The Contribution of Knowledge Exchange and Relational Capital to Project Success in Information Systems Development Efforts

by

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Problem Statement and Goal

Despite decades of effort to develop and refine various requirements elicitation techniques, incomplete or incorrect requirements capture remains one of the leading causes of the continued high failure rate of information systems development projects (Rajagopal, Lee, Ahlswede, Chiang, & Karolak, 2005). Conversely, software project teams exhibiting higher levels of relational capital (also referred to as bonding, social capital, or trust) are exhibiting higher rates of success (Hickey & Davis, 2003; Tansley & Newell, 2007). This concept of relational capital has origins outside of the software development field, but the basic definition of “mutual trust, respect, and friendship that reside at the individual level between alliance partners” (Kale, Singh, & Pearlmutter, 2000, p.221), applies to most activities involving human relationships.

The motivation for this study was to develop an understanding of the factors supporting relational capital in terms of how well information systems project team members understand *each other’s* needs and capabilities. The concept of *mutual* understanding lies at the core of relational capital, yet most software requirements elicitation techniques seek only to transfer knowledge from the end users to the development team.

For the purposes of this study, information systems development (ISD) projects are software development projects in which a software development organization cooperates with one or more organizational business units to automate an existing or anticipated business workflow. Examples include insurance claims processing, purchase management, and plant maintenance management. Excluded from this study are software and systems projects emphasizing large-scale calculations or time-critical applications such as scientific modeling, data warehouse management, and plant process automation. As the majority of essential requirements are contained in the heads of the subject matter experts and end users associated with the target business process, accurate and efficient requirements capture is difficult in these projects (G. Browne & Rogich, 2001).

Requirements elicitation

Much of the current research into software requirements elicitation emphasizes improving the quality and efficiency by which requirements can be "elicited" from the intended users of the software. In essence, requirements elicitation techniques attempt to transfer knowledge about business processes from the end-users to the development team. Many scholars focus on techniques for requirements elicitation, including interviewing techniques, contextual analysis, and (most popular) diagramming techniques (G. Browne & Rogich, 2001; Giesen & Volker, 2002; Hickey & Davis, 2003). In general, these various requirements elicitation techniques assume a one-way transfer of knowledge from subject matter experts in the process under automation to the analysts and developers responsible for implementing the new system. Other works concentrate on requirements management as part of a larger structure of related processes (Damian, Zowghi, Vaidyanathasamy, & Pal, 2004; Sommerville & Ransom, 2005).

Formal software engineering process definitions such as the Capability Maturity Model Integration (CMMI) address the problem through requirements traceability, configuration management, and quality assurance in an effort to assure that elicited requirements accurately translate into software (Chrissis, Konrad, & Shrum, 2004). Agile software engineering uses multiple prototype iterations in an effort to improve the quality of elicited requirements through live modeling (Cockburn, 2002). Organizational software process improvement (SPI) efforts focus on defining and instantiating a standardized approach to software development to minimize conflicting approaches and poor communications among project team members in an effort to improve the quality of elicited requirements. All of this formalism in requirements elicitation and management continues to produce less than optimal results (Georgiadou, 2003), indicating something else may be influencing the development of accurate, high-quality requirements in ISD projects.

Much of the current research in requirements elicitation and analysis expands on concepts initially described as much as three or more decades ago. For example, Browne and Rogich (2001) selected three difficulties in requirements elicitation from a list first published in 1982. The late 1970's and early 1980's featured much simpler software development efforts focused largely on mainframes and batch operations targeting data reduction and information production via printed reports (Grover & Davenport, 2001). These simpler problems yielded the mechanistic requirements elicitation and systems analysis approaches of the period.

Knowledge transfer

Today's ISD efforts focus on problems of significant complexity, combining business process automation with technology integration issues between the software, the users, and other systems in a dynamic, rapidly changing environment (Xia & Lee, 2005). In this dynamic environment, an ISD effort might not focus on the current business process but on a future, “re-engineered” process. A fact-based or interview-oriented approach to requirements elicitation is at great risk when the systems analyst is attempting to predict a future state. To define the future state, the analyst must make use of more than facts and information; the analyst must leverage *knowledge* about the business process to develop a reasonable model. Typically, this knowledge resides in the minds of specific subject matter experts. For the purposes of this research effort, knowledge management (KM) is an umbrella term describing systems and approaches used to support the transfer of knowledge from one party to another, allowing the receiving party to extrapolate from current facts to a reasonable prediction of a future state (Bellinger, 2004).

Academic literature from 1999 forward is starting to describe a significant overlap between the fields of SPI and KM, especially in the areas of knowledge transfer (Baskerville & Pries-Heje, 1999; L. Mathiassen & Pourkomeylian, 2003). In terms of ISD requirements development, knowledge transfer includes the transfer of explicit knowledge as well as tacit knowledge about the business process undergoing automation. Explicit knowledge is fact-based and shared in the form of data, reports, manuals, and specifications. Tacit knowledge is subjective and intuitive, with deep roots in the experiences of the individual (Desouza, 2003). Current requirements elicitation techniques are robust in terms of explicit knowledge transfer, but tacit knowledge is an integrative element; it enables the analyst to model a future state. Reliable, systematic tools to enable tacit knowledge transfer are needed; tacit knowledge is a key ingredient in identifying additional explicit knowledge and increasing the quality of existing explicit knowledge (Davenport & Prusak, 2000).

The relationship between tacit knowledge and explicit knowledge has the characteristics of a feedback loop, and all feedback loops have a trigger condition. Tacit knowledge enables richer explicit knowledge, but some initial explicit knowledge is required to establish a common framework for communication. The term “channel richness” describes the mechanisms that “act as connections among the partners of sharing and facilitate the transfer of knowledge from source to target” (Kwok & Gao, 2005, p. 46). To establish a rich channel, Kwok and Gao described informal and formal techniques including meetings, seminars, apprenticeships, and formal training. All of these techniques focus on formal knowledge transfer at first, followed by tacit knowledge transfer.

Recent research has shown richer knowledge transfer occurring with the establishment of significant relational capital among the various members of a team. Relational capital in software development is defined as “the level of trust, reciprocity, and closeness of working relationships among the members of a team” (Tiwana & McLean, 2005, p. 21). Increased relational capital within a team lowers barriers to communications, allowing members to volunteer and to receive new concepts more readily. A contributory factor to the development of relational capital can be termed knowledge exchange, where team members from different experiential and professional domains share basic domain information, or explicit knowledge, as a foundation for enhanced understanding. This is significantly different from the one-way knowledge transfer of traditional requirements elicitation. An ISD team that has established significant relational capital through the exchange of explicit knowledge about each other’s domains may be more likely to develop high-quality requirements.

Goal

Most research and practice in requirements elicitation and management concentrates on transferring knowledge (typically, explicit knowledge) from the end-user to the developer via specific processes or procedures. A process or procedure defines a systematic approach to gather resources and/or information, provide some level of transformation and/or interpretation, and produce a specific set of outputs. Explicit knowledge can successfully be transferred using procedure-oriented techniques, but this works well only when the resources and/or information are easy to identify and gather. As expert systems researchers have learned, focusing on easily captured knowledge yields a fragile application, unable to adapt to significant changes in the fact base (Williams, 1990). The transfer of tacit knowledge along with explicit knowledge may be the key that enables robust requirements models, but specific methods a project team could use to enable tacit knowledge transfer remain elusive.

A solution may exist in the area of relational capital (trust) development between the business process subject matter experts (the end users) and the development team. When the whole team bonds, everything just seems to go right. The problem is that this teaming behavior requires participants to overcome significant barriers in place against knowledge sharing such as willingness to share, confidence in oneself, trust in the source, and so on (Kwok & Gao, 2005). Current practices have the development team striving valiantly to learn about the business process of the end users, but that is as far as it goes. The additional knowledge gained when end-users learn something about the knowledge representation and lifecycle management techniques of systems analysts and software developers may result in increased relational capital and subsequent success in ISD projects.

The goal of this research effort is to examine the transfer of knowledge in two directions: 1) from the development team to the business process SMEs / end users, and 2) from the SMEs /end users to the development team. The main objective is to learn whether these two factors have individual or combinatorial effects on relational capital and, either directly or subsequently, on ISD project success. At least one study identified "knowledge overlaps" between the customer and vendor as beneficial in complex ISD efforts. This study identified "Client's technical knowledge," as knowledge about the specific tools and processes of the software development team, but possessed by the subject matter experts (Tiwana, 2004). The main research question is thus: Are successful ISD projects more likely to exhibit a team of end-users and developers that have established significant relational capital through bi-directional knowledge transfer regarding software development processes as well as system requirements?

Relevance, Significance, and Brief Review of the Literature

This study proposes to extend and integrate current research in SPI and KM by examining the emerging overlap of expertise integration and the influence of teaming behaviors on requirements quality for ISD projects. The relevance to SPI lies in the potential to identify a new factor in requirements development for ISD projects. The relevance to KM lies in the examination of relational capital as a factor in knowledge development and exchange.

The significance of this effort to SPI lies in a potential for reducing complexity in software engineering. Current SPI practices focus on the implementation of a complex, rigorous set of processes that attempt to compensate for a decades-long record of poor requirements capture, scope creep, inadequate/inappropriate testing, and resultant failures of software projects to meet the current needs of the end-user community. Requirements management, configuration management, quality assurance (peer reviews as well as testing), personnel qualifications and management, project management, task assignments, metrics acquisition, and risk management form the core “best practices” to which “mature” software development organizations should aspire (Chrissis et al., 2004). While some of these practices focus on the mechanics of software development such as code quality and build management, most of the practices focus on capturing and maintaining a high-quality picture of the needs of the end-user community.

The significance to KM lies in the potential to extend the importance of relational capital into a focus on bi-directional knowledge exchange, which may prove to be more influential than the current concept of knowledge transfer. If further research shows a correlation between relational capital and bi-directional knowledge exchange, additional research could focus on the best formal mechanisms to initiate and maintain relational capital in various team and organizational structures.

If bi-directional knowledge exchange and subsequent relational capital are associated with ISD project success, further research into the best approaches to initiate ISD project teams could lead to purposeful establishment of bi-directional explicit knowledge exchange as part of project initiation. Teams of end-users and developers possessing a rich knowledge base may be able to achieve higher requirements quality without the complex, high-rigor requirements elicitation and documentation techniques currently recommended as best practices in software engineering.

Literature Review

This literature review has two objectives: The first is to present a picture of the research background and trends associated with knowledge management, requirements elicitation techniques, and software process improvement as they pertain to teams of end-users and developers executing ISD projects. The second objective is to identify literature addressing the initial experimental constructs of this study: 1) knowledge exchange, 2) relational capital, and 3) ISD project success.

Background Literature

The three most relevant categories of background literature are: 1) knowledge management implementation and adoption, 2) knowledge elicitation and exchange, and 3) software process improvement (SPI) implementation. Figure 1 below provides an overview of the studies associated with each category. The KM implementation and adoption as well as the knowledge elicitation and exchange categories provide specific information regarding research trends in each area. SPI implementation literature acts as a bridge between knowledge management and software engineering in the context of this research effort. Some overlap exists between background literature and studies supporting the initial theoretical framework of this research effort.

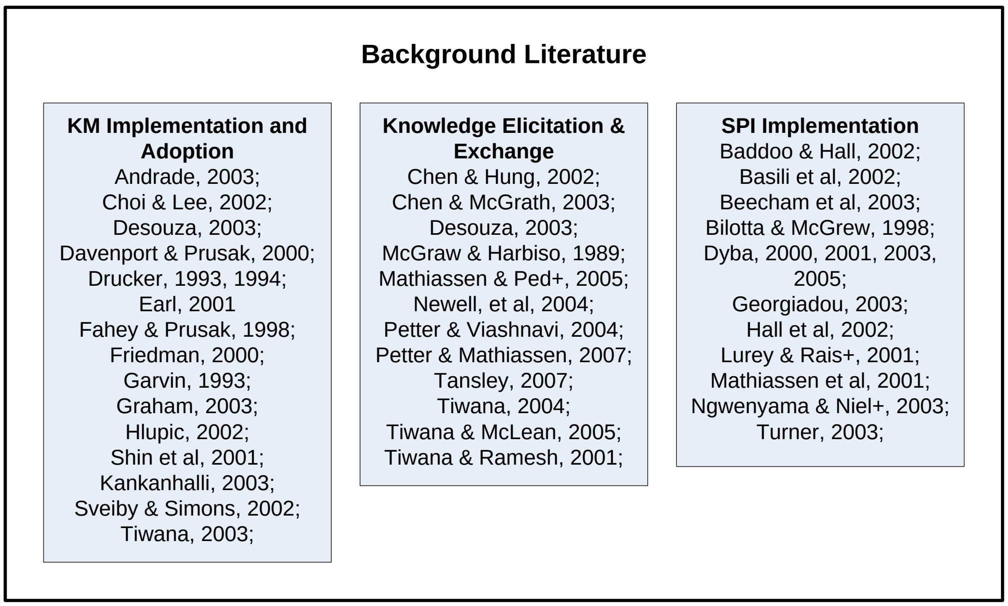

Figure 1. Background literature.

Knowledge Management Implementation and Adoption

The past decade has seen the introduction of no less than 19 separate definitions for knowledge management (Hlupic, Pouloudi, & Rzevski, 2002). A succinct definition of KM is advanced by Grey, “Working with objects (data or information) is Information Management and working with people is Knowledge Management” (Grey, 1998, p. 1)(Grey, 1998). A richer definition is provided by (Friedman, 2000):

> Knowledge Management is the ability to create and transfer as much of the right knowledge as possible to support as many people as possible in the best method possible in order to have a positive impact on the business. It’s about bringing the full weight of the company's knowledge base (hardware, software, and people) to bear, in a relevant and useful manner, upon the requirements of the user; thus enabling the individual and the organization to learn and adapt. (p. 1)

Peter Drucker coined the term “knowledge worker” in 1959 (1993). The term describes positions that require a significant amount of education as well as experience before the worker can be productive. In essence, formal education is a key discriminating factor between the knowledge worker and the service worker or manufacturing worker (Drucker, 1994). Although many writers focus on the “professional” positions requiring large amounts of formal education and experience, modern knowledge management texts also emphasize the advantages gained when knowledge management principles are applied to more mundane positions, such as assembly-line workers and accounts payable clerks (Davenport & Prusak, 2000).

Although formal education was the original discriminating factor separating knowledge workers from others, the bulk of current writings on knowledge management concentrate on describing something knowledge workers do that other workers do not: they *collaborate*. Collaboration may be the definitive factor that describes the modern knowledge worker. Organizations that foster a climate of collaboration show significant improvements in effectiveness of their knowledge workers over firms that allow barriers to remain in place, preventing the free exchange of knowledge (Sveiby & Simons, 2002).

Collaboration and exchange of knowledge implies a learning process is taking place. Continuous learning is another hallmark of the knowledge worker. Knowledge workers start from a base of formal education, but cannot be successful without continuously enhancing that base through additional training as well as collaboration (Argyris, 1991; Quinn, Anderson, & Finkelstein, 1996). The result is a continuous loop of knowledge acquisition, utilization, and enhancement that forms the experience base of the modern knowledge worker.

In any sharing model, there are providers and consumers. For knowledge consumers, most barriers are associated with locating the person with the right knowledge. For knowledge providers, most barriers are associated with the cost of participation: how much effort is required to make their knowledge available and whether it is worth the effort. In all cases, the tools and processes available to providers and consumers of knowledge must suit the culture of the organization (Davenport & Prusak, 2000).

Organizational culture is a natural and significant barrier to knowledge sharing activities and knowledge management efforts in general. Knowledge sharing can only take place when it is common for people within an organization to engage in discussions, share information, and communicate naturally without supporting technology (Desouza, 2003). Successful knowledge management efforts consider these factors and devote significant effort to communications and cultural change practices. Another set of barriers common to both consumers and providers are ease of access to and ubiquitous availability of knowledge resources.

For knowledge consumers, a significant barrier is associated with the search process. Locating the person or persons with the right knowledge with minimal effort and a high degree of accuracy is critical to adoption and continued use of knowledge management systems. One common recommendation for new knowledge management initiatives is to develop formal directories of skills and capabilities, sometimes referred to as Corporate Yellow Pages (Kankanhalli, Tanudidjaja, Sutanto, & Tan, 2003). Another successful method is the development of a network of communities of practice within an organization or among organizations (Garvin, 1993). Both methods require significant investment to gather the correct information and develop the supporting technology infrastructure. Simpler, more organic practices include the establishment of corporate search engines (Andrade et al., 2003), formal distribution mechanisms such as corporate intranets and CD-ROMS (Earl, 2001) and the development of peer-to-peer networks as informal communities of practice (Tiwana, 2003).

One of the fundamental errors made by organizations is to attempt to develop direct measures of knowledge (Fahey & Prusak, 1998). Direct measures of knowledge typically treat knowledge as objects and examine their utilization, commonly with the assistance of technology. Various approaches based on the traditional economic concepts of demand and marginal utilization use techniques such as counting the quantity and quality of online databases, “hits” on intranet Web sites, search engine utilization, and number of participants in collaboration efforts. This "knowledge as stock" approach focuses on continuous measures and ignores any benefits derived from the use and/or modification of tacit knowledge in combination with explicit knowledge, yet this is a typical source of innovation. Some proxies for these outcomes include new products, patents, process improvements and improved quality of service. However, measurement of these outcomes is difficult to quantify as their true value may not be immediately apparent or may be realized only when combined with other outcomes (Choi & Lee, 2002).

Knowledge Elicitation and Exchange

Knowledge elicitation techniques stem from systems analysis and design techniques developed in the 1960’s and 1970’s, expanding the earlier procedural and dataflow-oriented approaches with more human-oriented approaches. Expert systems developers, or “knowledge engineers,” needed to extract information primarily from human experts rather than data processing systems. The human-oriented approaches developed to accommodate this need included conceptual and domain analyses, structured interviews, solution and/or situation analysis, process descriptions, and concept dictionaries (McGraw & Harbiso-Briggs, 1989). Many of these approaches are a response to the observation that experts often have difficulties in describing their knowledge (L Mathiassen & Pedersen, 2005). The ideal domain expert with “sufficient knowledge about expert systems to enable him to define the knowledge” (Diaper, 1989, p.226) is extremely rare.

Domain experts have developed their internal knowledge bases over time and have usually repeated specific activities for a long enough period of time that many of their decisions occur without conscious thought. “Again, a number of studies have shown that people can display consistent and accurate behavior without being able to verbalize the concepts they are using. These points essentially constitute the knowledge elicitation bottleneck” (Okafor, Osuagwu, & Harman, 2006). Domain experts exhibit excellent performance when working within their domains because they are operating well within their comfort zone.

This comfort zone, also known as self-efficacy (the willingness of a person to adapt and persevere in a difficult task), can extend to new domains via various learning techniques. Many of these techniques require formal and/or repetitive training, considered a drawback in many environments. One technique, known as “feedforward,” shows promise. Feedforward provides “just in time” information about an activity and the techniques used to successfully perform the activity. Individuals appear to exhibit better performance in new or unfamiliar domains when feedforward is present (Petter & Vaishnavi, 2004).

The concepts and techniques of knowledge elicitation and transfer form a specialized domain in and of themselves. It is not reasonable to require a domain expert to become an expert in knowledge transfer but basic techniques to codify and express knowledge in an organized fashion are easier to learn. Simple, graphical techniques such as concept maps, tree diagrams, and storyboards provided as feedforward knowledge enable individuals to more easily define and represent their domain knowledge (Chen & McGrath, 2003). Establishing a common “language” for the representation of project-specific, design-contextual knowledge is useful when the inevitable shifts occur in team membership (Tiwana & Ramesh, 2001). People are more confident and more likely to share their knowledge with others when they feel they have the tools to do so.

In a successful ISD project, knowledge about the target business process transfers with high accuracy from the domain experts to the software engineering team. This knowledge transfer best occurs when the domain experts as well as the software engineering team members are operating within a common comfort zone. This mutual comfort zone is termed “relational capital,” or “project social capital.” Mutual trust and support between team members is increasingly recognized as an essential component of success in complex ISD efforts (Tansley & Newell, 2007). “Higher levels of relational capital increase the likelihood that individuals in the team trust each other, which in turn, increases their willingness to build on each other’s perspectives, ideas and expertise during the ISD process” (A. Tiwana & McLean, 2005, p. 22). Recent literature is also confirming that ISD project success increases when end-users possess knowledge about project-specific development processes (Tiwana, 2004).

SPI Implementation

The literature associated with this category comprises overview works and case analyses, as well as works identifying or confirming success factors of SPI efforts. A comprehensive work explores the entire topic in detail, covering lessons learned from four in-depth case analyses (L. Mathiassen, Pries-Heje, & Ngwenyama, 2001). An in-depth case analysis of a long-term, major SPI effort at the National Aeronautics and Space Administration highlights long-term problems associated with changes in the structure and mission of an organization (Basili, McGarry, Pajerski, & Zelkowitz, 2002). A comprehensive literature analysis provides an historical overview of SPI efforts and illustrates the relative lack of progress in the SPI field. Basically, SPI practitioners are still experimenting and collecting data (Georgiadou, 2003). Finally, a US Defense Science Board study (USDoD, 2002) prompted an article describing the problems associated with matching best practices in project management and software development with the needs and structure of each organization. In addition to the problems inherent in blind adoption or implementation by fiat, the author describes topics best suited to a tailored approach for each organization (Turner, 2003).

The impact of SPI reaches across the entire software development organization and extends to the customer. Different practitioner groups experience problems unique to their domains, ranging from goal development and culture issues facing senior managers to the minutiae of requirements management, testing, and production of documentation by development teams (Beecham, Hall, & Rainer, 2003). A SPI initiative is a high risk, multi-year effort with human, organizational, and implementation factors (Hall, Rainer, & Baddoo, 2002).

Human factors include the importance of SPI leaders as opinion leaders and change agents, the absolute requirement for substantial and continual management commitment, and the importance of staff involvement in development and adoption of new processes. Organizational factors include the importance of effective communication and the availability of adequate resources for the SPI effort. Implementation factors include establishing the SPI infrastructure in terms of personnel, policies, and technologies, setting clear and well-understood objectives, tailoring the SPI effort to the structure and maturity of the organization, and evaluating SPI progress. The majority of case analysis literature illustrates the problems stemming from a lack of proven, general-purpose approaches and resultant incompatibilities with organizational typology.

Recent empirical studies in SPI are primarily exploratory or confirmatory. Exploratory studies continue a trend established in the 1990s of exploring the organizational issues in software process improvement. A major influence on current SPI approaches is the Capability Maturity Model Integration (CMMI), in which the key process areas for the first three levels of organizational maturity represent a highly bureaucratic model. In contrast, the key process areas for the top two levels represent a model more suited to an adaptive, learning organization. Organizations with this level of flexibility are rare; this may be why so few organizations achieve and/or maintain CMMI capabilities above Level 3. "The fundamental issue for software organizations is how to achieve a balance between control and goal-orientation on the one hand and change and flexibility on the other hand -- between the rational culture and the developmental culture" (Ngwenyama & Nielsen, 2003, p. 111). In many cases, hierarchically structured organizations need to adopt consensual or developmental models for SPI to be successful. Other studies extend these concepts to include the prerequisite establishment of an organizational culture of knowledge creation and purposeful action. The "cookie-cutter" approach specified by the CMMI does not take into account the important differences among small and large software organizations, extant organizational culture, and the need for social collaboration before SPI can take root (Dyba, 2001).

Confirmatory studies review current literature to identify factors associated with SPI success and examine them empirically. Key implementation factors identified in the literature include human factors, organizational factors, and implementation factors. Human factors include the capability and reputation of the SPI leadership within the organization, the level of commitment maintained by management, and staff involvement. Organizational factors include adequate communication and availability of sufficient resources to the SPI effort. Implementation factors include establishing an adequate SPI infrastructure, establishing objectives and metrics, and tailoring SPI to the needs of the organization (Hall et al., 2002). Most firms with SPI initiatives use a sequential/iterative approach, guided by an overall pattern such as the CMMI, implementing processes and components that provide cumulative support to each other (Bilotta & McGrew, 1998). While this approach helps at the beginning of the SPI initiative, ultimate sustainability depends more on internalization by practitioners than the availability of tools and process guides (Basili et al., 2002). In some cases, high-maturity teams exist within low-maturity organizations. In these cases, the processes and management of the teams enable continuously high performance (Lurey & Raisinghani, 2001).

Successful management of all of these factors is rare, and is especially difficult in smaller organizations or organizations undergoing significant change over time, as with mergers and acquisitions. Over time, a natural resistance to change, lack of local evidence of SPI success, the perception of imposed SPI initiatives, resource constraints, and deadline pressures combine to make it difficult to achieve or sustain significant SPI success (Baddoo & Hall, 2002; Basili et al., 2002).

Literature Supporting the Initial Experimental Constructs

The primary intent of this study is to examine the contribution of bi-directional knowledge transfer to relational capital. The initial theoretical framework for this study comprises two independent variables focused on the bi-directional transfer of knowledge from the end users to the development team (KT_ED) as well as from the development team to the end users (KT_DE). Relational capital (RCAP) is a moderating variable, and ISD project success (PS) is the dependent variable.

Table 1. Literature Support for Each of the Initial Theoretical Constructs

Source	**Initial Theoretical Constructs**			
	KT_ED	**KT_DE**	**RCAP**	**PS**
(Bailey & Pearson, 1983)				Examples
(G. J. Browne & Ramesh, 2002)	Support			
(El Emam & Madhavji, 1995)	Support			
(Gravill, Compeau, & Marcolin, 2006)		Support		
(Hansen, 1999)			Examples	
(Hartwick & Barki, 1997)	Examples			
(Hofmann & Lehner, 2001)	Support			
(Hwang & Thorn, 1999)			Support	Support
(Kim, Garrity, & Sanders, 2002)	Support			
(Kujala, Kauppinen, Lehtola, & Kojo, 2005)	Examples			Examples
(Leonard-Barton & Sinha, 1995)			Support	
(Lin & Shao, 2000)	Support			Support
(Marcolin, Compeau, Munro, & Huff, 2000)		Support		
(McGill & Klobas, 2005)		Support		
(McKeen, Guimaraes, & Wetherbe, 1994)	Support	Support		Support
(Nelson & Cooprider, 1996)			Examples	
(Rajagopal et al., 2005)		Support		
(Rivard, Poirier, Raymond, & Bergeron, 1997)	Support			
(Szulanski, 1996)			Examples	

(Tiwana, 2001)		Examples	Examples
(Tiwana, 2004)	Support		
(Tiwana & McLean, 2005)		Examples	Examples
(Wu & Wang, 2006)			Examples

As shown in Table 1 above, the literature identified to date describes studies supporting all of these constructs with a significant number of studies providing direct examples of similar constructs and their validation. Studies described as supporting one or more variables did not provide actual examples of pertinent measurement items or their validation but remain important to the development of the measurements associated with this study. Supportive studies help to fill in the background when combined with studies providing direct examples. This study will use the supportive descriptions and examples from the literature to guide the development and validation of the final experimental constructs during the survey development and refinement stage.

Independent Variables: Knowledge Exchange

The bulk of research in requirements elicitation, knowledge elicitation, and knowledge transfer in software development has focused on the transfer of knowledge from the business process SMEs to the development team (KT_ED). This study attempts to examine bi-directional knowledge exchange, in which knowledge about requirements and software engineering techniques transfers from the development team to the end users (KT_DE). An additional characteristic of KT_DE may be that the end user SMEs had previously acquired this knowledge from an earlier training or knowledge transfer activity.

Studies providing support for the development of KT_ED include an examination of the communications between end users and developers, a study of user participation in IS projects, two studies on user engagement/satisfaction and IS success, and two studies focused on requirements engineering concepts. Studies providing support for the development of KT_DE include the previously mentioned communications study, a short paper describing a new approach for requirements elicitation, a study of user-developed application success, and an examination of the self-assessment capabilities of end users.

Literature Supporting KT_ED

McKeen, Guimaraes, and Wetherbe (1994) investigated four factors associated with user participation and user satisfaction: 1) task complexity, 2) system complexity, 3) user influence, and 4) user-developer communication. Their study identified a significant correlation between user-developer communication and user satisfaction and supports KT_ED, KT_DE, and PS. Lin and Shao (2000) studied the relationship between system success and user satisfaction and examined user participation as a construct in the participation-success relationship.

Kim, Garrity, and Sanders (2002) empirically validated an IS success model based on user satisfaction. The study had specific constructs for PS, but also used variables that in turn support KT_ED concepts. Rivard et al., (1997) developed an instrument to examine the quality of user-developed applications. The measurement items appear to be applicable to most ISD efforts. Although there is no data describing the extent or even the existence of formal requirements, the study does provide some support for the development of KT_ED measurements.

Three studies emphasized requirements engineering (RE) concepts. Browne and Ramesh (2002) identified problems associated with RE efforts and proposed a variety of solutions. Some of the RE techniques described could be used to generate measures supporting KT_ED. Hoffman and Lehner (2001) examined RE as a success factor in software projects through the use of a RE process view in combination with team knowledge and allocated resources. El Emam and Madhavji (1995) developed and validated a set of RE success constructs which were later validated by Hoffman and Lehner (2001). The RE concepts of these studies provide support for the development of the KT_ED construct.

Examples of KT_ED

Studies providing direct examples of variables similar to the purpose of KT_ED emphasized user participation / user involvement as well as RE process. For example, Hartwick and Barki (1997) developed variables associated with user participation in the software development process. Their constructs for communications between users and IS staff as well as hands-on activities in system design are directly useful for KT_ED. Variables developed by Kujala, Kauppinen, Lehtola, and Kojo (2005) in their study of user involvement and ISD project success included examples of measures directly useful as KT_ED, couched in terms of requirements quality. The variables and measurement items described by each of these studies are directly useful for the development of KT_ED measures.

Literature Supporting KT_DE

Rajagopal, et al., (2005) identified a key improvement in requirements elicitation associated with training provided to the end users in the capabilities and limitations of the computer systems and software that will serve as the target implementation platform. Their paper described advantages gained with training the end users and thus provided support for the KT_DE variable in the sense that knowledge regarding software and systems transfers (ostensibly) from the development team to the end users.

McGill and Klobas (2005) studied the system knowledge of end users and developers of spreadsheet applications and found that users with greater knowledge of spreadsheet development techniques reported greater impact (utility and importance) associated with the spreadsheets provided to them. An alternate definition of KT_DE is the level of knowledge possessed by the end users in RE and software development processes, whether it transferred from the developers to the end users during the current project or a prior activity. The McGill & Klobas (2005) study supports KT_DE in that sophisticated users reported greater utility associated with spreadsheets developed by others and provided for their use.

Marcolin et al., (2000) described an assessment of end user skills in user-developed applications and general abilities in usage of specific packages, but is not classified as example literature. Gravill, Compeau, and Marcolin (2006) studied the relationship between the self-assessed capabilities of end users as opposed to their actual capabilities. The study showed that user self-assessments were lower than actual capability at the low end of the scale, but closely aligned with capability at the high end of the scale. This study provides good support for end user self-assessment of knowledge of RE techniques and is useful for the development of KT_DE. Finally, Tiwana identified “clients technical knowledge,” as a measurement of the “client organization’s technical knowledge about project-specific tools, processes, development, and coding” (2004, p. 5).

Examples of KT_DE

Studies providing direct examples useful to KT_DE have been difficult to locate. The literature review and research model development stage of this study will include additional efforts to locate supporting studies as well as direct examples appropriate to KT_DE.

Moderating Variable: Relational Capital

The concept of relational capital is rooted in earlier literature examining the performance of teams and organizational subunits during various knowledge transfer activities. Leonard-Barton and Sinha (1995) studied user involvement and mutual adaptation in internal technology transfer efforts. User involvement was examined at three stages of development: 1) prototype, 2) pilot test (1st use in a production environment), and 3) general release. A scale ranging from 1 = “no involvement” to 7 = “partner in the development of the system” is an example of the early constructs associated with relational capital. The study compared user involvement and user satisfaction ratings, but found only a weak positive relationship. The study found mutual adaptation (tuning both the new system and the business processes of the users) to have a stronger positive correlation with user satisfaction. This study provides support for the initial concepts associated with RCAP but provides no direct examples or descriptions of survey instruments or scale items.

Szulanski (1996) examined the concept of “internal stickiness” or successful transfer of best practices from one part of an organization to another and found significant impacts associated with causal ambiguity, absorptive capacity, and arduous relationships between the source of the best practices and the recipients. Of particular interest to this study is the use of arduous relationship, which is useful as an antecedent to RCAP. The study provides a full description of the survey instrument and thus is directly useful for the development of RCAP.

Nelson and Cooprider (1996) studied the concept of shared knowledge as a combination of mutual trust and mutual influence between IS and other organizational units. Both of these variables are useful antecedents to the RCAP concept. The paper provides a full description of the instrument used and thus is useful to this study.

Hansen (1999) studied the effect of the strength of inter-unit ties (relationships) in an organization on the processes of knowledge search and knowledge transfer. The study found that weak ties are better for knowledge search activities as they allow broader searches with fewer assumptions and influences, but stronger ties are important for the actual transfer of the located knowledge. The “Interunit tie weakness” measure (p. 94) in the study exhibits similarities to portions of the RCAP concept. This paper also provides a full description of the survey instrument.

Hwang and Thorn (1999) performed an analysis of 25 studies covering user involvement / user participation and system success. In this analysis, the concepts of user involvement and user participation were combined into the term “user engagement” and positively correlated with system success, thus providing support for RCAP and PS. Although the paper does not provide a direct description of the survey instrument, it is useful for the development of the RCAP and PS measures.

Kale, Singh, and Perlmutter (2000) used relational capital as part of a set of latent variables in a study of factors influencing the formation of inter-firm alliances. The study focused on the needs of partner firms to both share their knowledge (and thus gain benefit from the alliance) as well as protect their own core proprietary assets. The study found a positive correlation between relational capital and knowledge transfer. The paper provided direct examples of the measures used to support each latent variable.

The dissertation of A. Tiwana (2001) described a study of the factors associated with knowledge integration on project success in e-business teams. One component of knowledge integration is relational capital. Another factor studied was “absorptive capacity,” which in light of its significance in other works (Cohen & Levinthal, 1990; Kwok & Gao, 2005; Zahra & George, 2002), may be useful in the refinement of the KT_DE and KT_ED variables. Finally, the study specifically examines project success as a dependent variable. The paper provides a full description of the survey instrument and is useful to the development of the RCAP and PS measures.

Finally, Tiwana and McLean (2005) studied knowledge integration at the team level and its impact on team creativity. The study specifically examined relational capital and absorptive capacity and found a positive relationship with expertise integration and team creativity. The paper provides a full description of the survey instrument and is very useful to this study.

Dependent Variable: ISD Project Success

Project success has antecedents in user satisfaction and system adoption studies. While project success has been specifically examined in recent literature, there is little commonality in variable or measurement item construction. A number of previously described studies provided support (Hwang & Thorn, 1999; Lin & Shao, 2000; McKeen et al., 1994) as well as direct examples of measures associated with project success (El Emam & Madhavji, 1995; Hofmann & Lehner, 2001; Kim et al., 2002; Kujala et al., 2005; Tiwana, 2001). In an earlier study, Bailey and Pearson (1983) identified five factors closely associated with user satisfaction and provided a description of factors useful for the development of the PS variable.

In a recent study, Wu and Wang (2006) extended the DeLeone and McLean IS success model (DeLone & McLean, 2002) to develop a variable construct termed “KMS Use” as a proxy for system success, focusing on the usage of a system as an indicator of its success. This study used five independent variables (system quality, knowledge or information quality, perceived KMS benefits, user satisfaction, and system use) to evaluate KMS use/success. The paper provides a full description of construct definitions and measures.

Summary

Practical knowledge and mutual support among practitioners appear to be significant factors in the success of SPI initiatives. The efficient development of high-quality software is a team effort, not an individual effort. Mutually supportive practitioners helping each other with code reviews, user interface discussions, architectural issues, test development, and infrastructure support are able to leverage strengths and compensate for individual weaknesses.

The successful implementation of any new business process depends heavily on the knowledge of the participants. Explicit knowledge, as codified in procedures and guides (what to do), is only one part of the picture. Tacit knowledge regarding the subtleties of process execution (when, how, and why) is of equal or greater importance. Successful collaborations enable tacit knowledge exchange as well as conversion of tacit knowledge into explicit knowledge when appropriate. This conversion often equates to innovation, another component of successful SPI efforts.

A significant number of studies provide either support for or direct examples of the variables and measurement items associated with the initial theoretical framework of this study. Substantial support exists for the development of measures associated with knowledge transfer from the end users to the developers, relational capital, and ISD project success. Additional research is necessary to identify examples of measures for knowledge transfer from the development team to the end user community.

Taken as a whole, the literature presents a picture of complex, cumbersome software engineering processes attempting to compensate for a seeming inability of ISD developers to capture a complete and accurate picture of the needs of the end-user community. The mechanistic approaches put forth as “best practices” attempt to facilitate knowledge transfer from the end-users to the developers, but recent research in knowledge management shows that behaviors associated with high-functioning teams can develop significantly better knowledge. This study uses the term “bi-directional knowledge exchange” to describe the mechanism that results in these teaming behaviors. If this research effort confirms the concept of bi-directional knowledge exchange as an advantageous factor in extant ISD projects, further research in this area could examine a simplified software engineering process that utilizes purposeful feed-forward activities at project initiation.

Barriers and Issues

The goal of this research effort is to determine whether relationships exist among 1) bi-directional knowledge exchange between end-users and developers of ISD projects, 2) the relational capital exhibited by the team, and 3) consequent or coincidental success of the project. Tiwana (2001) empirically examined the relationship between knowledge integration and project success, examining relational capital as a contributory element to knowledge integration. Tiwana and McLean (2005) examined relational capital in detail, but the study used project success only as a secondary check on the validity of a measure associated with team creativity. Ebert and De Man (2005) described a cross-disciplinary core team as an essential component in minimizing requirements uncertainty but project success is an implied result not explicitly examined. Other studies approach the topic from different angles, primarily associated with knowledge development and requirements quality. Studies that explicitly associate cross-domain knowledge exchange with the development of relational capital and subsequent ISD project success remain difficult to locate.

One of the key barriers to success for this research effort will be the development of a valid measure of knowledge transfer from the developers to the end users and SMEs in an ISD project team. There are many measures available to examine requirements quality and capture as evidence of knowledge transfer from the end users to the developers. Few measures supporting knowledge transfer in the opposite direction have been located.

Another barrier will be the development of a valid measure for ISD project success. Few ISD projects have formal measures for process adherence, earned value, or milestone attainment. Several models exist for the empirical evaluation of information systems success, most notably the DeLone and McLean IS Success model (DeLone & McLean, 2002). However, this approach requires a deep exploration of multiple variables in a structural equation model and requires interviews of end-users that did not participate in the development effort. This dual category of end-user interviews adds significant complexity to the study and focuses the concept of success on the opinions of the end-user community, which might not be entirely accurate. The project success measures used by Tiwana, et al (2001, 2005) are primarily subjective measures based on senior management opinion. This study will most likely use a similar surrogate.

Approach

This paper proposes a quantitative study of the relationships associated with: 1) bi-directional exchange of explicit domain knowledge between end-users and developers in ISD teams, 2) establishment of relational capital within those teams, and 3) ISD project success as determined by the project sponsors and associated managers.

Research Question

Are successful ISD projects more likely to exhibit a team of end-users and developers that have established significant relational capital through bi-directional knowledge transfer regarding software development processes as well as system requirements?

Initial Theoretical Framework

The research question describes two independent components: 1) bi-directional knowledge transfer, and 2) relational capital. The first component has two sub-components, resulting in three latent variables that could influence the dependent latent variable of ISD project success (PS):

- Explicit knowledge transfer regarding system requirements from the end-users to the developers (KT_ED),
- explicit knowledge transfer regarding the software development process from the developers to the end-users (KT_DE), and
- the level of relational capital (RCAP) reported by the team members.

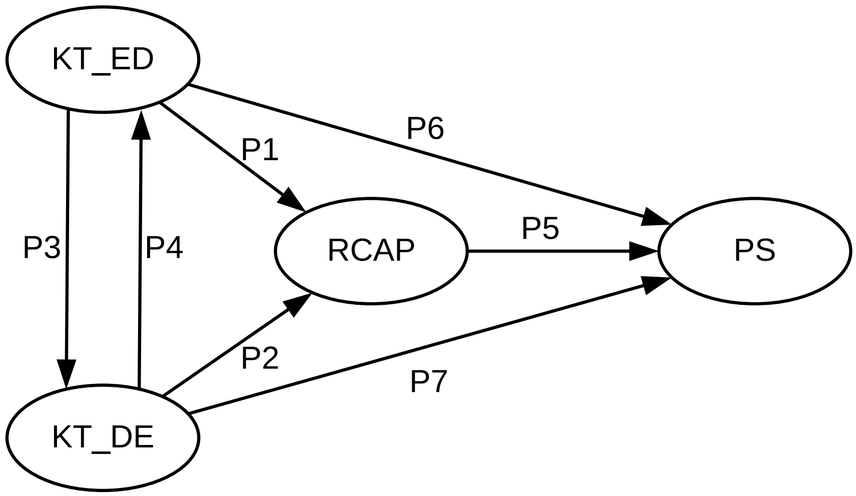

Figure 2. Initial theoretical framework.

This research effort proposes to examine the relationships among these variables to determine whether both subcomponents of bi-directional knowledge exchange influence each other and/or relational capital, which then influences ISD project success, or whether they directly influence ISD project success without regard to relational capital. As shown in Figure 2 above, this study proposes two independent latent variables (KT_ED and KT_DE), one mediating latent variable (RCAP), and one dependent latent variable (PS).

The theoretical framework for this research effort is similar to other frameworks in which structural equation modeling appears to be of benefit. In particular, the establishment of relative levels of influence among the two independent variables, the potential mediating variable, and the dependent variable could yield substantial insight into whether both subcomponents of bi-directional knowledge transfer are of equivalent value and/or influence each other.

Propositions

The initial propositions identified for this study are:

- P1: Explicit knowledge transfer from the end-users to the developers (KT_ED) positively influences relational capital (RCAP).
- P2: Explicit knowledge transfer from the developers to the end-users (KT_DE) positively influences RCAP.
- P3: KT_ED positively influences KT_DE.
- P4: KT_DE positively influences KT_ED.
- P5: RCAP positively influences ISD project success (PS).
- P6: KT_ED positively influences PS.
- P7: KT_DE positively influences PS.

Proposed Methodology

This study proposes to conduct a quantitative survey of ISD teams associated with successful as well as unsuccessful projects as determined by the project sponsors and key stakeholders. This will entail accessing senior managers at a variety of organizations, presenting them with the objectives of this research effort, and eliciting their support and recommendations for ISD teams to serve as the sample population. Survey components specific to managers, end-users, and development team members will be necessary.

Sample population

Participants in ISD projects can vary from one or two developers working for a single sponsor to a cast of hundreds for a large, enterprise-class project. The corporate culture, regulatory environment, and technical approach (among other factors) influence the characteristics and behaviors of ISD project participants. This study proposes to examine relational capital and ISD project success in relation to quality of requirements and design artifacts and the level of knowledge regarding software RE and development techniques possessed by the end user community. This restricts the available pool of projects to those with identifiable development teams, end user communities, and managers associated with each. The sample population for this study therefore consists of participants in ISD projects, in which each project has personnel fulfilling five specific roles as illustrated in Figure 3 below.

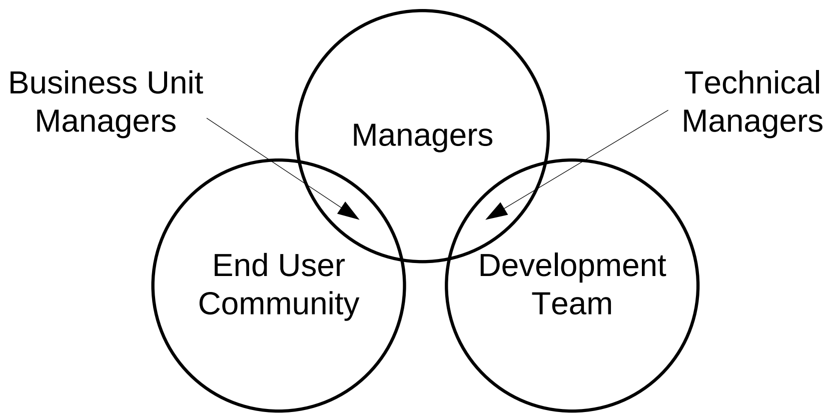

Figure 3. Target population project roles.

Each project must have a separate, well-defined end user community whose members have served or are serving as SMEs associated with the development and review of requirements and design artifacts. This in turn implies a separate development team that is responsible for the analysis, design, and delivery of the IS application. Finally, each project must have at least three managers: 1) a project sponsor, 2) team leaders or managers associated with the business units that make up the end user community, and 3) a project team leader or manager of the technical organization(s) in which members of the development team reside. A manager may have multiple roles in some projects. For example, a project sponsor may also be a business unit manager.

ISD projects with this separation of roles are typically associated with medium to large efforts using a defined software engineering process. These projects are also more likely to exist in organizations with high-risk operations or substantial regulatory compliance practices. This narrows the pool of potential organizations significantly but the resultant pool remains large.

This study proposes to identify target companies, managers, and resultant projects via a three-step process starting at the top of a hierarchical network of industry leaders. Social networking, or formally maintaining a set of contacts associated with a single person and using those contacts to reach others via *their* contact networks, is a long-standing business relationship concept that has recently been augmented by specialized internet services (Visser, 2003). Formal network management services such as LinkedIn.com enable permission-based contact across personal networks, and many people have large and extensive primary networks. This study will contact industry leaders with known large networks and request their cooperation in accessing business managers and development team leads appropriate to this study.

Those identified as principal project contacts will receive via emails in cooperation with the referring individual that explain the research effort, describe the benefits that will accrue to their project as a result, and solicit their participation in the study. At least three participants are required for each role in a project. Principal project contacts will indicate how many participants exist for each project and role combination but will not provide any identity-related information to this study.

This process will continue until at least 20 projects have committed to participating in the study. This will allow a sufficient population for pre-testing and re-testing as necessary to insure appropriate instrument reliability and validity.

Measures of Latent Variables

This study proposes to examine performance at the ISD project team and subteam level, rather than the IS group as a whole. The units of analysis for this study will therefore be team roles. The literature cited previously serves as the source for most of the latent variables and measurement items associated with this study. At this point, it appears that the only new measure to be developed will be KT_DE; all other measures have substantial examples.

Knowledge Transfer from End Users to Developers (KT_ED)

Successful knowledge transfer from the end users to the developers depends on sufficient user participation / user engagement in requirements generation and early design efforts (Hwang & Thorn, 1999; Kim et al., 2002; McKeen et al., 1994). Successful knowledge transfer efforts result in satisfactory requirements and early design artifacts, whether from prototype reviews or formal design efforts. There is some evidence that requirements quality is more difficult to achieve when the ISD effort defines a new, significantly complex, or significantly re-engineered business process (G. J. Browne & Ramesh, 2002). Finally, the quality of the RE process itself has an impact on the quality of the resultant requirements and design artifacts (Hofmann & Lehner, 2001). The measures for the KT_ED variable should therefore focus on user participation (in requirements and design activities), requirements quality, observed requirements process, and system complexity.

Table 2. Candidate Measures for KT_ED

Measure	**Source**
Requirements describe a system that meets the user needs	(Kujala et al., 2005)
Understandable requirements	(Kujala et al., 2005)
Requirements are completely defined	(Kujala et al., 2005)
There are moderately few errors in the requirements	(Kujala et al., 2005)
The requirements engineering was performed successfully in the project	(Kujala et al., 2005)
Exchanged facts, opinions, visions with IS	(Hartwick & Barki, 1997)
Exchanged facts, opinions, visions with other users	(Hartwick & Barki, 1997)
Discussed own concerns with IS	(Hartwick & Barki, 1997)
Discussed own concerns with other users	(Hartwick & Barki, 1997)
Designed report formats	(Hartwick & Barki, 1997)
Set system access priorities	(Hartwick & Barki, 1997)
Determined data access privileges	(Hartwick & Barki, 1997)
Designed screen layouts	(Hartwick & Barki, 1997)
Designed system security procedures	(Hartwick & Barki, 1997)
Designed input/output forms	(Hartwick & Barki, 1997)

The measures shown above provide adequate coverage for user participation and requirements quality. Additional control measures associated with RE process formality and system complexity may be necessary.

Knowledge Transfer from Developers to End Users (KT_DE)

This study examines end-user knowledge of the processes and terminologies of requirements engineering and software development in an attempt to determine the impact on relational capital and ISD project success. Requirements engineering terminology is not standardized and is often project-specific. Most projects are considered to be unique and systems analysts have a variety of RE techniques to draw from (Hickey & Davis, 2003).

The literature examining end user capabilities in software development arises from user-developed applications (UDA) and training / self-managed learning literature focused on assessment of user skills in specific software packages or the quality of user-developed applications (McGill & Klobas, 2005; Rivard et al., 1997). Studies covering RE knowledge of the end user community are difficult to locate. One article (Rajagopal et al., 2005) specifically identified the need to train project stakeholders in the capabilities of the technology and resources available to support the proposed system, but provided no citations or direct examination of this topic.

Development of a question-and-correct-answer measure as suggested by the current literature for software package use will be difficult given the multiplicity of RE techniques and terminology. A better approach might be to use measures focused on user self-assessment and self-efficacy (Gravill et al., 2006; Marcolin et al., 2000). These techniques might be useful to determine the absorptive capacity, or “comfort level” (Kwok & Gao, 2005; Zahra & George, 2002) of the end users with RE and design processes and artifacts when combined with generic requirements and design terms as described above for KT_ED.

Relational Capital (RCAP)

Relational capital is well examined in the literature (Hansen, 1999; Kale et al., 2000; Leonard-Barton & Sinha, 1995; Nelson & Cooprider, 1996; Szulanski, 1996; Tiwana, 2001; Tiwana & McLean, 2005). As shown in Table 3 below, adequate examples of validated measures are available and directly useful to this study.

Table 3. Candidate Measures for RCAP

Measure	**Source**
The level of trust that exists between the [IS organization] and the [line organization] is:	(Nelson & Cooprider, 1996)
The reputation of the [line organization] for meeting its commitments to the [IS organization] is:	(Nelson & Cooprider, 1996)
The reputation of the [IS organization] for meeting its commitments to the [line organization] is:	(Nelson & Cooprider, 1996)
Communication between <source> and <recipient> is:	(Szulanski, 1996)
Collaboration between <source+ and <recipient>:	(Szulanski, 1996)
How close is (was) the working relationship between your division and this division?	(Hansen, 1999)
There is close, personal interaction between the partners at multiple levels	(Kale et al., 2000)
The alliance is characterized by mutual respect between the partners at multiple levels	(Kale et al., 2000)

The alliance is characterized by mutual trust between the partners at multiple levels	(Kale et al., 2000)
The alliance is characterized by personal friendship between the partners at multiple levels	(Kale et al., 2000)
The alliance is characterized by high reciprocity among the partners	(Kale et al., 2000)
At multiple levels, this project team is characterized by high reciprocity among members	(Tiwana, 2001)

ISD Project Success (PS)

In general, software development project success has received extensive study using a variety of approaches. The most common approaches involve either highly detailed assessments (Bailey & Pearson, 1983; Kim et al., 2002), focus on user involvement or satisfaction as a proxy (Hwang & Thorn, 1999; Kujala et al., 2005; Lin & Shao, 2000; McKeen et al., 1994), or rely on the opinions of managers and senior personnel associated with the project (Tiwana, 2001). This latter approach minimizes instrument complexity and is the model favored for this study.

Table 4. Candidate Measures for PS

Measure	**Source**
In light of marketplace-mandated changes and new business requirements that arose during project execution, at the present time, this project…	(Tiwana, 2001)
• is within budget	

- is on schedule
- delivers ALL desirable features and functionality
- meets key project objectives & business needs

This information system is more useful than I had expected	(Kim et al., 2002)
This information system is extremely useful	(Kim et al., 2002)
The organization considers the project a success	(Kujala et al., 2005)
The result of the project is a success according to customer and user feedback	(Kujala et al., 2005)

Control Variables

ISD projects examined by this study will naturally fall into different project demographics such as size of project, current progress, perceived project complexity, team size, and team composition. A set of control variables will support analysis of covariance by grouping responses under different combinations. A. Tiwana (2001) conducted a study of ISD project teams and defined a set of useful control variables as shown in Table 5 below.

Table 5. Candidate Control Variables from A. Tiwana (2001)

Control	**Justification**
Demographics, and experience with ISD and Web development	Sex, tenure with the present company, and e-business and IT experience.
Project schedule (months)	Team with tight schedules might be under more pressure to integrate knowledge by doing "whatever it takes."

Project stage	Projects in later stages might achieve higher levels of knowledge integration.
Project novelty	The likelihood of execution success might be more strongly influenced by knowledge integration in novel projects.
Team size	Team size might impact learning and knowledge sharing' knowledge integration frequently requires interaction in small groups or teams.
Technological turbulence	Appropriability of knowledge is expected to fall systematically as the technology in question matures.

These controls provide a good baseline of examples for the development of the final control variables and associated measurements for this study.

Scale Development

For the most part, existing measurement items will be adapted to measure relational capital, ISD project success, and control variables. New measures are necessary to measure bi-directional knowledge transfer, focusing on requirements and design activities. Figure 3 provides an overview of the anticipated scale development process adapted from DeVillis (2003):

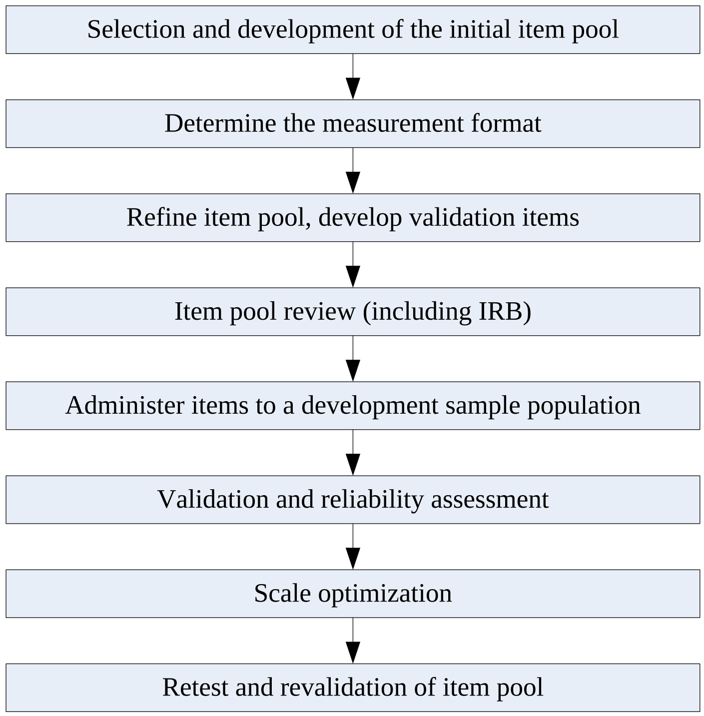

Figure 4. An overview of the anticipated scale development process.

The initial item pool will consist of measures adopted from the literature and translated to a common terminology appropriate to this study. KT_DE will require the development of a new set of measures. As this study examines multiple latent variables which in turn have influences on each other, traditional path-based and regression analysis will be inappropriate (Schumacker & Lomax, 2004). The nature of this study requires the development and use of a structural equation model (SEM) and the statistical analyses appropriate to such a model. SEM analysis depends significantly on the use of means and standard deviations to develop covariance values. Hence, the measurements associated with this study will need to be interval or ratio measures wherever possible.

The next step involves the development of validation items, which may include control measures associated with the respondent's desire to portray the project in an inappropriate light (either good or bad). It may also be appropriate to develop additional measures to enhance construct validity. The dissertation committee will then review the initial item pool. The pool with then be revised to resolve comments and receive the approval of the dissertation committee.

The next step is submission of the proposed item pool to the Nova institutional review board (IRB) for review. This study will not require participants to use equipment or perform actions that are unusual to their normal daily routine. This study will also use an online, Web-based survey instrument that protects the identities of the participants to the degree that no personally identifiable data (outside of the principal project contacts) are ever collected. Both of these conditions meet the criteria required for exemption from further IRB review (Cannady, 2007). As before, comments will be resolved before proceeding to the next step. This final approved item pool is termed the candidate item pool.

The next step is to pre-test the candidate item pool against a subset of the target population. This will yield valuable information on response rate, durations, and the amount of follow-up communications necessary to achieve a satisfactory response rate. Confirmatory factor analysis (Brown, 2006; DeVelllis, 2003) of each measurement item will drive further refinement of the survey instrument. Additional pre-testing may not be necessary if the only refinements involve dropping certain measures from the candidate item pool.

On the other hand, it may be necessary to optimize the measurement scales. Optimization involves either increasing the scales to improve the average interitem correlation or decreasing them to improve usability (DeVelllis, 2003). Additional pre-tests will be necessary to re-validate measures with modified scales. This study will explore the development of online surveys using sliding scales manipulated by the respondent. This user interface supports ratio values as opposed to interval values and thus may minimize some scale optimization issues.

Survey Instruments

Data will be collected using online, internet-based electronic surveys as described by Dillman (2007) and Schonlau, Fricker & Elliott (2002). Modern internet survey mechanisms are platform independent and function reliably on low bandwidth connections. The internet survey overcomes concerns about respondent anonymity and shortens the time and costs associated with data collection. In addition, busy professionals (the target population for this study) are exhibiting low and increasingly lower response rates to offline surveys (Deutskens, de Jong, de Ruyter, & Wetzels, 2006). The use of online surveys may therefore help to improve the response rate while minimizing attendant costs.

One concern regarding online administration of surveys is coverage error and its detrimental effect on sample quality when the sample population has varying levels of access to the Web (Roster, Rogers, Hozier, Baker, & Albaum, 2007). This study proposes to sample developers, managers, and end users involved in non-trivial ISD projects; virtually all members of this population will have full access to the Web via their normal corporate communications infrastructures. This study anticipates minimal sample quality degradation due to coverage error associated with lack of access to the Web.

Another concern is with generalizability of survey results to the general population. This study proposes to survey a variety of project teams in organizations across the nation to enhance generalizability from the design perspective. Roster, et al., (2007) found comparable generalizability between online and offline surveys, keeping in mind the need to insure the sample population has consistent access to and familiarity with Web-based forms submission.

While response rates and sample representativeness can be lower in online surveys (Granello & Wheaton, 2004), these effects are primarily associated with lack of access to or lack of familiarity with the technology. Outside of this, the normal problems associated with response rates and bias exist for this study (Creswell, 2003). This study will survey specific project teams, working with the project leaders and/or sponsors to follow up survey notices and requests to insure satisfactory response counts from the end users and development team members. Although the identity of specific respondents will remain confidential, it will be possible to count the number of responses and responding participant roles and compare them with the counts available for each project and role combination. This approach may minimize problems attributable to low response rates and/or bias (Griffis, Goldsby, & Cooper, 2003; Kaplowitz, Hadlock, & Levine, 2004; Truell, 2003).

Project Stages and Milestones

This research effort proposes to proceed in five stages: 1) literature review and refinement of the research model, 2) survey development and refinement, 3) survey execution and data collection, 4) data reduction, and 5) reporting.

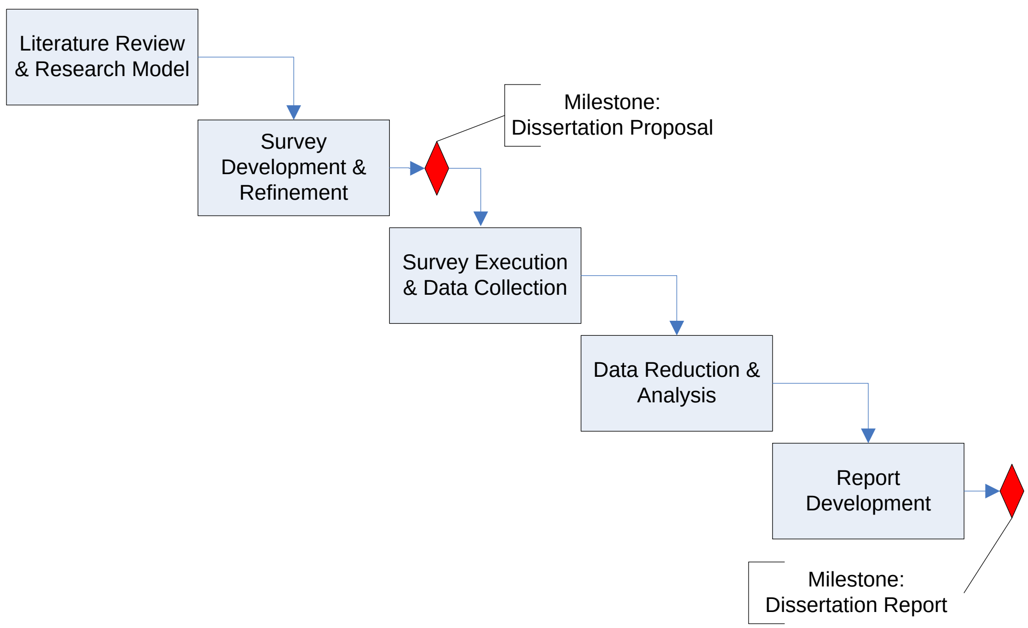

Figure 5. Project stage hierarchy and major milestones.

The first stage will focus on the literature review and subsequent development of the research model. The literature review will focus on the variable constructs identified in Figure 2, with a primary goal of identifying research efforts utilizing constructs appropriate to the research model for this project. The research model will utilize constructs from other studies to the greatest degree possible. The final output and exit criteria for this stage will be the approved literature review and research model.

The second stage of the project will focus on the development and testing of the survey and data collection mechanism. An important prerequisite to this effort will be identification of sliding scale user interface widgets to enable ratio measurements in online surveys. The final output and exit criteria for this stage will be the approved survey instrument and dissertation proposal.

The third stage of the project will address data acquisition via Web-based online surveys. The fourth stage of the project proposes to reduce the data and develop the conclusions. The fifth stage should result in the final dissertation report after the dissertation committee has reviewed the data and approved the conclusions drawn in the study.

Resources

The following resources will be required to complete this study:

1. A Web site describing the research effort and progress for the dissertation committee, principal project contacts, and other interested parties. This will be hosted at www.zoltai.com/study.
2. A relational database management system to support data accumulation, reduction, and reporting. The Oracle RDBMS integrates well with the statistical analysis and structural equation modeling tools supporting this study.
3. A survey delivery and data accumulation tool. The choice of tool will depend on the ability to support sliding scale user interface widgets.
4. A statistical analysis tool. SPSS will be used for this study.
5. A structural equation modeling tool. The AMOS SEM software integrates with SPSS.

With the exception of the survey development tools, all necessary resources for this study are currently in place.

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