12-31-2007

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Bob McQuaid
Pepperdine University

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INFORMATION SYSTEMS IMPACT MODEL
PROOF OF CONCEPT

J. Robert McQuaid, Ph.D.
Graziadio School of Business
Pepperdine University
Information Systems & Technology
Claremont Graduate University
bob.mcquaid@pepperdine.edu

Abstract
This paper reports a proof of concept by applying a model originally presented in 2004 to four firms. The model has been slightly revised to reflect input from conference attendees and 49 Executive MBA students who applied the model to their organization. The model now represents the impact of technical and application specific domain knowledge on potential impact of an information system as moderated by the development process. A 2x2 matrix represents the system impact with one dimension indicating impact within versus outside target and the other representing expected versus unanticipated outcomes. This model allows researchers to recognize the multidimensional aspects of information system performance and practitioners to assess their development needs based on their understanding of the current domain and technical situation. The paper reports on the application of the model to four companies and suggests plans for future research.

Introduction
Information System (IS) performance is commonly measured by practitioners in terms of schedule, cost, and functionality and by IS researchers in terms of multi-dimensional constructs spanning all phases of a system project (Yetton, Martin, Sharma, and Johnston 2000). As reported by the Standish Group, project failures are common, resulting in direct and indirect costs with little positive performance impact. Siau and Tan (2005) recognized that organizations use a wide variety of system development methodologies to manage and control projects. Lacking research on evaluative measures, organizations fail to comprehend the usefulness and effectiveness of available methodologies. However, there is a dearth of research connecting ultimate information system performance and the process used to develop it. Through application of a model to four organizations, this paper serves to further develop the linkages presumed by the model and characterize the theoretical connection between the ranges of performance achievable by an information system and the process used to develop it. The model in this paper is an extension of an earlier model by this author (McQuaid 2004).

Specific feedback received at the earlier conference was related to the familiarity construct. The use of a spectrum from certain to uncertain implied that this was a univariate concept. The recommendation was to review the literature for possible alternative definitions for familiarity. Feedback received from the application of the model by Executive MBA students to a recent implementation in their organization resulted in a better understanding of the current domain and technical situation. The paper reports on the application of the model to four companies and suggests plans for future research.

The original model from the earlier paper is shown in Figure 1. For an organization, a technology implementation usually solves a problem or addresses an opportunity. Agarwal and Tanniru (1992) proposed a framework to assess the impact of technology implementation on the phases of decision making (presented in the lower right of figure 1). Achieving the
planned outcome would be considered a direct and local impact. That is, it addressed the intended problem or opportunity and was measurable within the scope of the implementation. A direct and global impact expands the measurable results to systems or organizations outside the initial scope. The second row of the depth/breadth matrix is induced in that it was not intended as part of the initial scope. This can also be related either to the area specifically addressed by the information system or it could be external to that area.

The original model proposes that these various outcomes result from an organization’s familiarity with the technology and the process through which the system is implemented. In the original proposal, the process was defined as the traditional Systems Development Life Cycle and the familiarity was limited to technology. The model proposes that a firm’s initial familiarity with the technology determines the implications of the outcome achieved moderated by the extent to which they implement a Systems Development Life Cycle (SDLC) process. Familiarity was based on two prior models. The Roberts and Berry (Yeo 1995) model of technology acquisition as innovation and applications evolve within an organization identifying three stages of technology: Base, New (familiar), and New (unfamiliar). The Yeo (Yeo 1995) three state model addresses uncertainty of a company’s understanding of a technology acquisition as Relative Certainty (Base), Controlled Certainty (New – Familiar), and Uncontrolled Certainty (New – Unfamiliar).

As mentioned above, feedback from reviewers and conference attendees indicated that, while the impact matrix provided an interesting assessment tool, the familiarity and process constructs were underdeveloped and could possibly be enriched through broader or more recent advancements in these areas. In addition, they suggested applying the model to real world system implementations to demonstrate its generalizability. This paper presents a revised model and its application to a number of organizations. The next section examines model constructs including familiarity, process, and impact. The revised model is presented followed by its application to several organizations.

**Discussion**

This section describes the three constructs in the revised model. Familiarity is modified to domain knowledge and is further divided into Information System and Application elements. The Process construct is defined with a broader coverage of additional development processes. Finally, the impact construct is expanded to include negative outcomes.
**Domain Knowledge**

While the familiarity concept is widely used in marketing and brand research, the notion of domain knowledge provides more applicable and distinct categories. For purposes of this model, two domains further divide the construct into information system (IS) domain and Application domain (Khatri, Vessey, Ramesh, Clay, and Park 2006). In their study, Khatri, et al. find that both IS and application domain knowledge influence the performance of decision makers. Yetton, et al. (Yetton, Martin, Sharma, and Johnston 2000) ultimately identify the two domains as distinctly different when considering performance from the business and from the IS perspective. This distinction allows them to identify the determinants of performance for each domain.

The implementation of information systems’ solutions to business issues requires a thorough understanding of the business domain. Seruca and Loucopoulos (Seruca and Loucopoulos 2003) advocate that successful transformation requires reengineering efforts clearly identify and model business processes. They identify business directions, market data, and organizational needs along with an understanding of existing enterprise systems are relevant business domain issues. Their research focuses on identifying patterns in the business processes which can be reused by additional reengineering efforts rather than reinventing the wheel. When organizations institute business process reengineering efforts, they typically assemble process experts within their organization. Experts with considerable domain knowledge, can typically aggregate new, relevant information and conceptualize solutions quickly. They are ideally suited for current problem representation (Seruca and Loucopoulos 2003). However, two areas where non-experts outperform experts include conditions in which experts cannot make use of their domain knowledge (Chase and Simon 1973) and on tasks for which domain related stimuli does not correspond to typical structures of the domain (Voss, Vesonder, and Spilich 1980). Given these two conditions are often relevant to replacement of a non-IS business opportunity with an IS enabled process, the concept of business domain knowledge becomes relevant to the potential impact of the solution. It has also been established that IS experts with a relevant understanding of the application domain require less bottom-up development work to address the desired outcome (Shaft and Vessey 1995). In fact, Ranganathan and Sethi (Ranganathan and Sethi) hypothesize that shared domain knowledge will influence rationality of strategic IT decisions. Their premise is that the more top management, functional managers, and IT managers share in their understanding of both the IT domain and the business domain, the more appropriate and relevant information will be applied to strategic IT solutions.

**Process**

As computing power and network capability has grown, so have the different information systems development methodologies proliferated (Jayaratna 1994). Most acknowledge that, while there are hundreds differentiated for marketing purposes, these methodologies are not largely unique (Avison and Fitzgerald 1995). The process construct in the revised model represents typical development processes found in IS literature. Problem solving processes can be categorized based on their application to specific problem types as general (weak) and specific (strong). The former accommodates a wide range of problem types satisfactorily, while the latter solves unique types of problems by finding largely optimal solutions. According to Howard, et al. (Howard, Bodnovich, Janicki, Liegle, Klein, and Albert 1999), general development methodologies include Structured Systems Analysis and Design Methodology (Whitten, Bentley, and Dittman 2001), the Object Oriented Design methodology (OOD) (Conallen 2000), Rapid Application Development (RAD) Methodology and the Information Engineering Methodology (Whitten, Bentley, and Dittman 2001), among others. Specific methodologies include Relationship Management Methodology (RMM) (Howard, Bodnovich, Janicki, Liegle, Klein, and Albert 1999; Isakowitz, Kamis, and Koufaris 1998), the Neural-Network Development Methodology (NDM) (Glorfield 1996) and the Object Oriented Hypermedia Design Methodology (OOHDM) (Schwabe and Rossi 1998). Vinekar, et al. (Vinekar, Slinkman, and Nerur) identify numerous Agile methodologies including eXtreme Programming (Beck 1999), Scrum (Schwaber and Beedle 2002), Dynamic Systems Development Method (Stapleton 1997), Adaptive Software Development (Highsmith 2000), Crystal (Cockburn 2002), and Feature-Driven Development (Palmer and Felsing 2002). Since the revised model presented in this paper is intended to be generalizable, the process construct focuses on general development methodologies, both traditional and Agile.

**Impact**

In 1992, DeLone and McLean identified six categories of Information System success (D&M model): System Quality, Information Quality, Use, User Satisfaction, Individual Impact, and Organizational Impact. One conclusion suggested more field study research to measure the influence of MIS effort on organizational performance. In their 2003 update, the same conclusion is restated, although they modify the Organizational Impact dimension to Net Benefits. Seddon (Seddon 1997) suggested that term and “consequences” which, DeLone and McLean adopt as less pejorative. Interestingly, they also point out that after ten years and almost 300 citations, many researchers failed to heed their admonition to avoid a univariate
dependent variable. IS success is multidimensional and interdependent so researchers should create comprehensive metrics by combining individual measures from the success categories. As will be discussed in the application section, the model in this paper maintains the dimension “impact” as there are both positive and negative results from a system implementation. In order to make the model more practitioner friendly, the 2x2 matrix labels are modified as shown in Figure 2.

![Figure 2: Modified Information System Impact Model (ISIM)](image)

**Model Application**

This section describes the application of the ISIM within four organizations. Following this section, general findings will be reviewed and future research on this model will be described. The original paper (McQuaid 2004) was provided to two sections of Executive MBA students (n = 49). This is a part-time curriculum in which students are in mid-management and average age is 35 years. The assignment was to select a recent system implementation in their organization and describe the experience within the confines of the model. This section contains summaries of four submittals (specific firm identification withheld).

**Firm 1**

This organization is an international credit management network connecting financial institutions, merchants, and consumers. They process in excess of 100 million transactions per day. Net income exceeds $400 million annually. The respondent is a Senior Vice President in Operations. The new information system is a Media Measurement System (MMS) to automatically generate reports. The original intent was to improve research completeness, speed information retrieval and enhance reporting.

The existing process was manually intensive. The new system changed the business process, so while the internal team believed they fully understood the application, they likely did not. Lacking specific technology understanding, they contracted a vendor to build the MMS. At the time design was undertaken (2003), there was a revolution in new and untested available technologies for this application. The process from planning through design was highly repetitive as new features, technologies, or measurement processes became available throughout the 12-month schedule. This led to numerous redesigns. Table 1 applies the impact matrix to this implementation.

**Table 1: Firm 1 Impact matrix**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Breadth</th>
<th>Intended Target</th>
<th>Outside Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Impact</td>
<td>Reports did not include appropriate information for PR staff, management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unanticipated Impact | The process for measurement changed | Ability to report on media to entire organization hindered

The interpretation of these results indicated that low domain knowledge, in both application and information system led to the MMS not achieving expected direct, intended impact and led to a costly repetitive process. In this case, additional time in the development process did not result in improved impact, likely due to lack of domain knowledge.

**Firm 2**

This is a state organization jointly operated by the Office of Homeland Security, the California Highway Patrol, and the Department of Justice. The organization provides and maintains an information exchange system. They chose to implement Microsoft Groove Virtual Office to provide collaboration capability within the state of California. Collaboration on terrorism related investigation was the main goal, but there was no time to define information exchange processes or procedures. Application domain knowledge was considered low given no one really knew what would be necessary to collect and exchange. The choice of Groove was based on other state organizations use and the hope that a seamless information exchange solution could be created. Because of this inherited system, no analysis or evaluation was conducted to understand the capabilities and limitations of the Groove system.

<table>
<thead>
<tr>
<th>Breadth</th>
<th>Intended Target</th>
<th>Outside Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Impact</td>
<td>Enhanced collaboration between law enforcement in California and with Federal task forces.</td>
<td>Increased interest in using Groove by other states wishing to collaborate with Homeland Security</td>
</tr>
<tr>
<td>Unanticipated Impact</td>
<td>Identification of performance issues from capacity limitations of Groove</td>
<td>Need to implement task force structures in California to minimize performance issues of Groove</td>
</tr>
</tbody>
</table>

Established and known business processes, a higher understanding of the technology specifications, as well as more diligent planning and analysis of the tool could have resulted in more anticipated outcomes from the implementation of MS Groove.

The rush to implement a collaboration solution at STTAC caused the use of the existing user interface from HSIN. As a result, the user interface had to be redesigned to accommodate the workflow and information exchange processes specific to California law enforcement agencies. More time spent on developing processes and procedures would have resulted in identifying gaps in the existing user interface. The minimal time spent on analysis and design resulted in underestimating usage capacity and identification of the limitations of GVO. The consequence was the need to purchase additional hardware to accommodate overcapacity of information transactions. Additional time spent on analysis would have identified capacity requirements and would have led to a correct hardware design from the beginning. The combination of low familiarity in business process and technology, as well as minimal time spent on planning and analysis contributed to the outcomes that affected both local and global targets during the implementation of GVO.

**Firm 3**

This firm provides software solutions and intelligent appliances that addressing application performance management including network devices, applications, and servers. The system they implemented was Oracle’s ERP software. Specifically, the “purchase to pay” (PTP) and the “quote to cash” (QTC) modules were discussed. An external consulting firm implemented the $3 million project with a key goal to maintain a minimally customized system. The technical team had all worked on Oracle implementation projects in the past and team leaders had extensive experience with Oracle systems. Unfamiliar with the business process, they relied on sales and operations management. Unfortunately, key functional leaders were not on board until midway through the design phase. Gaps in the technical teams knowledge prior to this commitment led to “industry best practice” adoption as needed. About 50% of the total development time was spent in planning and analysis. The resulting impact is shown in Table 3.
Table 3: Firm 3 Impact matrix

<table>
<thead>
<tr>
<th>Depth</th>
<th>Intended Target</th>
<th>Outside Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Impact</td>
<td>80% of required/specifed features functional in first roll out. All “required” features and functions fully supported in the second update.</td>
<td>Extensions of modules to automate beta and production software download from external website. Business to Business web linkage interfaces to interoperete with four product fulfillment partners.</td>
</tr>
<tr>
<td>Unanticipated Impact</td>
<td>Extensions to link customer information to a third party website, for export control screening</td>
<td>Business Intelligence implementation layered on top Oracle ERP to provide executive reports Cross module “order linkage” reports</td>
</tr>
</tbody>
</table>

Findings indicate that a lack of business process knowledge in the early part of the cycle induced a high degree of uncertainty. This resulted in approximately 50% of the time spent in planning and analysis phase which is rather high for a short time frame project. Significant time invested in planning and analysis helped maximize direct-global outcome and their inclusion in the desired solution. The outside target, direct and unanticipated outcomes were rather high in this case. A stronger “business process” knowledge would most likely have helped the teams to “localize” the global outcomes during the planning phase, and include them as part of the desired solution.

**Firm 4**

This firm is a web based sales organization that connects job seekers with employers. To automate the advertising sales process, they elected Salesforce.com as it provided the fastest solution, required the fewest technical resources and was least expensive. Prior to this system, it was their practice to roll-up Excel spreadsheets to a management reporting presentation. Given the technology based company, the technical knowledge domain was considered strong, however, since the existing process was not technology based, the new business application domain was unfamiliar to the organization. The development process initially was very abbreviated. An early decision was to implement only one aspect of the Salesforce.com capability to replace the manual revenue roll-up. After four months of poor implementation, an outside vendor was hired and the process restarted. The consultant lacked business application knowledge, but was technically competent. As of one year later, the new system is of little use to the operations or sales organization. The impact is summarized in Table 4.

Table 4: Firm 4 Impact matrix

<table>
<thead>
<tr>
<th>Depth</th>
<th>Intended Target</th>
<th>Outside Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Impact</td>
<td>Provide accurate, real time reporting for booked and pipeline revenue across Monster products. Eliminate weekly roll-up of Excel document for sales visibility. Meet the local operational expectations while providing productivity measurements, projected revenue, and site/product data to the General Managers.</td>
<td>Product General Managers were not considered in initial technology roll-out and were marked for later product enhancements. Data for the General Managers is critical for managing the business efficiently. Global reporting requirements need to be met.</td>
</tr>
<tr>
<td>Unanticipated Impact</td>
<td>The need for business reporting data in the areas of productivity measurement and product sales was undervalued. Technology use beyond those identified in local operations was pushed to later roll-outs. Phased integration was not clearly understood until too late.</td>
<td>Not scheduled for inclusion until later phases, the business process need was underestimated. Failure to meet global stakeholder needs created backlash. Defining technology and business process needs proved difficult. With little experience developing a CRM solution, team lacked visibility of future needs.</td>
</tr>
</tbody>
</table>
Monster had low familiarity with business processes resulting in the local stakeholder not being satisfied. Off by a few degrees at the local level, the project fell apart globally as the error was magnified to global stakeholders in need of data, but removed from the process. Due to the lack of planning, the majority of Salesforce.com features are currently underutilized which minimizes the return on investment.

Conclusions

When the initial model was developed, several propositions were put forth related to what kind of impact to expect in the 2x2 matrix. These propositions reported positive impacts based on extended development processes or higher levels of initial domain knowledge. When the Executive MBAs responded to the application of the model to their organization, two specific findings resulted. First, their impacts were both positive and negative. While this seems somewhat apparent, the reason was not. In several cases, organizations failed to properly assess their own understanding of the business process, potential ramifications of changing that process, the technology, or the ability of an external consultant to effectively implement a system in their organization. With a false sense of security, then, they selected a system and implemented a development process that did not achieve the desired impact. The second finding was that most organizations do not have an established development process for the implementation of large-scale, strategic level information systems. Essentially, each team is an ad hoc combination of potential stakeholders commonly teamed with IS domain specific team members. The lack of stakeholder understanding of IS needs and the concomitant lack of understanding of the business application by process stakeholders leads to problems in the early stages of the development process.

Future research

This proof of concept paper is intended to establish a workable model for two follow-on studies. The first of the studies will be a case based research to scrutinize the model, its relationships, and to further define what kind of impacts belong in each cell of the matrix. This is expected to be conducted through interviews of organizations who have recently implemented large scale information systems. The second study will use a survey approach to prove the relationships established in the model are significant. It is hoped that at that point, the expanded impact matrix can be tested statistically from the survey results.

References:


