.

CURRENT CHALLENGES FACING THE ORGANIZATION

Challenges for Information Experience Lab

Data Collection

The agile project management presented major challenges on various levels. Agile techniques require frequent (every 2-4 week) testing and/or user feedback of new software iterations, which can improve customer satisfaction (i.e., Agile Manifesto Principle #1). One of the major challenges the Information Experience Lab faced included recruitment of physician test subjects. Physician recruitment was difficult because of their time demands for clinical care, medical record management, and unpredictable emergencies.

Another challenge was determining the technical methods to collect usability data using the mobile device. At the time of the project, there were no available software tools for capturing quantifiable usability data (e.g. user inputs, clicks, and audio) on mobile devices. The team could not expect the targeted user-group of physicians to travel to the dedicated usability lab because of the time demands. Moreover, the traditional usability lab with a user seated in a quiet testing room failed to replicate the bustling hospital environment. This required the usability team to construct novel and flexible workaround methodologies at various locations to obtain usability data. The project also constructed scenarios that addressed security considerations around data access outside the organizational network, lost or stolen devices and economizing data transfers due to cellular bandwidth limitations. This informed design considerations related to security, patient confidentiality, and communication.

Knowledge Transfer

Meeting daily with team members is another Agile Manifesto Principle (i.e. #4) that was difficult to follow, because most team members of the Information Experience Lab were working on at least one other project during this time period. The issue of consistency and knowledge transfer is a problem frequently experienced by the Information Experience Lab because the organization adds students as the project scale increases. This helps to ensure that personnel resources are not wasted on particular projects. In the context of the current project, the iterative and agile nature of the project meant that the feedback from the user testing was helping to refine the project scope. This sometimes led to difficulty in determining the amount of information needed for new team members to perform project tasks. To sustain and continue the development pace with little interruption (i.e., Agile Manifesto Principle #8), it became critical that the designated Information Experience Lab team leader communicate the project scope and status with new members prior to the weekly design meetings. That is, one student would convey the relevant information back to other students at the usability laboratory. This helped to reduce issues with knowledge transfer among Information Experience Lab team members, while also allowing load shifting during more time intensive activities, such as analysis of qualitative usability data.

Design

Arguably the most significant challenge was the actual development of a mobile application; specifically, the translation of a complicated EHR designed for a 12" screen into a handheld device. Industry standards, security concerns for mobile devices, cellular network access, and iOS constraints also imposed another layer of complexity to consider throughout the design process. The team, therefore, had ongoing discussions whether it was logical to mimic the current EHR or optimize the application for usability given the parameters of the device. This led to differences of opinion about the optimal use of the device and adherence to the overall scope of the project. However, because the project management methodology included extensive user-centered design research at the initial stages of the project, the engineering team was able to code the technology in such a way that other user-requested features could be easily integrated in future versions.

Challenges for Cerner and University HealthCare

Governance

Cerner and the University of Missouri had collaborated on previous projects prior to the beginning of the mobile app initiative. They discovered the institutions had widely divergent governance and financial reporting structures. Specifically, the differences in the way that the two organizations accounted for personnel overhead costs were an initial source of conflict. As such, the two organizations redefined their methods of cost sharing and profit sharing in their organizational charter.

The executive director currently manages the new Tiger Institute under the authority and supervision of the Board of Governors. The Tiger Institute includes a staff of full-time Cerner employees in management and engineering roles. The Living Lab medical director position was shared by two full-time University family medicine faculty members and funded by the Tiger Institute Living Lab budget. There was additional significant university faculty input on an unreimbursed basis. However, most of the faculty members also were significant stakeholders in projects for which software development was underway.

Communication

Communication efforts around the recruitment of subjects were flexible and nimble. Initially, the project attempted to create an ad-hoc Microsoft Excel database with physicians who were willing to participant in usability testing. However, this failed because participant replies were sporadic and could not support the rapid response required for iterative usability testing. The project later switched to sending recruiting e-mails through the Family and Community Medicine department chair office, but this approach was problematic because there was no assurance if recruitment e-mails were forwarded promptly to the physicians.

As part of the project testing, the team was given access to a testing site within the School of Medicine's Clinical Simulation Center as a way to collect usability data. The Clinical Simulation Center allowed the team to coordinate scheduling and distribute participant invitations from their Microsoft Outlook account. This provided several advantages including name-recognition for our invitations (the invitees were accustomed to this sender), visual coordination of the availability of the rooms, testing staff from the Information Experience Lab and tracking of appointment acceptance by the physician test subjects.

Collaboration

Collaboration was necessary at multiple levels in order to implement Living Lab projects. For instance, the engineering team was dependent on access to the data in an EHR. This required collaboration with multiple individuals at Cerner at different levels of the organization. In order to implement the software locally for testing at University of Missouri Health Care, the engineering team was in constant contact with the Information Technology implementation team at the University. Any changes that involved our project had to be incorporated into the software upgrade roadmap of UMHC.

Challenges for Inter-Organizational Collaboration

A significant issue was the newness of the Tiger Institute and inter-organization collaboration. As such, the stakeholders were constantly in flux as the scope of the institution (The Living Lab) and subsequent partnerships were dynamically being defined alongside the project. The core team used free online collaborative tools during the initial development such as Dropbox, Google Docs, and Evernote to overcome the communication challenges. As the product became more evolved, the team shifted to a corporate IT collaboration environment that offered additional security. However, the environment was significantly harder to access by people outside the core Cerner team.

Another key challenge included an initial lack of formal project facilitator as the project adapted to the agile management process. The project was managed both on a micro (internally within the specific institutions) and macro (three institutions) levels. This provided further confounds for the entire project team because the project had to account for dynamic changes in personnel resources, knowledge transfer, and governance reporting.

IMPLICATIONS FOR PROJECT MANAGEMENT

Although the project embraced some of the core elements of agile project management, the unique challenges and opportunities for this initiative caused the project requirements and goals to be somewhat evolving. Therefore, in terms of project management maturity, this project falls in the Level 2 category—some practices, with incomplete or inconsistent application enterprise-wide—because it used some elements of an agile development approach to user-centered design. In the presented case, the team initially thought that one of the project goals would include the design of a mobile electronic health record. However, observation of

prospective users in context helped to understand the holistic nature of the user workflow. The time invested in the user-experience in the initial stages helped to lay the groundwork for the remainder of the project. We believe that this approach helped to save considerable amount of time and energy as requirements changed (i.e., Agile Manifesto Principle #2).

In many cases, project documentation includes precise plans that detail specific stages of the software development cycle. The user-centered design and agile project management approach, however, suggests that flexibility is available as users define and redefine the requirements of the technological solution throughout the project. Consequently, it is important that project managers find ways to garner user data from various methodologies throughout the project as the scope is refined. The current case discussed how focus groups helped to provide a wider perspective in the initial stages. Alternatively, card-sort methodology reduced the issue of scope creep by allowing users to determine what system features were most important to their workflows. Low and medium fidelity prototypes helped to elucidate interface misconceptions and navigational issues as the design became more concrete. While some project facilitators may find it frustrating to start and stop the development aspect of systems design, our experiences found that applying appropriate user-centered feedback at the correct stages provides important feedback that was critical to the project success. That is, we did not have to waste engineering time, because we did not design the underlying infrastructure based upon faulty user assumptions. The investment in upfront, low-cost usability data provided empirical validation for the design and helped to ensure our project stayed on course to meet user-needs.

Promotion of alternative perspectives was also a critical element to the success of the project. The physician perspective helped to detail the physician frustration and information needs so we could provide a product that appropriately supported physician workflows. In turn, this informed usability methods that the Information Experience Lab utilized to collect data. The engineering perspective helped the other teams understand the project feasibility from a technical side. Lastly, the Information Experience Lab representatives helped to ensure the user experience was not forgotten as the scope and interface became more defined by the SME and engineering team. This project approach was beneficial for multiple reasons. We believe this helped to develop a more robust yet usable solution that was effective for surgeon workflows because each perspective was considered from the outset of the project. Furthermore, viewing these perspectives as equal helped to engender respect and congeniality throughout the project.

An important consideration for agile project management is the need to apply flexible resources throughout the project. This particular project added personnel on a "just-in-time" basis as various stages of the project became more time intensive. Inclusion of multiple usability specialists or engineers would have been a waste

of effort as the project scope was being constantly redefined based as new user feedback. For our project, the designated appointees of the Information Experience Lab and engineers were in charge of communicating within their individual teams. This was beneficial so larger meetings did not spend unnecessary time rehashing the project history or previous design decisions to new members. As such, this intra-organizational autonomy helped to ensure that knowledge transfer did not significantly impede the overall status of the project.

Lastly, this experience details the importance of tools that facilitated communication across team members. At various stages of the project, team members from each of these institutions would often be added to the project based on the needs of the current development phase. From a project management perspective it was important that the individual project team-leaders use various Web 2.0 collaboration tools (i.e. - Dropbox, Google Docs, etc.) to communicate with their colleagues, review the usability reports, and issue trackers as the project scalability increased. Given the agile-development nature of the project, the emphasis upon communication helped to preclude issues as they related to knowledge transfer loss.

SOLUTIONS AND RECOMMENDATIONS

- Project managers should invest and commit to fully understanding the user-workflow prior to any development efforts. In particular, observation of the user context is recommended early in the project. This helps to avoid faulty assumptions about the workflow and helps to ensure that a solution is generated that meet user-needs. A more holistic understanding at the early stages helps to save resources at the latter stages of the project.
- Project managers should consider applying different usability methodologies at various stages of the project. For instance, using methods such as ethnography and semi-structured interviews can help provide a broad understanding of the workflow. Alternatively, methods such as card-sorting are an effective way of prioritizing user interface needs when demarcating the scope of the project. Each method provides insight into a unique component of the user experience.
- Prototypes allow projects to generate multiple interface designs and promote creativity. Low and high fidelity prototypes are effective means to garner efficient usability data at latter stages of user-centered design projects. These tools enable cost-efficiencies because project managers do not have to dedicate costly engineering resources to resolve usability issues at later stages.
- When undertaking an agile development initiative for new technologies, it is important to think of different ways to use existing tools. In the case of a

mobile device, current technology was not able to capture user data because the software (Morae) only worked on desktops. Because user-centered design emphasizes the need for continual data collection, using Morae in novel ways allowed the team to accomplish the project goals.

- Embracing different perspectives in a project promotes the development of a more robust technology. Often, teams handoff to one another rather than collaborate throughout the project. This project illustrates how a subject matter expert, usability team, and engineers worked together to develop a mobile application. While some may believe that this leads to discord, our experience showed that this "level playing field" helped to provide an understanding and promote a mutual respect as more perspectives were discussed. As such, each team member was able to better understand the constraints, technology capabilities, and user perspectives of each perspective. This caused us to not lose sight of a particular perspective depending on the product development stage.
- Although the representative model worked well, it is important to make clear who is responsible for certain aspects in the project. In our example, there was some ambiguity about which organization would do the interface design. Project facilitators should take time to clearly outline milestones and subsequent responsibilities.
- Rather than include all group members, our experience found that a relatively small team (4-6) of representatives from each institution served best for overall project management. These representatives were then responsible for managing, communicating, and assigning resources within their respective organizations. This micro (within) and macro (across) management approach helped to monitor the scalability of the overall project. Moreover, utilizing artifacts such as usability reports and issue tracker through Web 2.0 software was a way of sharing the project milestones accomplishments and precluded issues of knowledge transfer.

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KEY TERMS AND DEFINITIONS

Agile Project Management: Project management approach that emphasizes flexibility for changes that emerge throughout the project. This approach emphasizes continuous user feedback, flexible timelines, less required documentation, and rapid decisions concerning design and development efforts in order to generate a quicker return on investment.

Iterative Design: A process whereby an interface is designed and evaluated multiple times throughout a development process. The process often employs prototypes for each iteration.

Prototypes: Initial designs that serve as potential representations of the final interface.

Subject Matter Expert: A knowledgeable individual who provides insight into the perspective of a particular user group.

Usability Testing: A technique used to evaluate a product by testing it with representative users.

User-Centered Design: A design philosophy that focuses on the user needs throughout the design process.

Waterfall Method: Project management approach that outlines a linear process related to requirements gathering, design, implementation, verification, and maintenance; Prescribes predictive planning and evaluation activities at the end of the product development life cycle.