USING THE TASK TECHNOLOGY FIT MODEL AS A DIAGNOSTIC TOOL FOR ELECTRONIC MEDICAL RECORDS SYSTEMS EVALUATION

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ABSTRACT

Electronic Medical Records (EMR) systems offer health care organizations numerous potential benefits. However, it can be difficult to ascertain whether users are satisfied with such systems, and if not, where concerns exist. Organizations wishing to evaluate a health care system implementation like an EMR system can choose from a variety of approaches that have been developed in the Information Systems (IS) discipline. After evaluating a number of alternatives, the researchers selected the Task Technology Fit (TTF) model and its associated instrument as a diagnostic tool to evaluate the implementation of the first phase of an EMR at a university hospital. A survey was administered and an analysis of the data found that the EMR system users, both physicians and nurses, were generally very pleased with the EMR implementation, and, therefore, it could be deemed a success. Based upon this study the TTF model and its associated instrument appears to be a useful diagnostic tool for evaluating a health care information systems implementation.

Keywords: Information Technology (IT), Task-Technology Fit Model (TTF), Health Care Information Systems, Electronic Medical Records, Information Systems Evaluation

INTRODUCTION

Health care organizations strive to attract insured patients by offering the latest technology and advanced medical procedures. At the same time, there is intense pressure to control costs while providing high quality care. As a result, many health care organizations are making significant investments in information technology applications. Electronic Medical Records (EMR) systems offer a number of potential benefits, including cost reduction resulting from diminished need for space and clerical personnel to maintain and store paper records and improved quality of care through enhanced availability of patient information. Problems that health care institutions hope to eliminate or improve through implementation of an EMR include: lengthy waits paper charts are retrieved, lost charts, misfiling of information, difficulty of locating a specific piece of information in a bulky chart, and the limitation of access to the paper chart by one person in one location. However, EMR systems must also meet the information needs and fit with the work patterns of health care providers if they are to enhance quality of care and productivity. Periodic diagnostic evaluations can help to assess the impact of an information system upon the performance of the employees who use it. This may be especially useful during the implementation of a new information system.

Information Systems (IS) researchers are interested in analyzing the degree to which these health care IS applications are meeting the varied needs of the individuals who use them. Fortunately, a number of conceptual frameworks and models are available for IS researchers to use in this analytical endeavor, each with perceived advantages and potential limitations

Health care organizational stakeholders are also very interested in evaluating the outcomes of IS implementations within their organizations. Some of the frameworks used by IS researchers can also provide useful diagnostic information so that organizational personnel can analyze and, potentially, take action in specific areas of concern. This article reviews some of the main theories/models that have been used for evaluating information systems. Then, some of the approaches that have been used specifically for the evaluation of health care information systems are reviewed. The Task Technology Fit model was selected as the theoretical framework for this study.

Following this review of theories used for IS evaluation, the article presents the results of research that is currently underway to analyze the implementation of an EMR system at a university affiliated hospital. This rurally-based hospital provides services that include two acute care units, a critical care unit, an emergency room, family and internal medicine clinics, specialty clinics, and special procedure areas. The survey was conducted

after the hospital had completed the first phase of EMR implementation, which was electronic diagnostic test result reporting. The new system replaced a previous electronic results reporting system that was difficult to use and failed to meet users' needs. This initial difficult experience made the hospital's administrators and IS staff eager to achieve a smooth transition to an improved system. The goals of this survey were: 1) to assess the success of the EMR implementation from the users' perspectives and 2) to obtain diagnostic information that would guide the IS staff as they made adjustments to the new system and planned for future phases of full EMR implementation.

Following the discussion of our research results, the article concludes with an analysis of the utility of one approach, the Task Technology Fit model, and suggests directions for future applications and research.

THEORETICAL BACKGROUND

A wide range of approaches to the evaluation of information system implementation are described in the IS and health care literature. This literature review discusses some of the key approaches that have been used for evaluating information systems, and then focuses on some specific examples of studies addressing health care system evaluation.

Evaluating Information Systems

There are many theories and frameworks for evaluating information systems. In the past, the most generally accepted measures of IS acceptance were user satisfaction and system usage [9, 12]. The following authors worked to define and measure the constructs related to user satisfaction:

- Bailey and Pearson [3] identified 39 different factors that affect user satisfaction.
- Ives, Olon and Baroudi [13] conducted replication and extension of Pearson's prior work to develop a validated survey instrument.
- Baroudi and Orlikowski developed an instrument to measure "User Satisfaction with the Information Services Function", described as "a pervasive measure of the success or effectiveness of an information system … for both management information systems (MIS) practitioners and researchers" [4, p. 44-45].
- Doll and Torzadeh [8] developed a scale to measure end-user computing satisfaction with five categories: content, accuracy, ease of use, format and timeliness.

Ives, Olson and Baroudi [13, p. 786] summarized the two types of satisfaction instruments that have been developed. "The first focuses on information systems product…. The second type … includes the organizational support for developing and maintaining the system as well as the system product itself". Both types of user satisfaction instruments have been used by a number of researchers as a way to assess information systems acceptance. However, approaches using the user satisfaction framework and associated survey instruments have been criticized for their lack of a strong theoretical basis [2, 10]. So, while measuring user satisfaction has been a widely used approach in the past, its weak theoretical underpinnings make it a poor choice for studying the subject of this paper, EMR implementation in a hospital setting.

In the past, the other widely accepted measure of IS acceptance was IS usage/utilization. System usage has been frequently proposed as a measure of IS success [7]. As Igbaria and Tan state, "System usage is a key variable in most of the theoretical frameworks of IT research literature focusing on the adoption of computer technologies." [2, p. 115].

For example, use is one of the key six categories of IS success proposed in the DeLone & McLean IS Success Model [6, 7]. In addition to use, the DeLone and McLean model includes the constructs of system quality, information quality, user satisfaction, individual impact, and organizational impact. One factor that may have limited some application of the DeLone and McLean model in practice is that it assumes volitional usage of the IS. Seddon [19] later developed a model of information system success that addressed both volitional and nonvolitional usage contexts. (For a comparison of the DeLone and McLean vs. Seddon's model of IS success see Rai, Lang, and Welker [17].) While both models can add to our understanding of IS success factors, the use of either model is limited, in practice, by the lack of a validated survey instrument that corresponds to the model/theory. Thus, this approach did not readily provide a way to assess the success of the EMR system which is the focus of this study.

In addition to user satisfaction and usage, a number of other frameworks/models have been used in the literature to assess IS systems. Some of these approaches include Rogers' Diffusion of Innovation model [18], the Technology Acceptance Model [5], and the Task Technology Fit Model [11]. Each of

these approaches provides an interesting and useful perspective for understanding IS acceptance.

Rogers' Diffusion of Innovation Model has been used in a variety of disciplines to understand how innovations are adopted and diffused [18]. IS researchers have explored how IS adoption decisions have been influenced by the five attributes of an innovation identified by Rogers: relative advantage, complexity, trialability, compatibility, and observability. A validated instrument was developed to assess these five factors and their relationship to IS adoption decisions [15]. However, in the case of the EMR system that is the focus of this study, the decision to adopt the system was made at an organizational, not an individual, level. Hence, Rogers' Diffusion of Innovation model and the survey instrument developed by Moore and Benbasat would not be applicable to the individual decision context of this study.

A discussion of approaches to analyze user attitudes toward IS systems would not be complete without a discussion of the Technology Acceptance Model [5]. The Technology Acceptance Model (TAM) analyzes individual behavior and utilization. The two key constructs, Perceived Ease of Use and Perceived Usefulness, are hypothesized to directly influence the user's intention to adopt the system of interest. Furthermore, the user's intention to adopt is presumed to be a valid proxy for their future usage of the system. One key assumption that underlies the TAM is that the usage of the system is volitional (not mandatory).

Another approach to evaluating information systems is the Task-Technology Fit Model [11]. Task-technology fit (TTF) is "the degree to which a technology assists an individual in performing his or her portfolio of tasks" [11, p. 216]. Goodhue [11, 221] focused on the "user domain of IT-supported decision making". Based on this task domain, the TTF model identified three main subtasks of knowledge workers who are using quantitative information in the performance of their tasks. These three subtasks are: 1) identifying needed data, 2) accessing identified data, and 3) integrating and interpreting accessed data. In the development and validation of an instrument to measure TTF, Goodhue identified a number of dimensions for each subtask and created questionnaire items to measure each one.

An analysis of the other approaches and the TTF model suggested that the TTF model best suited the needs of this study, an EMR individual adoption context where all users are not yet required to use the EMR system. The model addresses both voluntary and mandatory use situations, has a strong theoretical foundation, and is accompanied by a validated instrument. In addition, a key goal in the development of the TTF theory was the idea that "task technology fit, when decomposed to its more detailed components, could be the basis for a strong diagnostic tool to evaluate whether information systems and services in a given organization are meeting user needs" [11, p. 213]. Therefore, the researchers and hospital personnel decided to proceed with a EMR study based upon the TTF model.

Evaluating Health Care Information Systems

In addition to evaluating a number of theories/frameworks which IS researchers have used to study IS implementation, the health care information systems literature was also reviewed to see what types of approaches have been used for evaluation. To summarize our findings:

- some of the studies had no discernable theoretical basis that could be identified as the basis for their survey instrument;
- some of the studies did use one research framework/model, either as a way of organizing qualitative findings or as the basis for a quantitative survey;
- some of the studies attempted to combine various frameworks/models in order to create an integrated research theory on which to base an investigation;
- no study was found where the existing TTF model/instrument was used to evaluate a health care IS implementation.

An example of a study in the health information systems arena that used only one framework/model is the work of Van der Meijden, Tange, Troost and Hasman [20]. These researchers reviewed the determinants of success of inpatient clinical information systems and used the six dimensions of DeLone and McLeans's IS success framework as a way to organize their extensive literature review.

Another example of an empirical study based upon only one framework/model is the work of Liang, Xue and Wu [14]. The study conducted by these researchers used the Technology Acceptance Model [5] to explain physician acceptance of a computerized physician order entry system. The researchers concluded that the Technology Acceptance Model was a parsimonious tool for evaluating physicians and their acceptance of these types of systems.

One example of a study that attempted to integrate various theoretical approaches is the work of Osbourne and Clarke [16]. These researchers developed a theoretical model for studying the acceptance of new information and communication technologies in UK healthcare based upon the Technology Acceptance Model, Rogers' diffusion of innovation theory and the Triandis theory of interpersonal behavior. (Note: the Triandis theory was not reviewed in the preceding summary due to its limited usage in studying IT implementation.) The researchers hoped that their integrated model would better predict the adoption of new health care information systems. They anticipated that a follow-up quantitative study would support their integrated model.

The literature review identified one article in the health care information systems literature that reviewed existing frameworks (e.g., TAM and TTF) and suggested they all lack an adequate consideration of the interaction between the user and the task [1]. Then these researchers used their proposed Fit between Individuals, Task and Technology (FITT) framework in a retrospective analysis of the implementation of a nursing documentation system in a German Hospital in order to illustrate its utility. However, as indicated above, our literature review did not uncover any published evidence of the use of Goodhue's TTF model [11] or of his validated instrument [10] for the evaluation of a health care information system implementation. One objective of this study was to address whether Goodhue's TTF model and associated instrument would provide useful diagnostic tools for assessing health care information systems implementation.

METHODOLOGY

A survey design was used as the basis for this study. Questionnaires were distributed to 140 nurses and 80 physicians during regular staff meetings. No names or other information that could be used to identify respondents was included on the data collection form.

As pointed out in the prior section, a number of questionnaires have been developed to measure user evaluations of information systems based upon different theories/frameworks. Based upon the decision to use the Task Technology Fit model to ascertain user assessments of the fit between the technology (an EMR) and their tasks, the researchers decided to use the validated questionnaire developed by Goodhue [10]. The questionnaire used a seven point Likert scale to measure the constructs included in the TTF model. In order to reflect the health care systems context of this study, the wording of several items was slightly modified. In addition, the questionnaire included two open-ended questions that asked respondents to identify the best system EMR system features along with areas that needed improvement.

RESULTS

The questionnaire was completed by 91 respondents for a response rate of 41%. The following are the demographics of the respondents.

Table 1: Respondents Demographics

Gender	
Female	52.38%
Male	47.62%
Age	
Under 30	5.95%
31-40	14.29%
41-50	35.71%
51 and over	44.05%
Job Title	
Faculty Physician	41.38%
Resident Physician	2.30%
Nurse Practitioner or Physician Assistant	3.45%
Registered Nurse	36.78%
Licensed Vocational Nurse	13.79%
Medical Assistant	1.15%
Other	1.15%
Practice Location	
Primarily Inpatient	16.47%
Primarily Outpatient	52.94%
Both	25.88%
Other	4.71%

In order to understand which dimensions of the TTF model were important to the EMR users, we tested the hypothesis that the summary score for both doctors and nurses (mean) was not significantly different from 4 (the neutral response on the questionnaire). In order to examine whether an

average item score is significantly different from a neutral score of 4, the following t-statistic was computed:

$$t = \frac{\bar{x} - 4}{s/\sqrt{n}}$$

where $\bar{x}$ is the average score for an item, s is the sample standard deviation of scores on an item, and n is the number of responses received for an item. An average item score is deemed to be significantly different from 4 when a two-tailed test using the computed *t*-statistic reveals a difference with a confidence level of 95% (or a p-value of 5%). The dimensions of the TTF model where the item score is significantly different from a neutral score of 4 with p-value $\leq$ 5% are marked with an asterisk (*) in the following tables. Of the twelve TTF dimensions, only one (compatibility) was not significantly different from 4, a neutral score.

The results of the questionnaire are organized according to the three subtasks of knowledge workers who are using quantitative information in the performance of their tasks identified in the TTF model: 1) identifying needed data, 2) accessing identified data, and 3) integrating and interpreting accessed data. On the 7 point Likert scale that was used in the questionnaire, a 1 corresponded to "strongly disagree" and a 7 corresponded to "strongly agree". Note that dimensions that have low values (below the mean of 4) are negatively worded and thus the low value indicates a positive assessment of this dimension by the user. The column entitled "SD" in the following tables records the standard deviation.

Table 2: Results for Dimensions Related to Identifying Needed Data

Dimension	Question	Mean	SD
Right level of Detail	Online patient clinical information is at an appropriate level of detail for my needs	4.57*	1.29
Right level of Detail	Sufficiently detailed patient records are maintained by the organization.	4.43*	1.41
Confusion	Patient data is stored in so many different places and in so many forms, it is hard to know how to use it effectively.	4.47*	1.59
Confusion	There are so many different systems or files, each with slightly different data, that it is hard to understand which ones to use in a given situation.	3.66*	1.23
Locatibility	It is easy to find out what data the organization maintains on a given patient.	4.64*	1.29
Locatibility	It is easy to obtain data on a particular diagnostic test or procedure, even if I haven't used that data before.	4.39*	1.31
Meaning	The exact data definition of data fields relating to my tasks is easy to find out.	4.38*	1.20

Table 3: Results for Dimensions Related to Accessing Identified Data

Dimension	Question	Mean	SD
Accessibility	I can get data quickly and easily when I need it.	4.61*	1.47
Accessibility	It is easy to get access to the data that I need.	4.51*	1.38
Assistance	I am getting the help I need in accessing and understanding the data.	4.87*	1.21
Assistance	It is easy to get assistance when I am having trouble finding or using data.	4.51*	1.48

Ease of Use	The computer systems that give me access to data are convenient and easy to use.	4.51*	1.57
Ease of Use	It is easy to learn how to use the computers systems that give me access to data.	4.84*	1.21
Systems Reliability	I can count on the system to be "up" and available when I need it.	4.99*	1.31
Systems Reliability	The data is subject to frequent system problems and crashes.	3.43*	1.37

Table 4: Results for Dimensions Related to Integrating and Interpreting Accessed Data

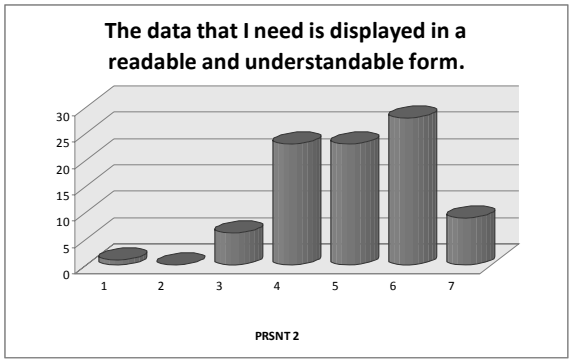
Dimension	Question	Mean	SD
Accuracy	Patient data is accurate enough to support clinical care.	4.71*	1.24
Accuracy	There are accuracy problems in patient data.	3.49*	1.37
Compatibility	When it's necessary to compare or aggregate data from online and paper records, there may be unexpected or difficult inconsistencies.	4.17	1.50
Compatibility	Sometimes it is difficult or impossible to compare or aggregate data from online and paper sources because of the variety of terms used for the same idea or procedure.	4.12	1.36
Compatibility	There are times when supposedly equivalent data from online and paper sources is inconsistent.	3.63*	1.36
Currency	The data is up-to-date enough for my purposes.	4.76*	1.22
Currency	I can't get data that is current enough to meet my needs.	3.26*	1.23
Presentation	The data is presented in a readable and useful format.	4.90*	1.45
Presentation	The data that I need is displayed in a readable and understandable form.	5.08*	1.19

DISCUSSION

The above responses to the questionnaire indicate that users were generally pleased with the new electronic diagnostic test result reporting module of the EMR. As indicated by the asterisk (*) beside the mean, all of the items except for the two compatibility dimension measures were significantly different from the mean (4). Thus, there was a neutral response for only the two items measuring the TTF dimension of compatibility. When these results were presented to organization, they interpreted this as evidence of a very successful EMR module implementation.

Furthermore, the results on the various TTF dimensions were found to be useful for diagnostic purposes. For example, the TTF dimensions where the new system appeared to best meet users' needs were related to data presentation, system reliability, ease of use, and the availability of technical assistance. The following histogram (Figure 1) shows the results for one of the data presentation dimension items.

Figure 1: Histogram of Presentation Dimension



Analysis of the neutral, non-significant responses for the items measuring the compatibility dimension was undertaken. It appears that users might be finding some inconsistencies between online and paper records. This finding may have occurred because a dual system of paper and online records was in place at the time of the survey. The organization soon plans to transition completely to the EMR information system, and so this potential compatibility issue may be resolved at that time. However, this compatibility dimension merits continued attention in future user surveys.

Written responses to the open-ended questions on the questionnaire fit well with concepts in the TTF model, providing evidence that the TTF model measured issues of importance to system users. Thus the written comments provided valuable supplementary information that helped the researchers and organizational personnel identify specific areas of strength and weakness in the new system.

One of the primary issues that EMR providers wanted to address with the new system was the problems with accessibility of information that occurred in the old paper chart system. The manual procedure to obtain a paper chart from the central file room was lengthy, cumbersome, and subject to error. Paper charts could only be used in one location at a time and were unavailable while in transport or waiting to be re-filed. This often resulted in delays in services to patients or clinical decision-making with incomplete information. One physician commented that by using the new EMR system, he was often able to locate all of the information he needed in order to answer a patient's question or make a clinical decision. This resulted in faster service to the patient and less work for hospital personnel, who did not have to retrieve, transport, and re-file the paper chart. A number of respondents echoed this user's comments; therfore improved accessibility of information was most often mentioned as a strength of the new system in the qualitative section of the survey.

Although Likert scale responses on the questionnaire indicated that respondents found the new system generally easy to use, the qualitative data identified two areas of concern with the new EMR system. Users were annoyed by a cumbersome navigation system requiring them to click through several screens in order to find needed information. Physician and nurse users were also frustrated by the system's automatic log-off feature that occurred after a brief period of inactivity. This problem is interesting when examined in the context of provider work patterns and the need for protection of the privacy of patient data. Unlike clerical personnel, physicians and nurses often share a single computer workstation in a clinical area where each uses that workstation for short intervals between patient encounters. Unexpected patient needs often cause these computer work sessions to be interrupted. Thus, it is not unusual to log in, partially complete a cumbersome navigation to find clinical data, and then have to leave the computer in order to respond to an urgent patient need. If the computer did not automatically log the provider off, other providers might not be able to use the shared computer. If the log-off did not happen quickly, unauthorized persons could use the active computer to access confidential patient data. Clearly the log-off procedure has to occur, but simplified log-in and navigation procedures could improve provider productivity while maintaining patient confidentiality. Shortly after the survey was completed, the hospital distributed new portable laptop computers to providers and implemented single network only sign-on using biometric scanning. This significantly improved provider productivity, while maintaining patient confidentiality.

The researchers and hospital personnel decided that the TTF model and its associated survey instrument did provide useful diagnostic information that could be used to readily evaluate the success of the EMR implementation. In fact, the hospital plans to conduct a longitudinal study using the TTF model and questionnaire as future modules of the EMR are installed and made available to users.

CONCLUSIONS

The Task Technology Fit Model provided a useful framework for assessment of the initial stage of electronic medical record implementation at this hospital. Assessment of the EMR's effectiveness in helping users perform tasks critical to their work fits

well with the organization's need to enhance clinician productivity while minimizing errors. In today's economic climate user satisfaction with new technology is not sufficient. The technology must also reduce costs, reduce errors, improve productivity, and/or improve client satisfaction. This hospital wanted their EMR implementation to contribute to the achievement of all of those goals.

Two of the four dimensions where the new system best met users' needs are directly related to the quality of information systems support. Users were especially satisfied with system reliability and the availability of technical support. In an organization that operates continuously and where the timing of an intervention can sometimes make the difference between life and death, it is crucial that users be able to depend on access to the information needed to make critical decisions. Thus information systems specialists play a key role in the success of an EMR.

Written comments from survey respondents related to the constructs assessed by the survey instrument, providing evidence that the instrument addressed issues of concern to them The addition of written comments or supplementary interview data helps provide users and IS personnel with specific information about what changes need to be made to improve the system (e.g. log-in problems). Others who choose to use the TTF instrument for diagnostic purposes would be well advised, based upon the results of this study, to also gather qualitative user data to provide insight into particular results/areas of possible concern.

The TTF analysis highlights user perceived weaknesses in deployed clinical IT systems, thus providing targets for system enhancements most likely to improve usability. This type of information may allow health care institutions to more effectively engage vendors in discussions regarding critical enhancements of future releases of their products. The data obtained also provide information regarding clinician usability priorities for clinical IT systems, and may allow distinction between priorities of different types of clinicians, e.g. physicians and nurses. Future serial TTF surveys may provide information on changing clinician priorities and usability challenges during subsequent more challenging phases of health care IT adoption such as direct provider order entry.

Although the Task Technology Fit Model was effective in assessing the effectiveness of a new system in helping users perform work-related tasks, it does not fully address the interaction between the user and the task. Ammenwerth, Iller, & Mahler [1] discuss the role of users in redesigning tasks to fit with a system. Further studies using that model are recommended to explore more fully the user influences upon a new information system

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