An Iterative Assessment Approach to Improve Technology Adoption and Implementation Decisions by Healthcare Managers

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The User-in-Context Iterative Assessment (UCIA) approach allows decision makers to acquire rich knowledge of their users and the way technology is used in the context of their work. A case study involving the introduction of a handheld medication administration device for nurses on a medical-surgical ward is used to illustrate how a UCIA approach can help provide healthcare IT professionals and hospital administrators with the data that they need to choose and implement IT applications that have the current and future potential to maximize cost savings while improving the delivery of patient care.

The US healthcare industry spends over 36 billion dollars annually on information technology (Frost & Sullivan, 2004). Fueling this economy is an increasingly competitive healthcare market and the perception that new technologies will add value by cutting costs, saving time, improving workflow efficiency, and reducing medical errors. Implementing a new medical informatics solution is a difficult, time consuming, and expensive process, and is only worth undertaking if that added value will be realized.

Although IT managers in nearly all industries are under increased pressure to deliver technology solutions which provide return on investment (ROI), managers in healthcare settings have a number of unique problems. For example, hospital administrators must be as concerned with patient care outcomes as they are with traditional financial metrics of success. Further, healthcare IT is often designed to be used in the delivery of patient care, and the IT users are highly skilled professionals with complex skill sets. Errors which occur in healthcare delivery can be particularly consequential in terms of their effect on patients' health and the financial well-being of the institution (e.g., from medical malpractice suits). Although these errors certainly occur in the absence of IT (Institute of Medicine, 1999), they can also occur when new technologies disrupt the workflow of healthcare professionals through lack of familiarity with the technology or simply because it is poorly designed. This is somewhat ironic, as the introduction of IT has been billed as one of the primary ways to reduce medical errors (e.g., Institute of Medicine, 2006).

Thus, healthcare IT managers face the daunting task of choosing and implementing technology solutions which are reliable, cost-effective, and improve the quality of healthcare delivery while introducing technology in a manner that fits the complex workflow involved in delivering patient care. This task is made all the more difficult because these IT managers often lack detailed knowledge about their professional users and the context in which IT is utilized.

The most effective way to know if a technology is worth the time and effort spent to implement it, is to perform an assessment. Traditionally, organizations of all types have been resistant to assessing the efficacy of technology implementations (Rogers, 1995), as they are typically perceived as being costly, time-consuming, and intrusive to users. When assessments are conducted, measures often vary in type and formality (Ginzberg, 1981; Goodhue, 1992; Hamilton, & Chervany, 1981). Typically, they consist solely of survey questionnaires or interviews which measure users' attitudes toward the new technology, the training received, system usage, or the perceived benefits (e.g., Straub, Limayem, & Karahanna, 1995), although other techniques such as usability testing are beginning to be used (Kushniruk, & Patel, 2004) . While users' attitudes about the new technology are important, they do not directly measure the efficacy of the proposed or newly implemented IT solution. Further, users' opinions often do not match their actual behaviors.

More broadly, what is often lacking in IT assessments is a detailed understanding of the job tasks faced by users, the work context in which these tasks must be accomplished, and the ways in which the new technology impacts (positively or negatively) these elements (see also Goodhue & Thompson, 1995). Most importantly, regardless of the technique used in an assessment, such evaluations are nearly always focused narrowly on the particular IT solution being implemented. Therefore, these assessments are not designed to provide knowledge which can have a broader impact on future implementations, not just the current implementation.

In summary, healthcare IT managers have to navigate a whole host of challenges when making decisions about technology deployment, and often lack data which would allow them to optimize these decisions. In this paper, we introduce the User-in-Context Iterative Assessment (UCIA) approach as a means of overcoming these common problems. The goal of this type of assessment is to provide a growing and detailed knowledgebase about users, the workflow, and the work environment as it relates to the introduction of new technology. Such a knowledgebase can allow healthcare IT managers to make better, more informed system requirements, purchase and implementation decisions.

We then provide a case study for which the UCIA approach was used to assess the pilot introduction of a handheld medication administration device for nurses in a medical-surgical ward. We believe this study illustrates how generalizable knowledge can be acquired in such assessments, and how it provides a means for defining success for current and future IT projects in the same work setting. We conclude by discussing some practical implications of our approach in the form of "lessons learned" for this healthcare setting as well as for healthcare IT managers and hospital administrators in general.

The UCIA Approach <A>

Basic Components <B>

The UCIA approach seeks data about four basic components and their interactions: the user, the workflow, the user's context, and the system (technology).

Based on Leavitt (1965) and others (e.g., Goodhue & Thompson, 1995), the components (targets of assessment) are shown in Figure 1.

- The *user* component consists of the knowledge, skills, attitudes, and physical capabilities that individual users bring to their work.
- The *workflow* component is a description of the tasks which users are called upon to do and includes the physical, cognitive, and communication skills which are required to perform those tasks.
- The *user context* component is the environment in which the tasks must be performed, and includes physical, social and psychological (e.g., morale) aspects of working conditions.
- The *system* component concerns all the technologies that users utilize in their work, not only the specific technology to be implemented.

In the case of medical professionals, the list of implemented technologies is usually quite long. Thus, the importance of the system component should not be underestimated, as even if a new technology fits well with a user's workflow, it may nevertheless conflict with some other technology that a user is required to use.

UCIA Goals and Value <B>

The primary goal of the UCIA approach is to provide a growing and detailed knowledgebase about users, the workflow and the work environment as it relates to IT. We note two important sub-goals which are critical elements of the approach. First, the UCIA examines users in their work context (see also Beyer & Holtzblatt, 1998; Goodhue & Thompson, 1995). This is important for a number of reasons. Survey assessments of technology implementation typically involve asking users questions when they are not actually using the technology or doing their work. This assumes that users: 1) can easily explain how they perform tasks or how a technology affects their work, and 2) that they can recall this knowledge when out of their work context. Neither assumption is merited based on research on human performance (e.g., Norman, 1993). In addition, IT implementations occur within a larger system. Healthcare professionals are highly-skilled and often have complex procedures for delivering care to patients. A new IT implementation must not only be reliable and cost-effective, but must not interfere with quality of care delivery. As will be seen later in the case study, the UCIA approach typically uses several methods to evaluate users and their contexts, including standard methods such as interviews and survey questionnaires. However, we emphasize the importance of also gathering data via structured observation, task analysis or other techniques in the work context as a means of overcoming some of the limitations of these standard methods.

A second important sub-goal concerns the generalizability (re-usability) of the knowledge which is acquired from the assessment. System assessments of all types typically suffer from the problem that they focus on the short-term at the expense of the long-term. In other words, the assessment is designed only to help understand the effects of a current implementation (“Does software X reduce medication errors?” or “What are the UI problems with this software?”). This is inefficient, and typically leads to piecemeal knowledge of users and the work context. A UCIA approach provides more rich and detailed data than a traditional one-point assessment because it focuses on understanding users and their context using a broader array of measures, and it involves an iterative approach. Its efficiency lies in doing more comprehensive assessment at the beginning of a series of projects so that 1) a detailed understanding of users and their context can more effectively drive later decisions, and 2) subsequent assessments need not be as extensive (and thus are less expensive) because the baseline data has already been collected. Further, just as problems caught early in the software engineering lifecycle (e.g., during requirements collection) are considerably less expensive to fix than problems caught later (Pressman, 1992), the same is true when considering a series of projects which are deployed over time. It also helps IT professionals to think more broadly about the type of data to obtain from an assessment and how they interpret the results.

Our own experience is that this approach helps healthcare administrators to better define the success of IT projects. This ability is important for a number of reasons. IT administrators are often called upon to manage the expectations of system users, their own superiors or other members of the executive team. A project is considered wholly or partially successful depending on whether these expectations are met. However, the expectations for the introduction of a new technology are often set by a vendor's marketing team, and are usually quite optimistic. When IT administrators have a more detailed picture of target users and their work context, they are able to scope the project more effectively and set more realistic goals; the adopted goals are typically more specific and cover a wider range of metrics. Thus, administrators are better able to judge which aspects of the project were successful and which were not, rather than judging the entire project on a more general basis (e.g., whether the technology was adopted or not).

In summary, the UCIA approach allows healthcare IT managers to accumulate a growing knowledge of their users, which allows them to make better short-term and long-term decisions. Over time, this approach helps develop a type of *learning organization* (e.g., Senge, 1990), in which each successive implementation builds on the past and the definition of implementation success is further refined. This approach can help the IT professional manage expectations, gather clear data on the success of the implementation, and use that data to diagnose and fix problems.

Five Phases <B>

The UCIA approach has five phases (see Figure 2): Context Modeling, Baseline and Initial Use, Assessment, Post-Implementation Assessment, Analysis, and Future Implementations. In the description of each phase below, we offer specific suggestions on how to best fulfill the goal of each phase. The phases are summarized in Table 1 and the process is represented in Figure 2.

Phase 1: Context Modeling. <C> The goal of this phase is to develop a detailed picture of how users do their job and the context in which they work. In other words, the IT professional is trying to obtain data about: 1) which tasks are performed, 2) how they are performed, 3) and the physical and social environment in which they are performed. This phase is best conducted as a part of gathering requirements but still has utility if the technology has already been chosen. We suggest a good first step is to perform a task analysis (see e.g., Kirwan & Anderson, 1992 for more detailed suggestions) of the major tasks which are performed by your target user population. Although task analyses can be done with varying degrees of formality and specificity (e.g., the level of detail the target user is asked to provide), this is often done by observing an expert or “super user” identified by clinical supervisors as someone who has extensive knowledge and experience. It is important to do such task analyses in the work setting or at least a "mock" work setting. The expert should do the tasks in front of the assessor and should explain what they are doing as they are doing it (i.e., they should "think aloud"). Further, an analysis should be conducted on a variety of job tasks and not simply those which are the direct focus of the implementation. The product of this analysis is called an "ideal" task model because it describes how a task is expected to be done. Besides a task description (e.g., the steps involved in a task), it is also important to obtain information about how the task is performed in the context of the workplace (e.g., when they perform the task, who the users interact with, what information they receive or give to others, what other technologies they use, etc.). Such information can provide the beginnings of a description of the user, the task, and the context.

A second important step in the process is to follow up the task analysis with formal or informal observations of the tasks and work process in other medical personnel actually performing the job. This task is often neglected in assessments and can leave IT personnel blind to the actual variability that exists in the way tasks are completed. One common reason for neglecting this step is seen when IT personnel are former clinical professionals who believe they already know how a task is supposed to be performed, and thus claim there is no need for assessment. However, even if they do have this knowledge, the "ideal" model is not always a realistic one. Often, tasks can be performed in a variety of different ways (some of which may be even more efficient than the prescribed procedure) and the context in which they must be accomplished can vary dramatically even within similar units in the same hospital. Thus, this step typically produces a "realistic" task model. This step also allows for greater observation of how tasks fit into the broader "job" of the professional. Ultimately, this allows the IT assessment team to flesh out their initial understanding developed during the task analysis of the expert.

The outcome of these two steps can be articulated in terms of written summaries, workflow diagrams, figures (see Beyer & Holtzblatt, 1998 for examples) or more detailed process models (see e.g., Diaper, 1989). The simple goal is to produce information which can easily be shared with others and archived. This information can be used by IT management to produce requirements for a new technology, to rewrite requirements or set goals for a currently planned implementation, or simply to verify that a currently planned implementation fits the needs of target users. The data obtained from this phase of the assessment should be used to set clear and realistic goals for upcoming implementations, thus allowing management of expectations.

Phase 2a: Baseline Assessment. <C> Once an implementation is planned, the second phase can be performed by observing users in the context of their jobs. Before observations begin, critical measures (those likely to be affected by the implementation) should be identified for the assessment. It is appropriate to consider both quantitative (e.g., time spent doing a task) and qualitative (e.g., the way a task is performed) measures. For example, if a new computerized physician order entry (CPOE) system is introduced, you might expect a reduction in time to write orders, an increase in adherence to an evidence-based protocol, or fewer requests for clarification from other personnel. While the focus is on these critical measures, it is also important to "cast a wide net" when identifying variables for measurement because it is often difficult to anticipate precisely which aspects of performance will be affected when a change is made. In the example above, if the CPOE system is burdensome physicians may spend less time in direct contact with patients, or may end up delegating the task to a subordinate. Finally, when doing observational research, it is particularly important to come up with clear operational definitions for how a behavior will be measured to increase reliability. For example, in the case study detailed later, we measured the time nurses spent using a laptop computer. This task was defined as “moving or touching the computer, typing or using the mouse, or looking at (reading) the screen”.

Data can be obtained from the system itself (e.g., log files), from literal observations of users, or through other types of assessment such as questionnaires or interviews. For example, it might be appropriate to have measures of the users’ attitudes towards the technology, their job tasks, or broader organizational issues (see e.g., Bradburn, Sudman & Wansink, 2004 for more advice). We do emphasize though, the importance of actually observing users at their job. As mentioned above, there is often a serious gulf between what people do and what they say. We also note that the goal of this phase is not simply to assess the implementation. By expanding the scope of this preliminary assessment, the healthcare IT manager can create a detailed database of the users’ behavior which will allow him or her to make better decisions about future implementations, even those which were not expressly anticipated.

We note a few methodological concerns when conducting structured observations. If multiple observers are to be used, they must be trained for reliability. Most often, this can be accomplished by having observers meet beforehand to agree on how the variables will be measured. As noted above, time spent defining variables will pay dividends later, as observers will make measurements in the same way. A second methodological issue concerns the need to ensure the observations are representative of the target user group.

Commonly, this means that different users are observed at different times of the day. Finally, it is important that observers develop a relationship with the users. In particular, it is important that users understand that you are not monitoring their behavior for reporting to management. In our work, we emphasize that we are trying to understand how they do their job, and since they are the “expert,” we are there to learn from them. This is important as we want to facilitate candid conversations and want them to perform tasks in the regular manner.

Phase 2b: Training and Initial Use Assessment. <C> It is easy to overlook the training and ramp-up periods of an assessment because IT managers are most interested in post-implementation performance. However, because the manner in which training and initial introduction is conducted can play a large role in the ultimate outcome, observations can often help identify features which were helpful or harmful. If, for example, a poor outcome can be traced to insufficient training, the solution may be less expensive than implementing a new product.

Phase 3: Post-Implementation Assessment. <C> The third phase should commence when users have had sufficient experience with the technology and are consistently using it. This phase involves collecting observations and other data just as in phase 2. Once data has been collected, variables can be examined to assess quantitative (e.g. time spent doing a task) and qualitative (e.g. doing a task differently) changes which may have occurred. It is also helpful to solicit user feedback about the specific implementation (informally or through questionnaires) to supplement observations.

Phase 4: Analysis. <C> Although analyses are also made at the end of Phase 1, the breadth of analysis and discussion is often greater at this point in the assessment. The goal is to judge the success of the implementation, and if appropriate to develop a plan of action. The first step is to ensure that all the data have been analyzed and put into a format that facilitates discussion. Quantitative changes between pre- and post-implementation can typically be demonstrated using charts, although more rigorous analyses might involve statistical comparison. Qualitative changes can be described using flowcharts, figures or summaries of user comments. A successful outcome of this phase is accurate information that management can use to drive decision-making. Decisions fall into two basic categories. First, data can be used to assess the efficacy of the current implementation. Did the solution deliver as anticipated? One of the many benefits of doing a detailed assessment is that if the answer is no, the IT manager has a wealth of data to determine why the implementation was not a success. The data may also help isolate problem areas so that the requirements, the workflow, or both can be revised. The data can also be used to pinpoint areas of success even if the implementation as a whole was not successful. Second, the data can be used to plan future implementations. For example, knowing exactly how users perform their tasks helps IT managers better select products that meet the needs of their users. Similarly, understanding the training needs of users may facilitate future implementations. These benefits can only be realized if the data is put into an accessible format for future use. Putting the conclusions on the company intranet for knowledge sharing or writing a technical report will ensure that the data can be used to inform future decisions, which is a key benefit to using this assessment model. Preserving and communicating the outcome of assessments is an integral part of the UCIA approach. It is critical that information is presented in an easy-to-understand format and is accessible to other IT personnel. One possible format is provided in an example summary shown in Table 2.

Phase 5: Future Implementations <C>. One of the key advantages of the UCIA approach is that healthcare IT managers continue to build a richer understanding of their users. If the data and conclusions of prior assessments are available at the time of decision-making, managers have a powerful knowledgebase at their fingertips. Further, this approach increases efficiency as the initial context modeling phase typically does not need to be repeated for subsequent implementations with the same user population.

In summary, the UCIA approach is a process that can be utilized by healthcare IT managers to improve the quality of IT decision-making. We next present a case study to illustrate how the approach might be used in the context of a healthcare IT implementation. The case study uses a fairly methodologically sophisticated version of the approach, but this need not be the case: assessments can range from formal, highly structured assessments to more informal ones. The complexity and rigor of the assessment will often vary with respect to the complexity, impact and size of the IT implementation.

Case Study: Handhelds for Medication Administration <A>

There are at least three opportunities for error in medication administration in a hospital setting. The doctor can prescribe the incorrect medication or dose, the pharmacist can misinterpret the doctor's orders or fill the prescription incorrectly, or the nurse can administer the incorrect medication, give the correct medication at the wrong time, or fail to administer the medication at all. Should any of these situations occur, the consequences are potentially devastating.

The following case details the pilot implementation of a medication administration software package on a handheld computer designed to reduce errors in medication delivery by nurses in a large hospital. The software used was a Beta release from a major healthcare software developer. The first phase of the rollout involved testing the software in one unit of the hospital to determine if the software was ready for hospital-wide use. (The nurses in this unit were aware that they were one of the first units in the hospital to use the device, but did not know it was a Beta version.) The authors were brought in to perform the UCIA after the requirements phase, but before the pilot implementation.

The users were nurses on a 14-bed medical-surgical ward in a large, private medical center located in a Southern state. The level of experience for nurses on the unit ranged from 2-30 years, with a mean of 6.4 years. The hospital was a Level II trauma center with over 600 beds. The handheld computer was designed to replace one feature of an existing system of laptops on carts, which were rolled into patients' rooms to chart medication administration. The existing process required nurses to retrieve medications for a particular patient from a central computerized storage vault. Upon "pulling" the medications from the vault, the nurse would compare the medications to the list on the storage vault's computer screen to ensure they had the complete set of medications. The nurses could then make an additional check of the patient's medications by using their laptop to access the patient's electronic medical record (EMR). The nurse would then roll the laptop into the patient's room and use the attached barcode scanner to scan the patient's hospital-issued wristband. Scanning the barcode verified the patient's identity and called up the medications prescribed to the patient on the laptop. As the nurse administered the medication, each one could be checked off as administered in the EMR. When finished, the nurse would then close the process by electronically “signing” the EMR, which created a report of which medications were administered to the patient with a time stamp. After the implementation, the plan was to continue to use the laptop for general charting and other tasks, but the handheld computers would be used to document medication administration in the patients’ rooms.

The IT project had several initial goals. It was expected that this implementation would increase compliance with the policy of scanning patient wristbands to ensure a match between medication and patient, thus reducing medication errors. The laptop carts were cumbersome, heavy and difficult to move from room to room. It was expected that by offering a more portable system, nurses would be more likely to comply with the hospital policy of scanning patient wristbands prior to administering medications. Of course, the goal of increased scanning is to decrease medication administration errors. It was also expected that nurses would adopt the handhelds fairly quickly as the functionality was similar to what was being currently used on the laptops.

Phase 1: Context Modeling <B>

In this first phase, we asked the nursing supervisor to identify an “expert nurse” who was experienced and followed best practices for a task analysis. We videotaped the nurse administering medication to a mock patient as well as performing other tasks central to her job (i.e., taking blood pressure, assessing mental status, setting up an IV). The nurse was instructed to think-aloud during the observation so that we would know what she was doing and why (Ericsson & Simon, 1993). Further, the nurse walked us through the typical medication administration process from doctor’s order to medication delivery. Videotaping the nurse's demonstration allowed the tasks to be reviewed multiple times to ensure that no details were missed. (Note that this step can be omitted in less complex tasks.) After this observation, each task was broken into its component parts. For example, medication delivery (the end point of the medication administration process) was broken down into steps such as: 1) scan patient wrist band with barcode scanner, 2) ensure match between to-be-administered medications and patient, 3) give patient medication, and 4) mark medication as administered.

This task analysis was supplemented by observations of other nurses on the unit performing their job duties. This analysis allowed us to develop a detailed workflow and identify specific variables we hypothesized might be affected by the transition to the handheld. This phase of the assessment revealed a number of important findings. Nurses on the unit were assigned an average of four patients per shift. The patients often varied dramatically in terms of their medical needs. At the beginning of each shift, nurses were briefed on their assigned patients by a nurse from the previous shift ("a handoff"). The briefing typically included specific patient needs, particular problems to look for, and information about the general status of the unit. We noted that most nurses developed paper-based artifacts (e.g., lists that were arranged by patient, time or both) that helped them to keep track of the tasks that needed to be performed during their shift even though software scheduling tools were available. During the shift, nurses would often update their lists to reflect new or revised tasks. Further, nurses were frequently interrupted during the shift with both important (e.g., "Dr. Smith just ordered an IV for Mr. Thompson") and relatively unimportant information (e.g., "Are you going to the cafeteria for lunch at 11?"). Not only did nurses need to keep interruptions from impairing the delivery of care, but when appropriate, needed to prioritize the new information in the context of other tasks than needed to be completed. Thus, nurses used these artifacts to augment their memory to manage the complex demands of their job.

Our initial assessment led us to the conclusion that the pilot implementation would yield relatively modest delivery improvements. Given the similarity of functionality between the laptop and the handheld, and the fact that nurses would continue to have to use the laptop for other tasks, we expected small changes in the critical task measures (e.g., bar code scanning), if any. Because of this, we felt that the primary goal of our subsequent UCIA should be to acquire additional data on nurse performance (i.e., task, context, knowledge) and evaluate the implementation with an eye toward identifying any "trouble spots" for subsequent implementations.

Phase 2a: Baseline Assessment <B>

Phase 1 allowed us to identify critical variables for further study. These variables were operationally defined in terms of time or count measures. For example, we measured the time durations of various tasks including the amount of time spent in a patient's room, educating a patient, giving a physical assessment, physically moving the laptop cart, doing paper work, etc. Other variables were raw counts of how many times a behavior occurred, for example: interruptions, the scanning of barcodes, and computer malfunctions. Although some of these variables were directly related to the implementation (e.g., barcode scanning), others were chosen to provide broader data about the nurses (e.g., time spent in patient rooms). All measures were helpful in providing a baseline to measure future implementations against. To collect this data, the team members utilized tablet computers and BEST™ analysis software. This portable digital interface enabled team members to quickly and efficiently track the behavioral measures of interest. Data was collected in both day and evening shifts, and generally involved observing at approximately 2-hour intervals for a total of 25 hours of observation. To ensure that our observations were representative of the entire workforce, a different nurse was selected at the beginning of each observation period. Nurses gave consent to be observed and the hospital allowed the observers to enter patient rooms under the condition that no personal information would be recorded. In addition to behavioral data, we also administered a survey to unit nurses that they completed at the end of a shift. The survey included questions about attitudes towards technology in general, and physical and mental tiredness (to assess whether the use of the handheld computers would reduce the physical demands of pushing the heavy laptop carts during their shift).

Phase 2b: Training and Initial Use Assessment <B>

Observers were present during training sessions and immediately after the handhelds were placed on the ward. Formal measures were not gathered at this time, but observers simply watched as the nurses attempted to use the new device. This was done to allow nurses to “get up to speed” with the handheld before gathering data to compare to the baseline measures.

Two major issues which occurred during this period were critical in the eventual outcome of this implementation. First, as is common in beta-testing, development problems at the vendor caused a delayed rollout. Because of this, the time from training until implementation was eight weeks. In addition, it was assumed that the transition from laptop to handheld would be fairly easy given that the information provided by the user interface (UI) was highly similar (although different in format, see below). Thus, the training session was short and involved going through printed screen shots rather than a hands-on demonstration. Although all the nurses on the unit regularly used a variety of technologies, many had no prior experience with pen-based handheld computers. When the handhelds were finally implemented on the unit, not only were some nurses trying to remember how to use the program, but they were learning for the first time how to use a pen-based operating system.

Phase 3: Post-Implementation Assessment <B>

Beginning two weeks after the implementation on the unit selected for the pilot, observers collected 20 hours of data over two weeks in the same manner as the baseline assessment phase. A second survey was also administered. In addition to the survey items used in the earlier phase, this survey also included specific questions about the new handheld device, such as: “What do you like about the new handhelds?”, “What don’t you like?”, and “What could be done to make the process of switching to the handhelds easier?” The purpose of this information was to supplement the observational data and informal conversations with the nurses.

Phase 4: Analysis <B>

We first compared data collected in the post-implementation assessment to the baseline data and found that the introduction of the medication administration software on a handheld computer did not produce changes in the primary measures. Most specific to the implementation, the number of times nurses failed to scan a patient wristband was similar at both time periods (although rates were already low at baseline). Further the distribution of time nurses devoted to various aspects of their job did not vary. For example, time spent in patients' rooms, doing paper work, administering medications, and other typical nursing tasks were very similar. Additionally, the nurses did not report a reduction in their physical or mental tiredness at the end of the shift after the introduction of the handheld. We also noted that although a stated purpose of the implementation was to reduce medication errors, because no medication errors were observed by the researchers at either time period, there was no opportunity to observe a reduction.

The fact that neither the observational nor the survey data captured the potential for these benefits pre- to post-implementation was therefore anticipated after the first phase of our assessment. However, the data we collected provided rich and detailed information about the users, their workflow, work context, and the technology, which resulted in a broader array of goals on which to evaluate the project. It also built a knowledgebase on these users for future implementations, and helped pinpoint issues which were important to remedy for the subsequent hospital-wide rollout. We discuss these findings below.

Lessons Learned <A>

As researchers, we were not directly involved in the decision to implement this handheld application. However, data from the assessment was provided to IT management and is currently being used to make decisions about the future of this and related technology implementations. The handheld device is also now in use hospital-wide. We expect that future implementations will benefit even more strongly from the UCIA approach because they will take advantage of its iterative nature. As we noted earlier, organizations which value learning are able to build on prior implementations to continually improve the decisions they make and the way subsequent implementations are carried out.

One advantage of the UCIA approach is that a project is evaluated based on multiple criteria, and thus the “success” of an implementation can be judged in a more nuanced, yet realistic, way. In contrast, IT implementations are often judged on whether or not the technology is adopted by users. Surprisingly, if this was the true of the current case study, IT management might have concluded the Beta test was largely a success because they received reports nurses were using the handhelds full-time. In subsequent visits to the unit, however, our team noticed that the handhelds were not being used. The nurses candidly reported that though management had asked that they use the handhelds, they still preferred the older laptops. Another learning here is that if we had not created an earlier relationship with these users, it is possible that they would have used the handhelds in our presence, making us think that the adoption had been more successful than it actually was.

Another typical way of assessing an implementation is to focus on one or two measures of performance based on initial goals for the project. Early in this project it was thought that the handheld would increase the frequency of scanning of patient wristbands. Given that this behavior was not affected by the implementation, one might conclude the implementation was a failure. In this case, however, the UCIA uncovered data in the first phase that suggested that major changes to nursing performance due to this technology were unlikely and thus expectations about these changes became more realistic.

Further, we were able to pinpoint problems with the implementation that could be remedied in the subsequent hospital-wide rollout. For example, the reliability of the technology at the time of implementation was a major source of frustration for users. In particular, problems with dropped wireless connections and more generally, with input entries which were not saved by the system, were frequently noted. Although these particular technical problems were remedied by software and hardware (wireless networking) improvements after they were identified, the potential problem, of course, is that users abandon the new technology if older, more stable, alternatives are available—and this was the case with nurses in our study, who could simply return to using the laptops.

Next, the assessment revealed a problem with an initial assumption of the IT team. Because the features on the new handheld were similar to the software on the laptop, it was thought that training could be brief. This assumption was incorrect because although the nurses used technology in their work, many had never used a pen-based system interface. Thus, this revealed an important knowledge gap that needed to be addressed in training that would be conducted before the full rollout.

Another learning was that the procedure elicited by the user interface (UI) design conflicted with the procedures typically used by nurses to administer medications. This was most clearly seen in the way that medications were displayed on the screen. Before the handhelds were implemented, the nurses were able to call up a complete list of the medications to be given to a patient on their laptop. As the nurse gave a medication to the patient, that medication could be checked off the list. This format also allowed nurses to ensure that they had all the medications for a given patient before entering the patient's room. The handheld UI forced users to view and sign each medication before moving to the next medication in an effort to reduce errors. This meant that nurses could not call up the full list before signing. Because this did not fit with the previous UI, it made the task more tedious. More importantly, nurses could not as quickly verify that they had all the medications for a given patient before they went to the patient's room. Several nurses reported they were embarrassed by having to leave the room halfway throughout the administration process to retrieve a missing pill. This workflow-technology mismatch could have been discovered if the UCIA had been implemented before the requirements phase. The lesson here is that a seemingly insignificant UI change ultimately had a negative impact on a previously effective medication administration procedure. Thus, we suggested the possibility of revising the UI in future iterations of the software or improving other aspects of the medication administration procedure, to facilitate this same information collection.

The UCIA was also helpful for pinpointing aspects which were not problematic. When technology is not adopted by users, it is common to assume they are simply resistant to change, yet this was not the case. Despite misgivings about the current version of the handheld, a number of nurses reported they felt it would eventually help them to do their jobs better. One nurse summed up the feelings of many on the ward by saying "I feel it could be an excellent tool for giving meds safely if they would just work correctly." Thus, the assessment also provided reasons to be hopeful for the success of the full rollout.

Our assessment also revealed a rich picture of what nurses do and the factors affecting the performance of their job in general. In particular, ward nurses are under a tremendous cognitive load. We use the analogy of an air traffic controller for illustration. Like controllers, nurses have multiple targets (patients) which require their attention. Nurses have many different types of tasks and have to prioritize them quickly. Nurses are frequently interrupted with information (some of it important, some not). Finally, and importantly, there is very high price for error (e.g., medication errors or missing important cues to a problem for nurses) in both occupations. Nurses are highly skilled professionals who have worked out ways of dealing with this complexity (e.g., the lists they often construct themselves). The introduction of IT into such a process should only be undertaken with a well-developed understanding of how nurses perform tasks in the context of their work environment.

The UCIA approach thus also highlights a typical shortcoming of healthcare IT in that applications tend to be developed to “fix” a particular issue. This is problematic in two ways: such IT implementations can introduce new problems, and this approach overlooks the potential for supporting good practice. By the latter point, we mean that nursing informatics applications could instead be used to reduce the cognitive load of nurses and thus make it easier for them to successfully perform their jobs (and thus reduce errors and improve patient care), although this is rarely the case.

A final lesson, then, is that our findings demonstrate the utility of looking at the entire work system (in this case, the medication administration “loop” from doctor to pharmacist to nurse) when deciding where to focus IT resources. Our data revealed that medication administration took up a small, but important, part of nurses’ jobs. However, the move to a handheld from a laptop computer in this pilot did not produce differences on any related measure. If the issue was looked at in the context of other potential sources of error in the medication administration loop, such data might lead an administrator faced with limited resources to consider which application of IT could lead to the largest improvement on critical metrics in the most cost-effective manner. For this case study, managers can now make decisions on where to spend future resources, and based on the limited impact of this handheld device, could choose to make improvements in the pharmacy or a Computerized Physician Order Entry (CPOE) system.

Conclusions <A>

Healthcare IT managers and hospital administrators face a difficult balancing act when deciding where to spend their IT dollars. Among other things, they must cut costs, reduce medical errors, and improve patient outcomes. Further, the users of healthcare technology in general are highly skilled professionals who have been trained in complex procedures for delivering patient care. In such a work system, the introduction of new technologies can often have unintended effects. Even if such technologies do not adversely affect patient outcomes, they may nevertheless lead to frustration among users. Because of the job market and the nature of their skills, many healthcare professionals can choose where they want to work. Thus, it is even more critical for healthcare IT managers and project teams to have a rich and detailed understanding of their users and the context in which they work.

The UCIA approach provides this knowledge by giving decision makers hard data about the interaction of users, their work, the context of that work, and technology. However, because the approach is iterative, it is most useful when integrated within a larger management process. In other words, there must be a commitment to the core value of understanding users and their context, and continuing to build upon the knowledge acquired from each implementation. This viewpoint has the benefit of aiding both short-term ("Should we purchase this software package?") and long-term ("How do we improve the quality of nursing care and reduce costs? ") decisions, and not only those strictly having to do with technology.

Healthcare IT managers might worry that performing a UICA might be expensive, time-consuming or require outside consulting. Although not cost-free, assessments can often be done for a relatively low cost and time commitment. The basic skills for the assessment can be acquired by most IT professionals with a modest amount of training. Further, the financial benefits to doing such analyses can be quite impressive, such as when an expensive purchase is avoided because an assessment reveals implementation problems which cannot be fixed by a vendor.

The goal of the UCIA approach is to develop an understanding of how the user interacts with technology in the context of their job, and to use that data to assess the efficacy of health informatics implementations as well as to support decisions about the future purchase and design of such applications. IT managers thus become better at predicting the likely impact of a new technology, setting clear and realistic goals for IT projects, and managing the expectations of users and hospital administrators. Ultimately, the UCIA provides a framework for defining and assessing the outcome of IT projects.

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Table 1. Description of phases of User-in-Context Iterative Assessment (UCIA) Approach.

Phase	Description
1. Context Modeling	• Task Analysis • Observations • Workflow Modeling (i.e. swim lane diagrams) • Use to write requirements or influence purchase decision • Use to set appropriate goals for implementation • If appropriate, opportunity to rewrite requirements
2a. Baseline Assessment	• Structured observations of users in context of their jobs • Measure implementation-specific and more general job-related variables (i.e. duration, frequency, ratings) • Develop relationships with users
2b. Training and Initial Use Assessment	• Data gathered can be used to diagnose problems with early-stage implementation
3. Post-Implementation Assessment	• Examine variables used in Phase 2a • Look for quantitative and qualitative changes
4. Analysis	• Use data to help make decisions about current and future implementations • Put data and conclusions in accessible format for future use
5. Future Implementations	• Use baseline data to guide new implementations

Table 2. Example of assessment summary.

Technology Assessment Summary

Technology Implemented: Brand X Handheld Medication Administration Device

Project Lead: Joe Smith (jsmith@hospital.net)

Date of Assessment: Pre-Implementation (May 1 – May 15, 2005), Post-Implementation (July 15 - July 30, 2005)

Project Description: Nursing staff medication administration functions were migrated from laptops on carts to custom handheld solution. Project assessed efficacy of new device and gathered baseline data for future implementation assessments.

Current Version of Software: http://hospitalintranet/it/medadmin.exe

Data files: http://hospitalintranet/it/handheld_data.xls (*Detailed data about assessment*)
http://hospitalintranet/it/task analysis.doc

Staff Involved: RN's and LPN's on Unit 2C

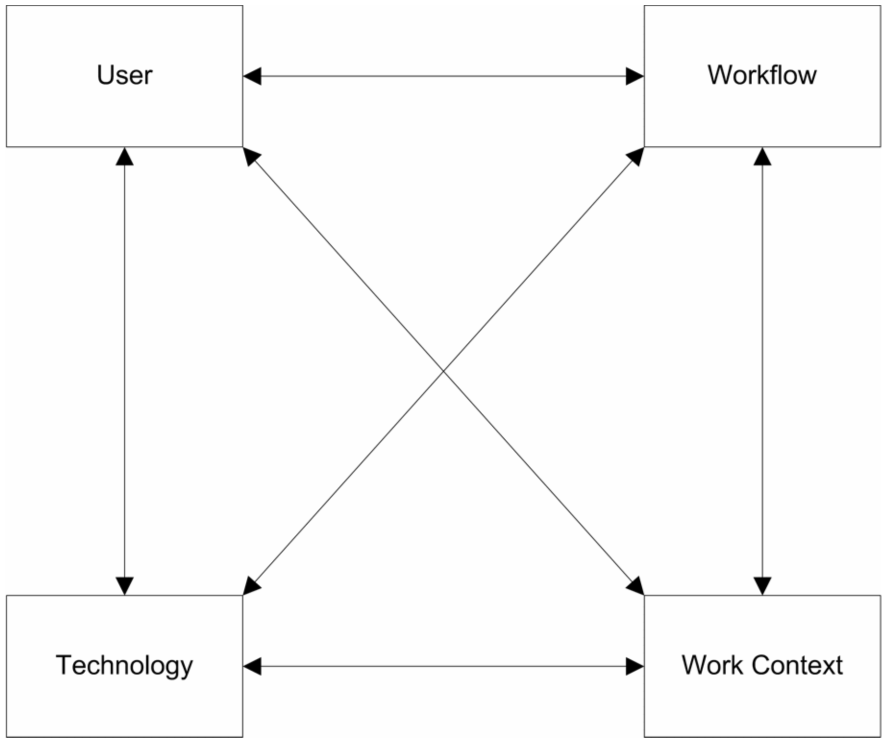
Summary of Lessons Learned:

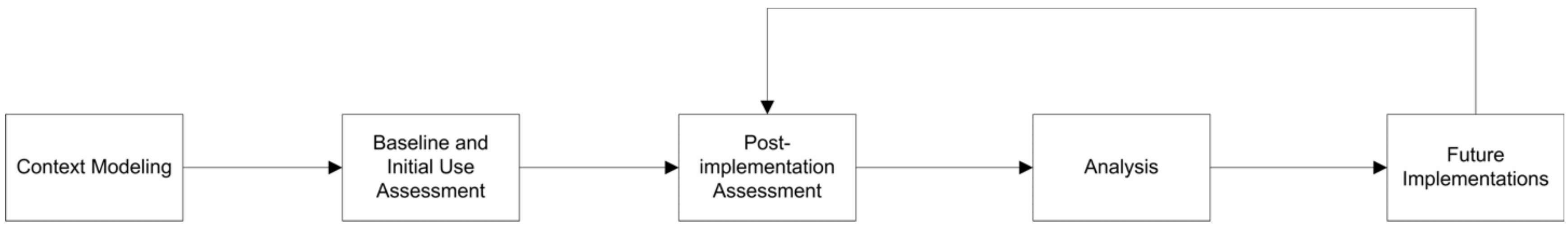
1. Nurses' jobs are very complex, and medication administration is a small, but important part of their job. Task analysis findings are summarized in document <linkto: http://hospitalintranet/it/task analysis.doc>
2. Nurses were frustrated when the UI on the handheld did not match the UI on the laptop. Handheld UI does not allow nurses to easily double-check medication before going to patient's room.
3. Additional technical problems included repeated wireless "drops" and failure to save input.
4. Training should be as close to "go-live" date as possible. If training is delivered and the implementation is pushed back, a refresher course should be offered. Training should include learning how to operate pen-based applications as not all nurses were familiar with the handheld OS (Windows CE).
5. Nurses are interested in using the handheld, but are primarily concerned with application reliability.

Figure Captions

Figure 1. The four components of the UCIA approach.

Figure 2. The phases of the UCIA approach.


User
Workflow
Technology
Work Context


Context Modeling
Baseline and Initial Use Assessment
Post-implementation Assessment
Analysis
Future Implementations