ACADEMY OF INFORMATION AND MANAGEMENT SCIENCES JOURNAL

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LETTER FROM THE EDITORS

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THE ROLE OF CONSULTANTS IN THE IMPLEMENTATION OF ENTERPRISE RESOURCE PLANNING SYSTEMS

Eddie Metrejean, Georgia Southern University
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ABSTRACT

Previous research shows that most organizations use consultants to assist with ERP implementations, but little, if any, research has been performed to determine in which phase of an ERP implementation consultants are perceived to be most effective and most necessary. Using survey methods, this research examines two issues. First, this study examines whether consultants are perceived to be more effective in the tasks they perform and more necessary within the different phases of ERP implementations. Second, this study examines which characteristics possessed by ERP consultants contribute to their effectiveness. Results show that ERP consultants are rated as more effective and necessary in the configuration and integration phase of an ERP implementation than in other phases. Results also show, although not conclusively, that technical skills and knowledge contribute more to the effectiveness of ERP consultants than other characteristics.

INTRODUCTION

Organizations implement enterprise resource planning (ERP) systems to solve their accounting, scheduling, and production problems and because existing business practices and procedures are inadequate to meet their current or future strategic needs (Nah, et al. 2001; Karakanian 1999; Davenport 1998). Details on the inner workings of ERP systems can be found in resources such as O'Leary (2000) and Jacobs and Whybark (2000).

Because ERP implementations are very complex, costly, and risky, organizations typically use consultants to assist them in their implementation. Many organizations lack the information technology (IT) personnel with the required expertise and time to undertake implementing an ERP system, and consultants often assist their clients throughout the entire implementation process (Glover et al. 1999; Nah et al. 2001; Thong et al. 1994; Yap et al. 1992).

Considerable research has been performed in the areas of ERP systems and the presence of consultants during these implementations. The use of consultants is often

cited as a critical factor for the success of an implementation (Nah et al. 2001; Thong et al. 1994; Yap et al. 1992). However, little research, if any, has examined the phases of an ERP implementation and how the consultants fit into an implementation on a phase-by-phase basis. If consultants are not necessary and/or effective in a particular phase, they can then be left out of the work on that phase, potentially saving considerable money for the implementing organization. The results give researchers a starting point for examining how consultants fit into the specific parts of an ERP implementation. Further, practitioners will have an idea about were to best use their scare resources when implementing ERP systems.

In light of this lack of research, this study has a twofold purpose. The first purpose is to examine whether consultants are perceived to be more effective and necessary in certain phases of an ERP implementation than in other phases. The results of this research should provide researchers who study ERP systems with information about the phases of an implementation in which organizations use consultants. If consultants are not perceived to be effective in a particular phase, then consultants may be left out of that phase and internal IT personnel may be used. The results show that IT managers do perceive that consultants are more effective and necessary in the configuration and integration phase of an implementation and least effective and necessary in the operation of the ERP system. Thus, organizations may be better able to focus the use of their ERP consultants on those particular phases, which should save resources.

The second purpose of this study is to examine whether certain characteristics possessed by ERP consultants contribute more to their effectiveness than other characteristics. Researchers who study ERP implementations should benefit from this research because the results will give them some idea of which characteristics and skills that real users consider most important. The results show that IT managers do perceive that four characteristics (technical skills, business context skills, commitment to quality, and the ability to manage ERP implementations) are related to ERP consultant effectiveness. ERP consultants may be able to focus on these particular skills to enable them to provide more value to their clients who are implementing ERP systems. Organizations may be able to look for consultants with a particular skill set because that skill set tends to improve the consultants' effectiveness.

The remainder of this paper examines the existing literature regarding the effectiveness and need for ERP system consultants and describes the development of a multiple-phase ERP implementation model used to structure the research instrument for this study. Next, the research method is described and results are examined. The final section includes a conclusion and a discussion of the limitations of the research.

REVIEW OF PRIOR LITERATURE

ERP implementations are costly in terms of both dollars and time spent by personnel. Estimates of a typical ERP implementation range from a low of 14 months to as high as 23 months to actually implement the ERP system and another 31 months to see the benefits of the effort (Bingi et al. 1999; Chen 2001; Koch 2002). Estimates on the cost of a new ERP system range from $2 to $4 million dollars for a small organization with simple processes to over $1 billion for a large organization with complex processes (Bingi et al. 1999; Chen 2001; Koch 2002). The fees of ERP consultants are included in those costs.

Although many organizations have successfully implemented ERP systems, studies have found that between 40 and 50 percent of ERP implementations are only partially successful and 20 percent of ERP implementations are scrapped as total failures (Davenport 1998; Chen 2001). Donovan (2002) suggests that 90 percent of the organizations that have implemented ERP systems have not had a truly successful implementation the first time. These implementations fail for many reasons such as a failure to effectively reengineer business processes, a lack of management support for the project, ineffective pre-implementation activities, and inexperienced consultants or IT personnel driving the implementation.

Because these systems are so costly and risky, most organizations use consultants to assist in the implementations. Good consultants can handle many tasks or projects that organizations are unwilling or unable to handle. External consultants may bring an outside perspective to the implementation team, which may contribute to the implementation's success (Willcocks and Sykes 2000; Thong et al. 1994; Spacek 2000; Mische 2000). In many instances, consultants have been an invaluable resource for the organizations implementing ERP systems. Ifenedo (2008) shows that the use of quality external experts is critical for the success of ERP systems. The study also shows that the user of external experts is more important that even management's support of the ERP system.

Several studies have examined the factors that lead to a successful ERP implementation. Bingi et al. (1999) outline several critical factors, including the use of ERP consultants, for success in an ERP implementation. Nah et al. (2001) determine, through a review of the literature, that 11 factors are critical to ERP implementation success. Previous studies in their literature reviews suggest that the ERP implementation team should include a mix of consultants and internal personnel. Yap et al. (1992) found that for organizations that used consultants, the likelihood of a successful implementation was associated with the use of an effective consultant. In other words, the effectiveness of the consultant is important to the success of an information system implementation.

Loh and Koh (2004) found that for small- and medium-sized organizations, consultants are key players in the early phases of ERP implementations.

Several other studies or articles offer advice about the use of consultants for IT or ERP implementations. Ko et al. (2005) examine the relationship between consultants and their clients. The authors find that it is important to create an environment in which the consultants and client personnel can interact frequently and freely so that knowledge can flow freely between the two parties. Spacek (2000) indicates that external consultants should be used because they bring an external and hopefully independent point of view to the implementation team. Slater (1999) suggests that using consultants may lead to getting things right the first time; however, many implementations in which consultants were used still have not been completely successful. Based on the arguments above, organizations should be encouraged to use external consultants for their IT and ERP implementations.

Several studies have identified characteristics of effective consultants. In their book, Arnoudse et al. (1989) identify four sets of skills that lead to effective information system consulting. These sets of skills are technical skills, human interaction skills, business context skills, and consulting framework skills.

Yap et al. (1992) use three characteristics to associate the effectiveness of consultants with information system implementation success. These three characteristics are consultant experience, consultant capability, and consultant effectiveness during the feasibility study. Experience typically leads to capability.

Thong et al. (1994) identify four variables to assess a consultant's performance during an information system implementation. These variables are consultant effectiveness in performing analysis of requirements of the business, consultant effectiveness in recommending the proper solution, consultant effectiveness in managing the implementation, and the relationship between the consultant and the other parties involved with the project.

Mische (2000) proposes several characteristics that are desirable in information systems consultants. These characteristics include communication skills; the consultant's background, experience, and familiarity with the issues in the implementation; the ability to determine the organization's needs and expectations and assign personnel to meet those needs and expectations; personality and chemistry; objectivity; expertise with systems implementations; and commitment to quality.

While many of the cited studies have examined characteristics of IT consultants, those characteristics should also be present in ERP consultants. ERP systems are quite different than other IT systems, but without good consultants with appropriate characteristics, the chances for failure of either IT or ERP systems increase. Knowing the characteristics of an effective ERP consultant is quite important for the organization to pick the best consultant for their ERP implementation.

THE ERP IMPLEMENTATION MODEL

One area that has been addressed in the ERP literature is the attempt to develop definitive models for ERP implementations. For example, Parr and Shanks (2000) and Markus and Tanis (2000) have proposed different ERP implementation models. ERP implementation models allow a deeper understanding of what occurs during the implementation.

Parr and Shanks (2000) developed what they called the project phase model (PPM) that has three major phases: planning, project, and enhancement. To give more detail of the actual installation, the project phase is further divided into five subphases: set-up, reengineering, design, configuration and testing, and installation. The PPM includes elements from two other models developed by Ross (1998) and Bancroft et al. (1998).

In the PPM, the planning phase includes tasks such as selection of the ERP system, assembly of the steering committee, and determination of the scope of the implementation. The project phase includes tasks to get the new ERP system up and running. These tasks include reengineering business processes, installing the software, mapping the processes to the software, detailed design, configuring the system to match the company, testing the new ERP system, and installing the ERP interfaces on the users' computers. Finally, the enhancement phase includes monitoring the system and repairing, maintaining, and upgrading the ERP system.

In their article, Parr and Shanks (2000) used the PPM and case studies of two companies that had recently implemented ERP systems to determine which critical success factors (CSFs) are necessary in the particular phases and subphases of their model. However, the study makes no mention of whether the PPM is actually used by organizations as a model to be followed in the implementation of ERP systems.

Markus and Tanis (2000) developed a theoretical model called the enterprise system experience model (ESEM) that has four phases: chartering, project, shakedown, and onward and upward. In the ESEM, the chartering phase includes activities leading up to the beginning of the implementation, including selecting the ERP system, identifying a project manager, and building a case for the implementation. The project phase involves getting the system up and running and includes selection of the project team, modeling and reengineering current processes, software configuration, integration of "bolt on" software and other systems that the organization wishes to retain, data conversion, training, and rollout. The shakedown period includes time for employees to get acclimated to new information systems and includes tasks such as debugging and retraining users, among others. The onward and upward phase includes tasks such as continuous business improvement, user training, and a post-implementation assessment.

While both the PPM and ESEM are good models, neither was judged a perfect fit for this study. For example, the PPM includes the subphases of the project phase that allow for a more detailed look at the project phase In the present study, more detail is needed to differentiate the tasks done by the consultants in an ERP implementation. In addition, the ESEM gives a good description of the shakedown phase. This phase is important because users of ERP systems must have time to become acclimated to the new system, but the PPM does not include a separate phase in which users become acclimated to the system.

Since neither of the aforementioned models is a perfect fit for this study, a model that combines elements of both the PPM and the ESEM is developed. The new ERP implementation model consists of four phases: planning, project, shakedown, and operation. The project phase is further divided into five subphases: reengineering, design, configuration and integration, testing, and installation and conversion.

Table 1. Activities Included in the Phases of the Current ERP Implementation Model	
Phase/Subphase	Activities
Planning Phase	Building a business case for ERP system Assembly of a steering committee Selection of an ERP system Selection of project managers Determination of scope of project Approval of budget and schedule for implementation
Project Phase	
Reengineering Subphase	Detailed examination and evaluation of current processes Installation of ERP system
Design Subphase	High-level and detailed design Prototyping to get feedback from users
Configuration and Integration Subphase	Creation of the detailed configuration based on processes Preliminary testing of the configurations Building and testing interfaces and reports
Testing Subphase	Testing of the system as a whole
Installation and Conversion Subphase	Building necessary networks Installing software on users' PCs
Training of users	Conversion of data and archive files
Shakedown Phase	Testing the system in operating mode Debugging and fine-tuning the system
Retraining users	Staffing to handle temporary inefficiencies
Operation Phase	Continuous improvement and modifications
Debugging	
Repair and maintenance	
Continuous user training	Post-implementation benefits analysis

The first phase is the planning phase. Activities involved in planning are building a case for the implementation, selection of the steering committee, ERP system, and project manager, and approval of a budget, among others. The project phase includes activities involved in configuring the system and integrating the new system with other applications, such as reengineering, design, configuration of the system to match the organization's processes, integration of existing systems, testing the new system, installation of the interfaces on the users' computers, and conversion of data to the new system. The shakedown phase includes tasks such as debugging and fine-tuning the system and training users. Finally, the operation phase includes modifying the ERP system, debugging, repair and maintenance, and post-implementation analyses. Table 1 summarizes the activities that are included in each of the phases and subphase of this ERP implementation model in greater detail.

HYPOTHESES

One aspect of this research addresses whether individuals feel that consultants are effective in the tasks that they perform and are necessary members of the implementation team on a phase-by-phase basis. Effectiveness is commonly defined as producing a definite or desired result and, in this study, refers to how well a consultant performed the tasks that are involved in a particular phase of an ERP implementation. Consultant effectiveness can be concretely measured by how well a task is performed by the consultant. Conventional wisdom suggests that when a consultant is effective in their tasks, their work should lead to a successful ERP implementation. Following this discussion, the following hypothesis is examined.

> *H1:* *Relative differences exist in the effectiveness of consultants across the phases of an ERP implementation and overall.*

Necessity is commonly defined as being indispensable, unavoidable, or required and, in this study, refers to whether an individual perceives that ERP consultants are an indispensible part of the implementation team. Consultant necessity is more of a perception of whether one feels that the consultants are needed on the implementation team. Because of the complex nature of ERP implementations, consultants are certainly thought to be necessary; however, no prior research has examined the specific phases in which consultants are necessary or if they are perceived as being more necessary in one phase versus other phases. Following this discussion, the following hypothesis is examined.

> **H2:** *Relative differences exist in the necessity for consultants across the phases of an ERP implementation and overall.*

It is possible that a consultant could be very effective in a particular phase, but not necessary to a particular organization in that phase. Conversely, it is possible that an organization would have the need for assistance in a particular phase, but their experience suggests that consultants lack effectiveness in that particular phase. Accordingly, the effectiveness and necessity measures are not expected to be perfectly correlated.

As discussed above, prior studies have shown that certain characteristics impact the effectiveness of information system consultants. These prior studies included a total of 18 characteristics, many of which are similar. An examination of these characteristics to determine whether they were essentially the same as other characteristics pared the 18 characteristics down to eight distinct characteristics. These characteristics and their descriptions are:

> *Technical skills and knowledge* – knowledge of a variety of technologies, including ERP systems
>
> *Human interaction and communication skills* – ability to communicate with and relate to others
>
> *Business context skills* – ability to gain an understanding of the detailed operations of the client organization
>
> *Consulting skills and knowledge* – ability to perform analysis of information requirements and feasibility analyses (among other things) and to make proper recommendations
>
> *Objectivity* – freedom from bias regarding the organization and ERP vendors
>
> *Experience with ERP implementations* – whether the consultant has been involved in ERP implementations and the similarity of previous implementations
>
> *Commitment to quality* – responsibility to perform the implementation to the best of the consultant's ability and to produce the best possible product
>
> *Management ability* – ability to manage projects and implementations and supervise personnel.

This study examines whether these characteristics have some impact on the effectiveness of ERP consultants. Following this discussion, the following hypothesis is examined.

> **H3:** *Individual characteristics possessed by ERP consultants contribute to the perception of consultant effectiveness in ERP implementations to varying degrees.*

Prior studies (Yap et al. 1992; Thong et al. 1994) indicate that all characteristics are rated similarly, and no single characteristic stands out as having more of an impact on effectiveness. For this study, the expectation is that the characteristics contribute to the effectiveness of consultants to varying degrees; therefore, no predictions are made regarding which characteristics have more of an impact on effectiveness.

METHODOLOGY

A research instrument was administered via email and the Internet to chief information officers (CIO), vice presidents of IT, and IT directors and managers using rented lists of subscribers to the magazines *CIO* and *Enterprise Systems Journal* and to individuals who had indicated involvement with various ERP user groups. Subscribers to *CIO* and *Enterprise Systems Journal* were used because the target audiences of these magazines are IT executives who are looking for an information source that focuses on their needs and that provides information clearly and concisely. Since virtually all Fortune 1000 companies and many smaller organizations have implemented ERP systems, many CIOs and IT managers who subscribe to these magazines have probably been involved with ERP implementations to some degree. Members of ERP user groups are used because many of these individuals have been involved to some degree with an ERP implementation.

Four thousand email addresses were rented from each of the two magazines based on the respondents' positions in their organizations (CIO, vice president of IT, or IT director). The transmitted email included a description of the study and the purpose of the research instrument. Prior research indicates that response rates for emails surveys are typically higher than for traditional mail surveys when the email is sent to computer savvy individuals (Sheehan 2001; Fricker and Schonlau 2002; Schuldt and Totten; Ali and Jones 2002). However, in an era of "spam" and the spread of destructive programs via email, the response rates for this study were quite low. Of these 8,000 individuals, only 43 (0.5 percent) completed the research instrument. However, some overlap may have been present. In other words, some subscribers chosen by *CIO* may have also been chosen by *Enterprise Systems Journal*, thus decreasing the real number of individuals in the population. A decrease in the number of individuals in the population would, in turn, increase the response rate. Because the two journals retained control over the emails and email addresses, so there is no way of knowing if any overlap occurred.

Since so few responses were received via rented email lists, the public domains of websites for the SAP, Oracle, and J.D. Edwards user groups were searched to find as many names and email addresses as possible. Other ERP user group websites could not be found or required registration and membership in the user group to access information on the website; therefore, no email addresses were found for ERP user groups such as

PeopleSoft and Baan. Also, since the data collection, there have been mergers among ERP systems vendors, so these user group websites may no longer exist. The user group website searches netted a total of 1,675 viable email addresses. Of the individuals emailed using this method, 143 (8.8 percent) responded to the research instrument. As with the two magazines, there may have been some overlap in subjects. In other words, some of the subjects chosen from the user groups may have also been in the group of individuals chosen from one or both magazines. Again, such a situation would reduce the number of individuals in the population and thus increase the overall response rate. In total, 9,675 emails were sent, and 186 responses were received for an overall response rate of 1.9 percent.

To test for non-response bias, early and late respondents were compared on organization size, industry, and ERP consultant type. The results of Chi-square tests showed no significant differences among these key organizational characteristics.

While the response rate for the study is low, the demographics show that the respondents are quite diverse. Several interesting results were noted. Of the 112 respondents who answered the item regarding the type of consultant used, 74 (66.1 percent) used consultants who were owned by or involved with ERP vendors. One questions whether a consultant can be (or should be) truly objective in a consulting engagement when such a relationship exists. A large majority of the respondents (136, or 73.1 percent) indicated that their organizations use SAP. Only 23 respondents (12.4 percent) indicated that their organizations had fewer than 500 employees, so most organizations were fairly large. Most respondents (72, or 38.7 percent) work in organizations that they classify as manufacturing companies.

One hundred thirty-two respondents (74.6 percent) felt that the implementation was successful, while only 45 respondents (25.4 percent) felt that the implementation was not successful or was only partially successful. This rate of unsuccessful implementations is lower than those found in other studies such as Davenport (1998), Chen (2001), and Donovan (2002). Respondents gave varying reasons why they felt that their implementations were not successful. Reasons given were: the organization had not achieved its full return on investment (ROI); the consultants "milk the clients;" no knowledge transfer took place; cost overruns; inadequate time, financial resources, testing, or training; resistance to change; lack of communication between management and the consultants; long implementation time, and unrealistic expectations. Each of these causes of unsuccessful implementations has also been noted in the studies mentioned above.

THE RESEARCH INSTRUMENT

The research instrument included four parts. Part 1 was an introductory section that explained the purposes of the study and included definitions of consultant effectiveness and necessity to help the individuals differentiate the two items. Instructions informed the respondents of pop-up boxes that included descriptions of each of the phases and subphases of the ERP implementation model and of the characteristics of consultants. This information was provided to ensure that the individuals understood what happened in each of the phases and what each characteristic meant. The final item of Part 1 was a question that asked whether the respondent had ever been involved in an ERP implementation. Depending on the response to this question, the respondent was redirected to one of two forms of the research instrument tailored to an individual who either had experience with an ERP implementation or who did not have such experience. Part 1 of the research instrument is included in Appendix 1.

For individuals who had experience with ERP implementations (ERP implementers), Part 2 of the research instrument included items regarding both consultant effectiveness and necessity during an actual ERP implementation. These items asked the respondents to rate their consultants on effectiveness and necessity in the individual phases and subphases of the ERP implementation model and overall in the implementation using a Likert-type scale from one (Strongly Disagree) to seven (Strongly Agree). For non-ERP implementers, Part 2 of the research instrument included items regarding only consultant necessity because they had no way of rating consultants on their effectiveness. Although data were collected from these non-ERP implementers, their responses have been omitted from most analyses because so few non-ERP implementer responses were received (nine of 186). No significant differences were observed in the responses between implementers and non-implementers. Only Part 2 of the research instrument differed between ERP implementers and non-ERP implementers. The remainder of the research instrument is included in Appendix 2.

Part 3 of the research instrument was included to gather data on which characteristics the respondents felt contribute to the effectiveness of ERP consultants. All respondents completed Part 3 because even non-ERP implementers should have some perception of whether a characteristic contributes to the effectiveness of a consultant. The respondents were first asked to indicate the phase or subphase in which they felt that their consultants were or would be (in the case of non-ERP implementers) most effective. The respondents were then asked to rate the characteristics' contributions to effectiveness using Likert-type scales from one (Low Contribution) to seven (High Contribution). Part 3 also included an open-ended item that asked the respondents to indicate any additional characteristics that they felt contributed to consultant effectiveness. Finally, respondents were asked to indicate the phase or subphase in which they felt their consultants were or

would be (in the case of non-ERP implementers) least effective. These last two items allowed for the consideration of characteristics not included on the research instrument and also allowed confirmation of the results of other parts of the study.

Part 4 of the research instrument included questions designed to gather demographic data about the respondent. All respondents were asked to complete Part 4.

A pretest of the research instrument was performed to determine if changes were necessary. Four members of ERP implementation teams from two organizations that had recently implemented ERP systems were asked to complete the research instrument and provide any comments regarding the items on the instrument and the overall understandability of the instrument. These individuals were also asked whether they felt that effectiveness and necessity should be more clearly defined to eliminate confusion about whether they represented the same construct. All individuals indicated that the instrument and instructions were understandable and that they understood the difference between effectiveness and necessity. Only insignificant changes were suggested. The responses from the pretest are not included in the results.

RESULTS

Consultant Effectiveness and Necessity

Analyses of means and frequencies were performed on both consultant effectiveness and necessity by phase. Higher means indicate that a consultant was considered to be more effective in the tasks they performed or more necessary to the implementation. Table 2 shows the means for consultant effectiveness and necessity for each phase and subphase of the implementation model. The highest mean rating for consultant effectiveness is for the configuration and integration subphase, with a mean of 5.21. Consultant effectiveness in the operation phase received the lowest mean rating, with a mean of 3.95. Overall, consultant effectiveness was rated 4.83, indicating that the respondents feel that their consultants were effective overall but not overwhelmingly so.

Part 3 of the research instrument asked the respondents to indicate the phase or subphase in which they felt their consultants were most effective and least effective. An examination of frequencies for these responses shows that the vast majority of respondents indicated that their consultants were most effective in the configuration and integration phase. Most respondents indicated that their consultants were least effective in the operation phase. These results are consistent with the ratings in Table 2.

Table 2 also shows the means for consultant necessity for each phase and subphase. The highest mean rating for necessity was in the configuration and integration subphase, with a mean of 5.52. Consultant necessity in the operation phase received the

lowest mean rating, with a mean of 3.60. The overall mean rating was 5.20, indicating that the consultants were perceived to be necessary overall.

Table 2. Mean Ratings on Consultant Effectiveness and Necessity by Phase						
	Consultant Effectiveness			Consultant Necessity		
Phase or subphase	Mean n=177	Standard Deviation	Rank	Mean n=177	Standard Deviation	Rank
Planning phase	4.83	1.47	3	5.23	1.771	3
Reengineering subphase	4.46	1.505	6	4.74	1.816	5
Design subphase	4.88	1.462	2	5.35	1.514	2
Configuration and integration subphase	5.21	1.534	1	5.52	1.612	1
Testing subphase	4.67	1.539	5	4.66	1.713	6
Installation and conversion subphase	4.82	1.5	4	4.87	1.786	4
Shakedown phase	4.41	1.434	7	4.44	1.647	7
Operation phase	3.95	1.625	8	3.6	1.739	8
Overall	4.83	1.284		5.2	1.452	
Note: Ratings were on a scale of 1 to 7 with 1 being strongly disagree that consultant is effective/necessary and 7 being strongly agree that consultant is effective/necessary. Only responses of the ERP implementers (n=177) are used in the analysis of consultant necessity because so few responses were received from non-ERP implementers. No significant differences were observed between the two groups.						

Table 2 also includes the rankings based on the mean ratings of the phases and subphases. The mean ratings for consultant effectiveness and consultant necessity are consistent. The only difference in the rankings occurred between the reengineering and testing subphases. For consultant effectiveness, the testing subphase was ranked fifth, and the reengineering subphase was ranked sixth. Conversely, for consultant necessity, the testing subphase was ranked sixth, and the reengineering subphase was ranked fifth.

Although the rankings in the phases are quite similar, effectiveness and necessity were not expected to be perfectly correlated, as stated in an earlier section. Table 3 shows that for effectiveness and necessity by phase, correlations range from .506 for the testing subphase to .678 for the configuration and integration subphase. Thus, while effectiveness and necessity appear to be related, they are not perfectly correlated.

Hypothesis 1 states that relative differences exist between perceptions of consultant effectiveness in the various phases and subphases of an ERP implementation. Repeated measures analysis of variance (ANOVA) is used in this study because the study examines the respondents' ratings for successive phases within an ERP implementation, i.e. repeated polling of the same subjects. According to Stevens (1999), repeated measures ANOVA is appropriate when the same subjects are "polled" about successive

points during a process. The results of the repeated measures ANOVA show that significant differences exist in the perceptions of the effectiveness of consultants across the implementation model (F=22.820, p<.001). Therefore, Hypothesis 1 is supported.

Table 3. Correlation between Consultant Effectiveness and Necessity by Phase									
		Effectiveness							
		Plan	Reeng	Design	Config	Test	Install	Shake	Oper
Necessity	Plan	.542*							
	Reeng		.591*						
	Design			.580*					
	Config				.678*				
	Test					.506*			
	Install						.566*		
	Shake							.584*	
	Oper								.639*
* Significant at p<.01									

To determine between which phases the differences occur, a post hoc test using a Bonferroni adjustment was performed. Table 4 shows the differences among the mean ratings for consultant effectiveness between the individual phases. These differences are calculated as the mean for the phase on the top of the table minus the mean for the phase on the left of the table. Table 4 shows that, in general, respondents rated consultant effectiveness significantly lower than all other phases and lower than overall effectiveness. The respondents also rated consultant effectiveness in the configuration phase significantly higher than all other phases except planning. Finally, the respondents rated consultant effectiveness in the shakedown phase significantly lower than in all phases except reengineering, testing, and operations, which is rated lower than shakedown.

These results suggest that ERP consultants must work on becoming more effective in the phases that are rated significantly lower than others. Clients might feel that resources are wasted when a consultant is not perceived to be effective in the tasks performed in any given phase of the ERP implementation. Reengineering is particularly important in ERP implementations, and consultants were rated significantly lower than in the design phase and in the configuration and integration subphase.

Hypothesis 2 states that relative differences exist in the ratings regarding consultant necessity in the phases and subphase of the implementation model. The results of a repeated measures ANOVA show that significant differences exist in the

perceptions of the necessity for consultants across the implementation model (F=43.782, p<.001). Therefore, Hypothesis 2 is also supported.

Table 4. Differences in Mean Ratings for Effectiveness in ERP Implementation Phases and Subphases									
	Mean	Plan	Reeng	Design	Config	Test	Install	Shake	Oper	Overall
Mean		4.83	4.46	4.88	5.21	4.67	4.82	4.41	3.95	4.83
Plan	4.83	---								
Reeng	4.46	0.37	---							
Design	4.88	-0.05	-.42*	---						
Config	5.21	-0.38	-.75***	-.33**	---					
Test	4.67	0.16	-0.21	0.21	.54***	---				
Install	4.82	0.01	-0.36	0.06	.39*	-0.15	---			
Shake	4.41	.42**	0.05	.47**	.80***	0.26	.41***	---		
Oper	3.95	.88***	.51**	.93***	1.26***	.72***	.87***	.46***	---	
Overall	4.83	---	-0.37	0.05	.38***	-0.16	0.01	-.42***	-.88***	---

* Significant at p<.05
** Significant at p<.01
*** Significant at p<.001
Note: Differences are calculated as the mean rating for the phase on the top of the chart minus the mean rating for the phase on the left side of the chart. A positive difference indicates that the mean for the phase on the top is higher than the mean for the phase on the left side. A negative difference indicates that the mean for the phase on the top is lower than the mean for the phase on the left side.

Table 5. Differences in Mean Ratings for Necessity in ERP Implementation Phases and Subphases									
	Mean	Plan	Reeng	Design	Config	Test	Install	Shake	Oper	Overall
Mean		5.23	4.74	5.35	5.52	4.66	4.87	4.44	3.6	5.2
Plan	5.23	---								
Reeng	4.74	.49**	---							
Design	5.35	-0.12	-.61***	---						
Config	5.52	-0.29	-.77***	-0.17	---					
Test	4.66	.57**	0.08	.69***	.86***	---				
Install	4.87	0.36	-0.13	.48**	.65***	-0.21	---			
Shake	4.44	.79***	0.3	.91***	1.08***	0.22	.43**	---		
Oper	3.6	1.63***	1.14***	1.75***	1.92***	1.06***	1.27***	.84***	---	
Overall	5.2	0.03	-.46**	0.15	.32**	-.54***	-0.33	-.76***	-1.60***	---

** Significant at p<.01
*** Significant at p<.001
Note: Differences are calculated as the mean in the phase on the top of the chart minus the mean in the phase on the left side of the chart. A positive difference indicates that the mean of the phase on the top is higher than the mean of the phase on the left side. A negative difference indicates that the mean of the phase on the top is lower than the mean of the phase on the left side.

Table 5 shows the results of a post hoc test using a Bonferroni adjustment to determine where the differences between phases exist. Consultant necessity in the configuration phase stands out as being more highly rated than in all other phases, and the ratings for the shakedown and operation phases are lower than in most other phases.

Perhaps consultants should "market" themselves more aggressively in the phases in which their necessity is rated significantly lower than others. Alternatively, ERP consultants may be, in reality, less necessary to the typical user in certain stages of the implementation. If so, a more effective strategy may be for consultants to concentrate their efforts in the stages of the implementation in which they are most effective. These results give consultants a starting point for focusing their resources on making ERP implementers feel a greater need for consultants' services throughout an implementation, particularly in phases in which consultants are perceived as necessary for ERP success.

Table 6 shows the mean ratings on consultant effectiveness and necessity by phase and the differences between the mean ratings on a phase-by-phase basis. To determine whether the differences were significant, paired t-tests were performed on the mean ratings by phase. If the respondents rated their consultants higher on effectiveness than on necessity, the consultants appear to be outperforming the expectations of their clients. Alternatively, if the respondents rated their consultants higher on necessity than on effectiveness, the consultants appear to be underperforming or not living up to expectations.

Table 6. Differences in Mean Ratings for Effectiveness and Necessity by Phase			
Phase or Subphase	Effectiveness	Necessity	Difference in Means
Planning phase	4.83	5.23	-.40**
Reengineering subphase	4.46	4.74	-0.28
Design subphase	4.88	5.35	-.47***
Configuration and integration subphase	5.21	5.52	-.31**
Testing subphase	4.67	4.66	0.01
Installation and conversion subphase	4.82	4.87	-0.05
Shakedown phase	4.41	4.44	-0.03
Operation phase	3.95	3.6	.35**
Overall	4.83	5.2	-.37***
** Significant at $p<.01$ ***Significant at $p<.001$ Note: Differences are calculated as mean on effectiveness minus mean on necessity. A positive difference indicates that the consultants were rated as being more effective than necessary; a negative difference indicates that consultants were rated as being more necessary than effective.			

Respondents rated consultants as more effective than necessary only in the operation phase (at p<.01), indicating that the consultants are outperforming their clients' expectations only in the operation phase. On the other hand, the respondents feel that their consultants do not meet expectations in the planning phase (at p<.01), in the design (at p<.001) and configuration and integration (at p<.01) subphases, or overall (at p<.001). Such results should be of concern to the consulting industry and may also be a factor in the high rate of unsuccessful ERP implementations that have occurred over the years. Consultants must improve their skills and abilities and apply these skills more effectively in these phases and subphases and in the overall implementation. If clients continue to perceive that consultants are ineffective in certain phases, they may see the consultants as unnecessary and look elsewhere for assistance in their ERP implementations.

Characteristics of Consultants

Table 7 shows the mean ratings for the individual characteristics and their contributions to the effectiveness of ERP consultants. Higher ratings for the characteristics indicate that the respondents feel that the characteristic makes a high contribution to the effectiveness of ERP consultants.

Table 7. Means of Respondents' Ratings on Characteristics of ERP Consultants			
Characteristic	Mean (n=177)	Standard Deviation	Rank
Technical skills and knowledge	5.59	1.403	1
Human interaction and communication skills	4.81	1.345	6
Business context skills	4.77	1.503	7
Consulting skills and knowledge	5.06	1.335	3
Objectivity	4.84	1.449	5
Experience with ERP implementations	5.49	1.434	2
Commitment to quality	4.87	1.529	4
Ability to manage ERP implementations	4.73	1.554	8
Note: Ratings were on a scale of 1 to 7 with 1 being low contribution to effectiveness and 7 being high contribution to effectiveness. Only the responses of the ERP implementers (n=177) are used in the analysis of the characteristics because so few responses were received from non-ERP implementers. No significant differences were observed between the two groups.			

Technical skills and knowledge received the highest mean rating with a mean of 5.59. Consultants' ability to manage ERP implementations received the lowest mean rating, with a mean rating of 4.73. Table 7 includes the mean ratings and the relative rankings of all characteristics included on the research instrument. All characteristics

have a mean rating above four (neutral rating), so all characteristics appear to contribute to the effectiveness of ERP consultants. This result is consistent with prior studies such as Yap et al. (1992), Thong et al. (1994), and Mische (2000). Respondents who indicated that their ERP implementations were successful consistently indicated that the characteristics, except business context skills and objectivity, contributed significantly more to consultant effectiveness (at p<.05) than respondents who indicated that their ERP implementations were not successful. These results are not unexpected given that these respondents' implementations were successful and they were likely happy with their consultants and their skills.

Hypothesis 3 states that characteristics possessed by ERP consultants contribute to the effectiveness of the consultants to varying degrees. To examine this hypothesis, two regression models are estimated using two different dependent variables. For these models, the characteristics of ERP consultants (independent variables) are used to determine whether ERP consultants are effective (dependent variables). Table 8 shows the eight independent variables used in the regression analyses. Explanations of the characteristics are given in a previous section. The general regression equation can be written as:

$$RATING\ FOR\ PHASE = \beta_0 + \beta_1 TECHNICAL + \beta_2 COMM + \beta_3 BUSINESS + \beta_4 CONSULT + \beta_5 OBJECT + \beta_6 CONSULTERPEXPER + \beta_7 QUALITY + \beta_8 MANAGE.$$

Table 8. Explanation of Variables for Regression Equations	
Variable	Explanation
TECHNICAL	Technical knowledge of the ERP consultant
COMM	Human interaction and communication skills of the ERP consultant
BUSINESS	Business context skills of the ERP consultant
CONSULT	Consulting skills and abilities of the ERP consultant
OBJECT	Objectivity of the ERP consultant
CONSULTERPEXPER	ERP consultant's experience with IS and ERP implementations
QUALITY	ERP consultant's commitment to quality
MANAGE	Management skills of the ERP consultant

The prediction for the regression coefficients is that all variables have a positive effect on ERP consultant effectiveness because previous studies have shown that these characteristics contribute to the effectiveness of IS consultants.

The research instrument instructed the respondents to consider the phase in which they felt their consultants were the most effective. Therefore, for the first regression

model, the dependent variable includes the ratings given by of each respondent for the phase in which their consultant was rated as most effective. In other words, if a respondent indicated that the consultant was most effective in the planning phase, that respondent's rating of effectiveness in the planning phase was used as the dependent variable for that observation. If a respondent rated the consultant as most effective in the reengineering subphase, that respondent's rating on effectiveness in the reengineering subphase was used as the dependent variable. This method was used for all respondents' ratings.

Table 9 shows the results of the regression equation for the characteristics of ERP consultants and their contributions to ERP consultant effectiveness. The regression equation is significant at $p<.001$, and the adjusted R^2 is .192. The TECHNICAL, BUSINESS, and OBJECT variables are all significant at $p<.10$. These results indicate that technical skills and knowledge, business context skills and objectivity are all moderately related to the effectiveness of ERP consultants. All of the regression coefficients are in the predicted direction, except for the coefficient for the BUSINESS variable. The negative coefficient on the BUSINESS variable indicates that a consultant's ability to gain knowledge about and understand the detailed operations of the client organization is inversely related to effectiveness in the planning phase, although only moderately ($p=.070$). Such a result could indicate that as a consultant learns more about a business, he or she becomes too comfortable and fails to listen to the needs of the client. This result could also mean that consultants attempt to apply "cookie-cutter" solutions to their clients' businesses or giving what they think the client needs rather than what is really needed.

Table 9. Regression Results for Contributions of Characteristics to Effectiveness of ERP Consultants by Phase in which Consultants are Rated Most Effective			
Variable	Predicted Sign	Coefficient Estimate	p-value
Intercept	?	2.921	0
TECHNICAL	+	0.157	0.075
COMM	+	0.111	0.245
BUSINESS	+	-0.153	0.07
CONSULT	+	0.003	0.976
OBJECT	+	0.156	0.054
CONSULTEXPER	+	0.044	0.669
QUALITY	+	0.109	0.244
MANAGE	+	0.083	0.385
Adjusted R^2 = .192 F=6.081, p<.001			

Very few respondents indicated that their consultants were most effective in several phases. In particular, 10 or fewer respondents indicated that their consultants were most effective in the reengineering, testing, and installation and conversion subphases and the shakedown and operation phases. Only the configuration and integration subphase received a sizeable number of responses. The results in Table 9 should be interpreted with this in mind.

A second regression model with a different dependent variable was used to analyze the characteristics of ERP consultants and their contributions to the overall effectiveness of ERP consultants. While the respondents were asked to think about the phase in which their consultants were most effective when rating the characteristics, an analysis of the relationship of the characteristics and the overall effectiveness of the consultants is a reasonable progression of the examination of consultant effectiveness. The dependent variable is the average of each respondent's ratings in all phases and subphases of the ERP implementation model. While the respondents indicated a rating on their consultants' effectiveness overall, the average of their ratings for effectiveness in the individual phases is still a reliable measure of overall effectiveness of consultants. The averages of the respondents' ratings for all phases are highly correlated (r=.855) to the respondents' ratings for the consultants overall. Such a high correlation indicates that the respondents were consistent in their ratings by phase and overall.

Table 10 shows the results of the regression on the overall rating of ERP consultant effectiveness using the average of each respondent's ratings in all phases. This regression equation is significant at p<.001, and the adjusted R^2 for the equation is .394. The TECHNICAL, QUALITY, and MANAGE variables are significant at p<.05, and the coefficients of these variables are in the predicted directions, so the respondents feel that these characteristics contribute to effectiveness of consultants overall. The fact that only three variables are significant is somewhat unexpected because all characteristics in this study have previously been shown to contribute to the effectiveness of IT consultants. Perhaps the respondents in this study place more emphasis on other characteristics or assume that consultants possess some of these characteristics by default. Two variables, BUSINESS and CONSULTEXPER, although not significant, were not in the predicted direction, while all others are in the predicted direction.

The respondents were given room on the research instrument to indicate any other characteristics that they felt might contribute to ERP consultants' effectiveness. Examples of additional potential characteristics that may contribute to consultant effectiveness are product knowledge, experience in the client's specific industry, the ability to transfer knowledge to the client's personnel, and honesty.

Table 10. Regression Results for Contributions of Characteristics to Overall Effectiveness of ERP Consultants			
Variable	Predicted Sign	Coefficient Estimate	p-value
Intercept	?	1.784	0
TECHNICAL	+	0.173	0.009
COMM	+	0.025	0.721
BUSINESS	+	-0.071	0.258
CONSULT	+	0.062	0.413
OBJECT	+	0.033	0.577
CONSULTEXPER	+	-0.067	0.385
QUALITY	+	0.149	0.031
MANAGE	+	0.276	0
Adjusted R^2 = .394 F=15.289, p<.001			

CONTRIBUTIONS, LIMITATIONS, AND CONCLUSION

One purpose of this study is to determine whether a consultant is perceived as being more effective and more necessary in certain phases of ERP implementations. Respondents reported that their consultants were both most effective and most necessary in the configuration and integration subphase, while their consultants were least effective in the operation phase, thus showing that the perception that consultants are better in certain phases does exist. Results also show that consultants are consistently rated higher on their necessity than on their effectiveness in the phases of the ERP implementation model. Only in the operation phase did the respondents indicate that their consultants were more effective than necessary. These results indicate that consultants are not performing up to the expectations of their clients.

Another purpose of this study is to determine whether certain characteristics of ERP consultants contribute to the effectiveness of ERP consultants. The results of regression analysis of the characteristics of consultants are not conclusive. In a model using the respondents' ratings for the phase or subphase in which the respondent indicated that their consultants were most effective, the regression equation was significant, but none of the variables were significant, indicating that none of the characteristics contribute to consultant effectiveness. The second regression analysis examined the overall effectiveness of ERP consultants. In this analysis, the regression equation is significant, and the model includes three significant variables – TECHNICAL, QUALITY, and MANAGE. This result shows that the respondents feel that technical skills and knowledge, a commitment to producing quality work, and ability to manage the ERP implementation all contribute to the effectiveness of ERP consultants overall.

This study uses a research instrument to captures respondents' perceptions on consultant effectiveness and necessity. The limitations applicable to using a research instrument apply. Examples of these limitations are self-selection bias, honesty of respondents, and a limit on the ability to expand on answers, among others.

Another limitation of this study is the low response rate. While the response rate is low, enough responses were collected to enable meaningful and sound analyses, and the sample is diverse. Another limitation is the fact that most respondents were SAP users, which may have introduced bias into the results. Also, some consultants may have completed the research instrument, which would likely bias the results in favor of consultants.

Additionally, the sample of subjects is not completely random since ERP user group websites were examined to find names of ERP users. However, the subjects from the two magazines were chosen at random based on their positions within their organizations. There may also have been some overlap between the two groups of subjects. That is, some of the ERP users group subjects may also have been subjects selected by *CIO* or *Enterprise Systems Journal*; however, there is no way of knowing this for sure.

Finally, the intercepts in the two regression equations are significant. Such a result generally indicates that independent variables not included in the analysis contribute to the dependent variable. Because of the nature of behavioral research and the methods used in this type of research, it is not uncommon to have potentially significant independent variables that are not included. This result could have some impact on the predictive ability and generalizability of the regression equations. Also, very few independent variables (characteristics of consultants) are significant. In this study, the independent variables are taken from prior studies and are not exhaustive.

In spite of these limitations, the results of this research should provide many benefits to the companies who have implemented them. The knowledge of the phases in which ERP consultants are most effective and necessary and which characteristics contribute to consultants' effectiveness should provide an advantage to many organizations that decide to implement ERP systems.

The results of the study provide organizations that plan to implement ERP systems with knowledge of the phases of ERP implementations in which consultants are perceived to be most effective and necessary. By using the consultants only when necessary or only in certain phases in which the consultants are the most effective, organizations can utilize internal personnel and resources and reduce their expenditures for the consultants. The results of this study provide the knowledge to assist organizations in achieving cost savings regarding consultants.

Consultants themselves can also benefit from this research because they can see which areas they should stress more in their practices and which areas they should

improve to give their clients more value. Any consulting firms that are interested in entering the ERP consulting area can see the areas on which to concentrate from the beginning. Of course, the resources and abilities that the vendors and consulting firms possess may limit their choices in strategy, but this research gives them insight on how their potential clients feel about the use of consultants for their ERP implementations.

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KNOWLEDGE MANAGEMENT CAPABILITIES CONSENSUS: EVIDENCE FROM A DELPHI STUDY

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ABSTRACT

This paper aims to present the results of a Delphi study conducted from November 2006 to March 2007. The objective of the study was to find a consensus among experts developing key concepts on knowledge management (KM) capabilities. In fact, during the last two decades, KM literature has focused on getting organizational performance via the alignment of knowledge management strategies to business strategies. However, since the last 15 years, researchers started to point out that the alignment alone is no longer sufficient to explain organizational performance; we must add new elements such as the development of specific organizational capabilities. In short, we must go beyond the importance accorded today to the literature related to the development of organizational KM capabilities. But what organizational capabilities must be developed? In this paper, we use the Delphi method to present a consensus on KM capabilities to develop for a good KM practice.

INTRODUCTION

The Delphi method, more and more known by mid- to long-term strategy development specialists, aims to collect via an open survey the justified opinions from a panel of experts in different spheres of activities. The procedure based on retroaction avoids confrontations between experts and preserves their anonymity. The results of a first questionnaire are communicated to each expert (including a summary of the general tendencies and particularities, opinions and justifications, etc.) that is then invited to react and answer to a second questionnaire developed in function of the first opinions collected, and so on until the strongest possible convergence of answers be obtained. The Delphi method distinguishes itself from usual group communication techniques on the following axes: (1) it helps to get experts opinions in a sector; (2) it allows to collect information at a distance, via the Web, fax, or mail, while the respondents have not to meet; (3) it facilitates the task of identifying and selecting experts since the number of

experts participating in the study is limited to 7 to 18 (Paliwoda, 1983; quoted in Okoli & Pawlowski, 2004, p. 4); (4) it is flexible in its conception and its survey administration: this allows rich data collection leading to an appropriate understanding and a consensus on knowledge management (KM) capabilities; (5) it allows quasi-certainly to get a consensus via the issuance of consecutive questionnaires; (6) it allows a controlled feedback consisting of a series of steps from which a summary of the previous step is provided to the participants; so, if they want, they can review their previous judgements; (7) it has an advantage over other methods of group decision making given the analysis of anonymous experts opinions which are identified before the study (for example the nominal group and the analysis by social judgement) (Rohrbaugh, 1979; quoted in Okoli & Pawlowski, 2004, p. 4); and (8) it can be used as successfully in management, economic, or technological sectors as it can in social sciences.

On the other hand, several constraints are limiting the use of the Delphi method: it is lengthy, costly, fastidious and intuitive rather than rational, among others. In addition, the procedure constraints (multiple rounds of surveying) are questionable since only the experts that stray from this norm have to justify their position. However, we can also consider that strayed opinions, in prospective terms, are more interesting than those close to the norm. Finally, the interactions between the different hypotheses proposed are not taken into account and they are even avoided, leading the promoters of the Delphi method to develop probabilistic cross impact methods. Furthermore, it is obvious that a Delphi study does not base itself on a statistically representative sample of a population. It is rather a mechanism for group decision making that requires the participation of qualified experts having a clear understanding of the phenomenon being studied. It is for this reason that one of the most critical factors of this approach is to find qualified experts.

The objective of the present research is not to conduct a study aiming the improvement of the Delphi method or to perform a comparative study between the Delphi method and the other methods or techniques of group communication, but rather to try to understand the phenomenon of KM capabilities by identifying the key concepts and the characteristics of each concept in order to reach a consensus from experts. Thus, the use of the Delphi investigation shed the light on the ideas of KM experts and helped to find a consensus from experts on the theoretical concepts of the KM capabilities.

The paper is structured as follows: first, a brief history and some applications of the Delphi method in management, information systems (IS)/information technologies (IT), and KM are presented; second, the steps of the Delphi investigation related to this study are described; and the paper ends by providing some examples of general comments from the experts participating in the study and their profile.

DELPHI METHOD HISTORY AND APPLICATIONS

Developed in 1950 by Olaf Helmer at Rand Corporation (Okoli & Pawlowski, 2004), the purpose of the Delphi method is to highlight the convergence of opinions and to reach a consensus on a subject, often with an important prospective, from the consultation of experts and the use of questionnaires (Dalkey & Helmer, 1963). Experts are defined here as people who are consulted during the process of the Delphi inquiry. The selection of these experts must take into account: (1) their knowledge on the subject; (2) their legitimacy compared to the panel of experts they could represent; (3) their availability during the process of the Delphi inquiry; and (4) their independence toward commercial, political, or different pressures. To summarize, the main steps of the Delphi method are depicted in Figure 1. We can see in Figure 1 that this method is articulated around two important phases: the steps related to the experts' selection procedure and the steps related to the process of administering the questionnaire.

Figure 1
Main Steps of the Delphi Method

Experts' selection process

Step 1: Elaboration of the experts' selection criteria

Step 2: Elaboration of a list of potential experts

Step 3: Contact the listed experts

Step 4: Invitation of the experts to participate in the study

Questionnaire administration process

Step 5: Administering the questions

Step 6: Consolidating the answers

Step 7: Classification of the answers
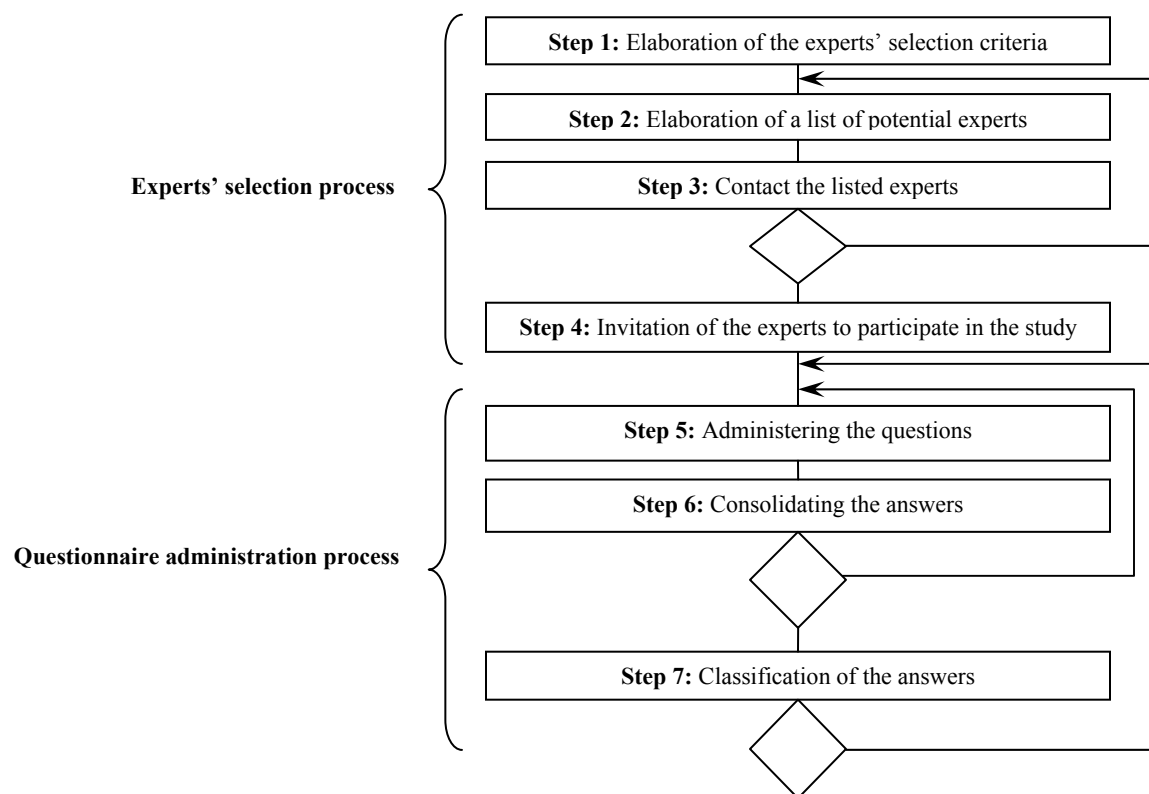
The experts' selection procedure includes four steps: step 1: development of the experts' selection criteria; step 2: development of a list of potential experts and attribution of a number to ensure the experts' anonymity during the questionnaire administration; step 3: contact with the selected experts; and step 4: invitation of the experts by email or fax to take part in the study.   As for the process of administering the questionnaire to the selected experts, it is performed in three steps: step 5: administration of the questions: at this time each expert receives a series of questions on the subject of the study; step 6: consolidation of the answers for the elaboration of the report for each round until a consensus is obtained: here the questionnaire is administered, then we analyze the answers and administer them once again while asking, if possible, to the experts to reexamine their original answers (opinions) or to answer some specific questions according to the feedback obtained from the other respondents taking part in the study; step 7: the classification of sub subjects (if necessary): it helps to produce the final report of the Delphi investigation and to validate it with the participating experts.

During the two processes, the respondents remain mutually anonymous, except for the researcher, to neutralize the mutual influences. With respect to its usage, the Delphi method is more and more used today by several researchers as listed in Table 1 which presents the various applications of the Delphi method in the design of models (Okoli & Pawlowski, 2004) within the fields of IS, IT, and KM, specifically in the development of organizational capabilities in IT as well as in IT project management.

Table 1: Application of the Delphi Method in the Design of Models (adapted from Okoli & Pawlowski, 2004, p. 3)	
Authors	**Studies**
Bacon & Fitzgerald (2001)	*Goal*: To develop a conceptual framework of the main fields of the information systems. *Participants*: Researchers within the field of information systems.
Holsapple & Joshi (2002)	*Goal*: To develop a descriptive conceptual framework of the elementary activities of handling knowledge. *Participants*: Researchers and experts within the field of knowledge management.
Mulligan (2002)	*Goal*: To develop a typology of the capacities of information technologies in the industry of finance departments. *Participants*: Members from 11 different organizations.
Nambisan et al. (1999)	*Goal*: To develop a conceptual taxonomy of the mechanisms of action of organizational design to increase the propensity of the technology users in order to innovate in information technologies. *Participants*: Senior officers of various industries.
Schmidt et al. (2001)	*Goal*: To develop an ordered list of common risk factors for software projects as a basis for the construction of theories in information systems projects. *Participants*: Three groups of experienced software project managers in Hong Kong, Finland, and United States.
Scholl et al. (2004)	*Goal:* To give more structure to the field of knowledge management and to obtain the prospects on the valid developments during the ten years to come.

DELPHI INVESTIGATION

The Delphi investigation of the present study respected the seven steps evocated in the previous section. Thus, after having prepared the questionnaire, we selected a panel of experts (the respondents) on the basis of the suitable criteria. Then the questionnaire was administered. After this, we analyzed the responses and administered them once again while asking to experts to reexamine, if possible, their original responses (opinions) or to answer some specific questions according to the feedback of the other respondents participating in the study. This process was performed until the respondents reached a satisfactory degree of consensus. During all the process, the respondents remained anonymous to each other, except for the researcher, in order to limit the influence of the ones on the others.

Indeed, a Delphi inquiry of three rounds was necessary. On the first round, the links that presumably exist between the concept of KM capabilities and each of its three key dimensions (KM-infrastructures, KM-processes, and KM-competences) were presented to the experts. On the second round, on the basis of the answers of the first round, a report of the first round Delphi questionnaire was provided to the participating experts. Thus, on the basis of this report, it was asked to the experts to draw a conclusion about the questions, conclusion specifically focused on the points of consensus and divergence of opinions. Finally, on the third round, the report of the second round is produced and proposed to the experts in order that these ones draw a conclusion on the points of consensus and persistent divergences. In fact, the steps followed by this research are: (1) definition of the selection criteria for participating experts; (2) development of a list of experts; (3) contact with the listed experts and summary of procedures; (4) invitation of the experts to take part in the study; (5) questionnaire administration; (6) complete examination and consolidation of the answers according to the various perceptions and the presentation of results; and (7) development of a synthesis and classification of the key concepts characteristics. Then, there are two important parts: steps related to the procedure of expert selection and steps related to the process of questionnaire administration.

Step 1: Development of the Experts' Selection Criteria

In this step, people retained were those who were published in journals or those whose articles were accepted in International Conferences having an evaluation of peers within the field of KM related to KM capabilities or to the maturity models. The following conferences and journals were retained given their popularity and the number of experts academicians which contribute to them both by their articles and by the topics

examined: *Information Resources Management Association* (IRMA): international association of informational resource management based in the United States and holding annual conferences with more than 250 scientists coming from all around the world and discussing topics of informational resource management (including KM); *International Conference on Knowledge Management* (ICKM): annual international conference specialized on KM with more than 100 scientists coming from all the continents and discussing various aspects of KM (including strategic aspects); *European Conference on Knowledge Management* (ECKM): annual international conference on KM based in England grouping together more than 250 scientists coming from Europe and other continents, and discussing various topics on KM; *Journal of Knowledge Management* (JKM): scientific journal on KM based in England (a leading journal); *International Journal of Knowledge Management* (IJKM): scientific journal on KM published by *IGI Global* (a leading journal).

Step 2: Development of a List of Experts

The present study was based on conferences proceedings or journals articles to develop a list of expert authors or scientific joint authors of articles answering the following criteria: (1) to have been author or co-author of a scientific article within the field of KM with an orientation on strategic planning; (2) to have been author or co-author of a scientific article within the field of KM with an orientation on the strategic aspects of KM; (3) to have been author or co-author of a scientific article within the field of KM with an orientation on the development or the application of maturity models; (4) to have been author or co-author of a scientific article within the field of organizational capabilities or KM capabilities. The reason for which the present study retained only scientists as participants in the Delphi investigation is that KM concepts and organizational capability are not yet well defined and understood by everyone, and that the participation of the practitioners would come only add some confusion. Moreover, the results of the Delphi investigation show how much the experts opinions are divergent when the time comes to the understanding of concepts commonly used. Thus, following the consultation of IRMA 2005, ICKM 2005, and ECKM 2003 conferences proceedings, as well as the papers published in JKM and IJKM from 2005 to 2006, a list of 256 experts has been developed in a *Microsoft Word* document containing the following information for each expert: number assigned to the expert, email, function (title) of the expert, university, department or organization of association, phone number, fax number, country, and, if possible, postal address. It is to be noted that in order to guarantee anonymity, each expert was allowed a unique confidential number known only by the researcher.

Step 3: Contact with Listed Experts and Summary of Procedures

During this step, we contacted by email the experts listed at step 4 and, as recommended by the Delphi method, we asked each one to refer us to other experts answering the study criteria. If the number of experts agreeing to take part in the study was lower than 10, then step 3 would be performed again, that is, we forwarded reminder letters to the experts who had not yet answered our request. As soon as the list had reached more than 20 acceptances, we were going at step 4. Thus, on a total of 256 potential experts solicited, 22 experts regrouped in 13 countries (England, Australia, Brazil, Canada, United States, Spain, Estonia, Finland, Hungary, India, Portugal, Switzerland, and Thailand) agreed to take part in the Delphi investigation, which largely exceeds the minimum of 7 participants and the maximum of 18 suggested by the Delphi method. We provided the expert respondents with pseudonyms in order to keep their anonymity. In addition, the names of the departments, faculties, and universities are kept in the source languages in order to identify them according to the country to which they belong.

Step 4: Invitation of the Experts to Take Part in the Study

We invited each expert to take part in the study by explaining to him/her its objectives, the procedures to be followed, and the tasks related to his/her participation to guarantee the success of the study. We asked each participant to use the email or fax for the reception or the sending of the questionnaires and answers. All the participants chose the email for all their correspondences.

QUESTIONNAIRE ADMINISTRATION

During this step, each expert received a series of questions related to the points mentioned at step 4. These questions consisted of asking the expert to give his/her point of view about: (1) the links existing between the concepts of the KM capabilities (KMC) and its three dimensions; (2) the links existing between each dimension of the KMC and the characteristics describing each dimension; (3) the other more representative KMC concepts; (4) the addition, modification, or suppression of dimensions or characteristics. Thus, three rounds of the Delphi investigation were finally necessary to reach a consensus regarding the KMC concepts and characteristics.

First Round: Sending the Questionnaire and Consolidation of the Answers from Experts

As mentioned in the previous section, the first round of the questionnaire, which was held from November 16 to December 14, 2006, consisted of defining the key KMC concepts, the key characteristics of each dimension of the KMC as suggested by Abou-Zeid (2003) and Chang and Ahn (2005). Thus, in the first round, we presented to the experts the links that are supposed to exist between the KMC concept and each of its three dimensions, that is, KM-infrastructures, KM-processes, and KM-competences. For each dimension, some links between the characteristics and each dimension of the KMC were submitted to their opinions. Then, three additional questions were added: a first question about the KM-infrastructures characteristics; a second question about the KM-processes characteristics; and a third question about the KM-competences characteristics. For each of these four questions, each expert was asked to answer by yes or no if he/she was in accordance to provide his/her point of view. In addition to the questionnaire, a cover letter for the first round of the Delphi investigation was sent by email.

It is to be noted here that instead of one week, as it was determined at the beginning, the first round of the Delphi investigation took 4 weeks because the majority of the experts had not answered in time and it was necessary to grasp a sufficient number in order to ensure the success of the investigation. Thus, in order to better determine the results of the first round of the Delphi investigation, a detailed report was written and became a starting point for the structure of the initial questionnaire aiming to facilitate the experts' understanding during the second round. The results of the first round emphasized the experts' differences in opinion on their understanding of the KMC concept. Four fundamental questions were presented to the experts in order to get their point of view.

Question 1 of the Delphi investigation first round questionnaire on the KMC: "The present study defines the concept of the KM capabilities as being a whole of capabilities related to KM-infrastructures, KM-processes, and KM-competences. Do you think that these three constructs define effectively the concept of KM capabilities?" The answers from the panel of experts during this first round already revealed a consensus on some dimensions defining the KMC concept, as shown in Figure 2, in spite of some reserves showed by certain experts in their comments: there was a divergence of opinions regarding some dimensions defining the KMC concept.

As shown in Figure 2 and Table 2, there is a consensus on the dimensions of KM-Infrastructures (93.75%) and KM-Processes (81.25%) as strongly defining the concept of KM capabilities. On the other hand, there is no consensus on the dimension KM-Competences. Indeed, as seen in Table 2, the consensus is moderated regarding the first round of the Delphi inquiry for the three constructs (KM-Infrastructures, KM-Processes, and KM-Competences) as a construct or dimensions defining the concept of KM

capabilities. However, the experts' opinions show that the absence of consensus on this dimension is not due to its contents, but it is due to its application. Because, according to the experts, the dimension "Competences" in KM applies sometimes to the organization and other times to the individual. On the basis of the experts' opinions, we have formulated the following proposition: It can be better to use "Management of actors" instead of "Competences" in KM. In fact, as some experts wish, these capabilities could include some of the following sub-dimensions or characteristics: the culture, the KM-Structures (or function), the KM-Rewards, the individuals' motivation, the orientation of the KM policy, the KM-Responsibilities, the vision of KM-Competences development, the KM actors, etc. Question 4 of the questionnaire is related to the dimension "KM-Competences".

Figure 2
Consensus Observed on Some Dimensions of the KMC Concept
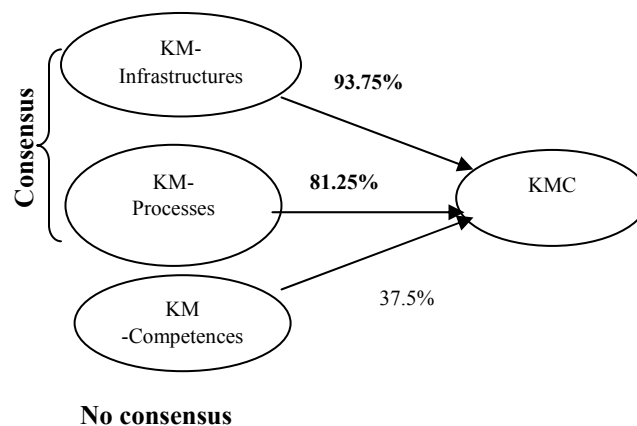
Question 2 of the Delphi investigation first round questionnaire on the KM-Infrastructures: "The 'KM-Infrastructures' refer to: (1) the technological infrastructures of KM; (2) the structures specific to the KM; (3) the organizational culture of knowledge as a strategic resource. Do you think that these three characteristics define the constructs of organizational capabilities related to the KM-Infrastructures?" The answers from the panel of experts regarding the characteristics of the dimension "KM-Infrastructures" revealed a consensus, as in the first round, focusing on some characteristics defining the dimension (see Figure 3), in spite of the reservations of certain experts. Indeed, some characteristics showed a divergence of opinions on the questions involving them as defining the KM-Infrastructures (see Figure 3 and Table 3).

Table 2
Summary of the Results from the First Question of the Delphi Investigation First Round

Constructs/Dimensions	Very in agreement (%)	Rather in agreement (%)	Rather in dissension (%)	In total dissension (%)	TOTAL (number of respondents)
The three constructs (KM-Infrastructures, KM-Processes, and KM-Competences) define the KMC concept	7 (43.75%)	6 (37.5%)	0 (0%)	3 (18.75%)	16
KM-Infrastructures	15 (93.75%)	0 (0%)	0 (0%)	1 (6.25%)	16
KM-Processes	13 (81.25%)	1 (6.25%)	0 (0%)	2 (12.5%)	16
KM-Competences	6 (37.5%)	0 (0%)	4 (25%)	6 (37.5%)	16

With regard to the consensus on certain characteristics, we noted that, in general, the consensus is very strong concerning the "Technological infrastructures" of KM (100%) and it is moderate for the "Structures" specific to KM (62.5%) as a characteristic defining the dimension of KM-Infrastructures. However, we also noted the absence of consensus on the characteristics defining the "Culture" of KM (56.25%) which would be explained, according to the experts, by the fact that the characteristic of "KM culture" has rather its place in the dimension of "KM-Competences".

Table 3
Summary of the Results from the Second Question of the Delphi Investigation First Round

Characteristics	Very in agreement (%)	Rather in agreement (%)	Rather in dissension (%)	In total dissension (%)	TOTAL (number of respondents)
The three following characteristics define the dimension of KM-Infrastructures: KM technological infrastructures, KM structures, and KM culture	6 (37.5%)	9 (56.25%)	1 (6.25%)	0 (0%)	16
KM Technological infrastructures	16 (100%)	0 (0%)	0 (0%)	0 (0%)	16
KM Structures	9 (56.25%)	1 (6.25%)	1 (6.25%)	5 (31.25%)	16
KM Culture	6 (37.5%)	1 (6.25%)	2 (12.5%)	7 (43.75%)	16

Figure 3
Consensus Observed on Some Characteristics of the KM-Infrastructures
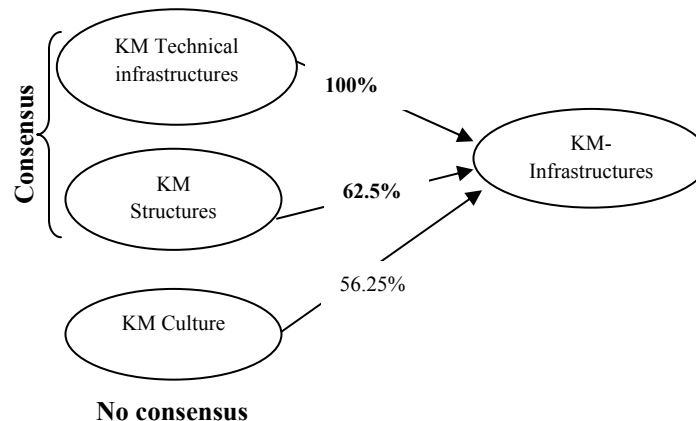
Taking into account the experts' interrogations and opinions, we formulated the following proposition: "KM-Infrastructures", as a dimension of KM capabilities, includes two important characteristics, that is, "KM Technological Infrastructures" and "KM Structures", while the characteristic "KM Culture" is transferred to the dimension "KM-Competences".

Questions 3 of the Delphi investigation first round questionnaire related to KM-Processes: "The organizational capabilities related to KM-Processes refer to: (1) the process of knowledge generation; (2) the process of knowledge manipulation; (3) the process of knowledge application. Do you think that these three characteristics define the constructs of organizational capabilities related to KM processes?" The answers from the panel of experts concerning the three characteristics defining the "KM-Processes" revealed a consensus as in the first round (see Table 4 and Figure 4).

Regarding the consensus on some characteristics at the conclusion of the first round of the Delphi investigation results, we noted that, in general, the consensus is moderate on the three characteristics: "Process of knowledge generation" (75%), "Process of knowledge manipulation" (62.5%) and "Process of knowledge application" (62.5%) concerning the characteristics defining the KM-Processes dimension.

Question 4 of the Delphi investigation first round questionnaire related to KM-Competences: "The organizational capabilities related to KM-Competences refer to: (1) the facilitation of the KM-Processes; (2) the skills to motivate and manage human resources; (3) the skills to use and manage KM technologies. Do you think that these three characteristics define the constructs of organizational capabilities related to KM-Competences?" The answers from the panel of experts during the first round of the Delphi investigation regarding the characteristics of the dimension "KM-Competences"

revealed that there is a very moderate consensus on the three characteristics defining this dimension (see Figure 5 and Table 5).

| Table 4 Summary of the Results from the Third Question of the Delphi Investigation First Round					
Characteristics	**Very in agreement (%)**	**Rather in agreement (%)**	**Rather in dissension (%)**	**In total dissension (%)**	**TOTAL (number of respondents)**
The three following characteristics define the dimension of KM-Processes: processes of knowledge generation, processes of knowledge manipulation, and processes of knowledge application	7 (43.75%)	2 (12.5%)	1 (6.25%)	6 (37.5%)	16
Process of knowledge generation	12 (75%)	0 (0%)	2 (12.5%)	2 (12.5%)	16
Process of knowledge manipulation	9 (56.25%)	1 (6.25%)	5 (31.25%)	1 (6.25%)	16
Process of knowledge application	9 (56.25%)	1 (6.25%)	5 (31.25%)	1 (6.25%)	16

Figure 4
Consensus Observed on the Three Characteristics of the KM-Processes
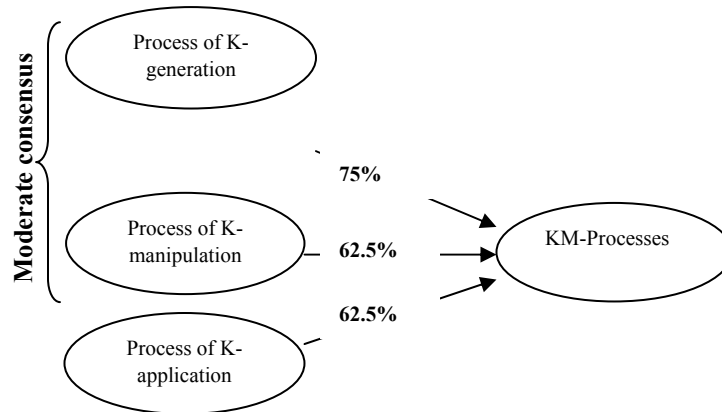
Figure 5
Consensus Observed on the Three Characteristics of the KM-Competences
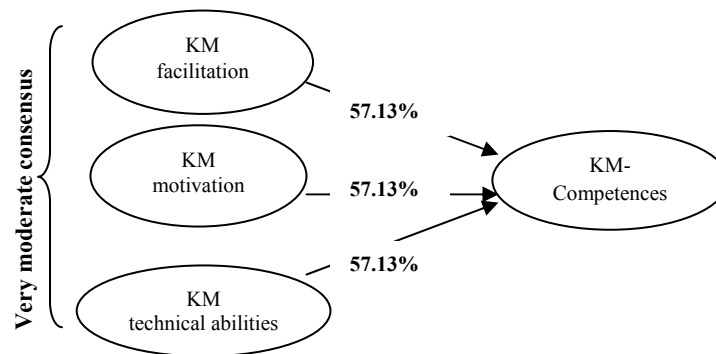
Indeed, the consensus is very moderate for the three characteristics of the dimension KM-Competences: "KM facilitation", "KM motivation", and "KM technical abilities" (each characteristic got 57.13%).

In summary, the points of view obtained from the experts in the first round of the Delphi investigation provided the following results: (1) there is a consensus on three dimensions of the organizational capabilities specific to the KM (OCSKM) defining the construct (dimension); (2) there is a divergence of opinions on the application or the use of the dimension "Competences" which has been replaced by "People or actors" of KM; (3) there is a solid consensus on the characteristics "Technological infrastructures" and "Structures" of KM defining the construct (dimension) of "Infrastructures" of KM; (4) there is no consensus on the characteristic "Culture" of KM defining the construct (dimension) of "Infrastructures" of KM which has been transferred to the dimension (construct) "Competences" in KM according to the opinions from the majority of the experts; (5) there is a moderate consensus concerning the characteristics of the "Processes of knowledge generation", "Processes of knowledge manipulation", and "Processes of knowledge application" defining the construct (dimension) of "Processes" of KM in spite of some comments formulated by some experts; (6) there is no consensus on the term "Competences" in KM as a construct defining the OCSKM concept. Consequently, there is no defining consensus on the characteristics of the construct (dimension) "Competences" in KM, beyond the need for initially arrive at a consensus on the characteristics of the construct (dimension) and on the terms suitable to use for defining the third dimension (construct) of the OCSKM.

Table 5					
Summary of the Results from the Fourth Question of the Delphi Investigation First Round					
Characteristics	**Very in agreement (%)**	**Rather in agreement (%)**	**Rather in dissension (%)**	**In total dissension (%)**	**TOTAL (number of respondents)**
The three following characteristics define the dimension of KM-Competences: KM facilitation, KM motivation, and KM technical abilities	5 (35.71%)	3 (21.42%)	0 (0%)	6 (42.85%)	14
Facilitations with knowledge management	5 (35.71%)	3 (21.42%)	0 (0%)	6 (42.85%)	14
Motivation to the management of knowledge	5 (35.71%)	3 (21.42%)	0 (0%)	6 (42.85%)	14
Technical skills in knowledge management	5 (35.71%)	3 (21.42%)	0 (0%)	6 (42.85%)	14
N.B.: *Two participants were undecided on the fourth question of the first Delphi round.*					

Second Round: Examination, Classification, and Consolidation of the Key KMC Concepts

Having noted differences in opinion concerning the understanding of the experts on two of the three dimensions of the KMC concept during the first round of the Delphi investigation, a second round helped to advance the debate in order to reach a consensus on the KMC concepts and characteristics. Since the information gathered from a Delphi study is often rich and relevant, the negative comments collected from the experts are treated with much attention and are often more interesting than the positive feedback. Indeed, they allow identifying the main points of divergence and disagreement which are at the basis of a misunderstanding of the concepts and possible problems with their application. Following this assertion, we can obtain important advantages from a second round of the Delphi investigation: first, the phenomenon can occur because the discussion with similar subjects increases the certainty; second, some individuals can moderate their answers according to opposite points of view; third, the reciprocal argumentation influences some members and the others can reinforce existing orientations. With regard to the distribution of the questionnaire, we started from a list of sixteen experts from twelve countries (Finland, Portugal, Switzerland, Canada, United Kingdom (England), United States, Thailand, Spain, Estonia, Hungary, India, and Australia) who took part in the first round of the Delphi investigation in which we requested the collaboration of the experts academicians. A cover letter to the second round of the Delphi investigation was sent by email. It is to be noted that instead of taking one week, as anticipated at the beginning, the second round of the Delphi investigation took 4 weeks (from December 11, 2006 to January 15, 2007), the majority of experts having not answered on time and forcing us to wait in order to get a sufficient number of respondents to avoid

compromising the success of the investigation. In order to better determine the results of the second round of the Delphi investigation, a detailed report was written and served as a starting point of the initial questionnaire in order to facilitate the understanding of the experts during the third round of the Delphi investigation. In fact, the second round of the Delphi investigation aimed at seeking and increasing the consensus on some KMC concepts and characteristics. The results of the second round emphasized a general consensus on the definition and the understanding of the majority of the concepts with very few divergences. Indeed, five fundamental questions were proposed to the experts in order to get their opinions on the KMC concept according to the lack of consensus in the first round.

Question 1 of the Delphi investigation second round questionnaire related to the KMC: question 1 of the Delphi survey questionnaire was revised as follows for the second round: "After consideration of the experts' opinions in the first round of the Delphi investigation, the present study defines the KMC concept as being a set of capabilities connected to the following constructs (dimensions): KM-Infrastructures, KM-Processes, and KM-actors/people (Competences). Do you think that these three constructs are well defining the KMC concept?" The answers got from the panel of experts during the second round confirm the consensus gained during the first round (see Figure 6 and Table 6) on the dimensions of "KM-Infrastructures" and "KM-Processes" defining the KMC concept. However, the dimension "KM-actors/people (Competences)" continues to divide the experts' consensus.

Figure 6
Consensus Observed on Some Dimensions of the KMC
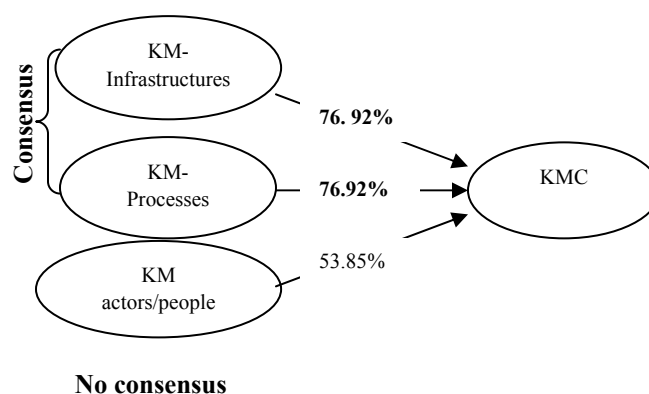
Indeed, the "KM-actors/people (Competences)" dimension, as defining the KM capabilities concept, continued to get the most divergences in the panel of experts, with 53.85% of disagreement. However, as in the first round, the lack of consensus on this

dimension, while taking into account the experts' opinions, is attributable to the concept application rather than its contents. Thus, the experts' opinions and comments resulted in considering the wording of this dimension as follows: "KM-Actors/people". It is what explains why the three dimensions taken together (as shown in Table 6) strongly define the KMC concept, while the participating experts' opinions form a consensus (76.92%).

Table 6 Summary of the Results from the First Question of the Delphi Investigation Second Round			
Constructs/Dimensions	**In agreement (%)**	**In dissension (%)**	**TOTAL (respondents)**
The three constructs (KM-Infrastructures, KM-Processes, and KM-Competences) define the KMC concept	10 (76.92%)	3 (23.08%)	13
KM-Infrastructures	10 (76.92%)	3 (23.08%)	13
KM-Processes	10 (76.92%)	3 (23.08%)	13
KM-Competences	6 (46.15%)	7 (53.85%)	13

Question 2 of the Delphi investigation second round questionnaire related to KM-Infrastructures: "The present study defines the concept of the KM capabilities as a set of capabilities related to two main characteristics (sub-dimensions): (1) KM technological infrastructures; (2) KM structures. Do you think that these two characteristics define the construct (dimension) of KM-Infrastructures?" The answers from the panel of experts during the second round of the Delphi investigation remained very favorable as they were during the first round. The characteristics "KM technological infrastructures" and "KM structures" revealed that there is a consensus on these ones defining the "KM-Infrastructures" dimension (see Figure 7 and Table 7).

Figure 7
Consensus Observed on the Two Characteristics of the KM-Infrastructures
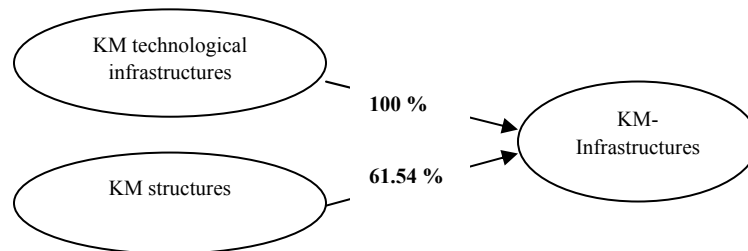
Table 7 shows, as in the first round of the Delphi investigation, a consensus for the two characteristics "KM technological infrastructures" (100%) and "KM structures" (61.54%) defining the "KM-Infrastructures" dimension.

Table 7 Summary of the Results from the Second Question of the Delphi Investigation Second Round			
Constructs/Dimensions	In agreement (%)	In dissension (%)	TOTAL (respondents)
The two following characteristics define the KM-Infrastructures dimension: KM technological infrastructures and KM structures	9 (69.23%)	4 (30.77%)	13
KM technological infrastructures	13 (100%)	0 (0%)	13
KM structures	8 (61.54%)	5 (38.46%)	13

Question 3 of the Delphi investigation second round questionnaire related to the KM-Processes: "The present study defines the construct of KM capabilities by referring to the following characteristics: (1) KM process of knowledge generation; (2) KM process of knowledge manipulation; (3) KM process of knowledge application. Do you think that these three characteristics define the KM capabilities related to the KM-Processes?" The answers from the panel of experts during the second round regarding the characteristics of the "KM-Processes" dimension showed a consensus on the three characteristics defining this dimension (see Figure 8 and Table 8), in spite of some reserves of certain experts.

Figure 8
Consensus Observed on the Three Characteristics of the KM-Processes
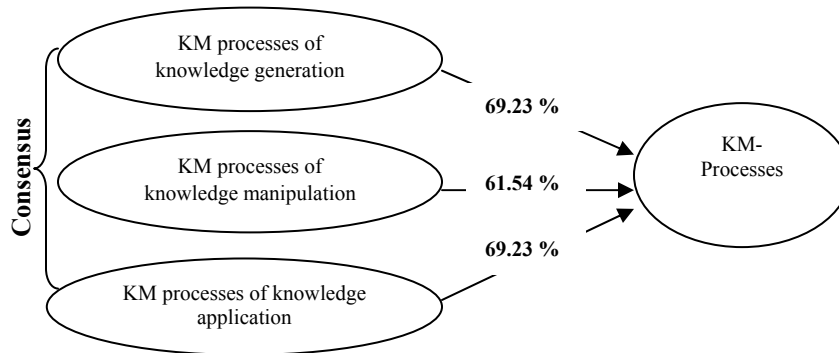
With regard to the consensus on the three characteristics, as in the first round of the Delphi inquiry, we observed that, in general, there is a consensus on the three characteristics: "Processes of knowledge generation" (69.23%), "Processes of knowledge manipulation" (61.54%), and "Processes of knowledge application" (69.23%) defining the "KM-Processes" dimension.

Table 8			
Summary of the Results from the Third Question of the Delphi Investigation Second Round			
Constructs/Dimensions	**In agreement (%)**	**In dissension (%)**	**TOTAL (respondents)**
The three following characteristics define the dimension of the KM- Processes: KM processes of knowledge generation , KM processes of knowledge manipulation, and KM processes of knowledge application	9 (69.23%)	4 (30.77%)	13
KM processes of knowledge generation	9 (69.23%)	4 (30.77%)	13
KM processes of knowledge manipulation	8 (61.54%)	5 (38.46%)	13
KM processes of knowledge application	9 (69.23%)	4 (30.77%)	13

Question 4 of the Delphi investigation second round questionnaire related to KM-Competences: Taking into account the experts' opinions in the first round, the 4a and 4b questions are formulated in order to make sure that the characteristics proposed for the "KM- Actors/people (Competences)" dimension are those that the panel of experts really wishes to see appearing. Therefore, concerning the 4a and 4b questions, we noted the answers and the comments which are synthesized in tables 9 and 10.

Question 4a of the Delphi investigation second round questionnaire: KM-Competences or other concepts? "The following concept can be used as the third dimension of the KM capabilities instead of "KM-Competences" (see the list of concepts in Table 9)."

The answers from the panel of experts with regard to the designation of a concept which should replace those of "KM-Competences" revealed that there is a consensus on the "KM-Actors/people" concept, that is, 8 favorable respondents out of 13 (61.54%) and 9 respondents out of 13 (69.23%) if we distribute the undecided ones. In addition, the "KM-Competences" concept got the second position after those of "KM-Actors/people", with 7 favorable respondents out of 13 (53.46%) and 8 respondents out of 13 (61.54%) after distribution of the undecided ones. As a result, taking into account the experts'

opinions, we will use the expression "KM-Actors/people" as the third dimension of the KM capabilities.

Table 9: Summary of the Results from the Question 4a of the Delphi Investigation Second Round						
Concepts	**Experts' answers**					
	Very in dissension (-2)	**In dissension (-1)**	**Undecided (0)**	**In agreement (+1)**	**Very in agreement (+2)**	**Experts' comments**
KM-Competences	3	2	1	2	5	Competence is, from my point of view, a concept of individual level It is a good idea to not consider it
KM-Actors/people	2	1	2	2	6	Because it is part of human resources of KM
Human resources for KM	2	2	2	5	2	The men are more than a resource I would view this as a process
KM vision	3	49	3	2	1	It is too narrow
KM culture	3	1	32	4	3	It is too narrow
KM abilities	3	1	4	3	2	This would lead to terminological disorder The same thing as "competences in KM" Sounds good at first sight but what would you say of the employees' knowledge?
KM skills	1	4	5	2	1	I think that it is more specific and more suitable To also put the skills and competences All the other titles cover this one
KM governance	3	3	4	3	0	I do not think that "governance" is suitable I wonder how it would be evaluated in a model of maturity

Question 4b of the Delphi investigation second round questionnaire related to the characteristics defining the "KM-Actors/people" dimension. "Do the following characteristics correctly describe the third dimension of the KM capabilities? (see the list of characteristics in Table 10)."

Table 10: Summary of the Results from the Question 4b of the Delphi Investigation Second Round						
Characteristics (sub-dimensions)	Experts' answers					
	Very in dissension (- 2)	In dissension (-1)	Undecided (0)	In agreement (+1)	Very in agreement (+2)	Experts' comments
KM culture	1	1	2	3	6	Ok, but it is better "orientation"
KM motivation/ rewards/ initiative			2	5	6	It is the best among the alternatives Individual level
Skill management	2	1	7	1	2	The concept is not very clear
KM employability (usability)	4	2	5	2	0	Put this in "infrastructures" dimension This is related to the infrastructure more than to people Which expert proposed that? I did not find it
KM abilities	4	1	4	2	2	This concept is too broad for a characteristic
Human resources for KM	3	1	1	2	6	I would consider this for the "process" dimension
KM orientation	1	1	5	2	4	They are very good, this refers to various orientations such as the orientation of training or the orientation undertaking

The answers from the panel of experts with regard to the designation of the characteristics which best define the "KM-Actors/people" dimension revealed that there is a consensus on the characteristics "KM culture", that is, 9 favorable respondents out of 13 (69.23%) and 10 respondents out of 13 (76.92%) if we distribute the undecided ones. In addition, the characteristics "KM motivation", "KM rewards", and "KM inciting" got a stronger consensus defining the "KM-Actors/people" dimension, with 11 favorable respondents out of 13 (84.61%) and 12 respondents out of 13 (92.31%) after distribution of the undecided ones. So this proves that we can use the three characteristics as defining the "KM-Actors/people" dimension. Thus, following the answers from the panel of experts to the questions 4a and 4b, question 4 was reformulated as follows: "The KM-Actors/people (Competences) as the third dimension of KM capabilities refers to the characteristics: (1) KM culture; (2) KM motivation; (3) KM rewards; (4) KM incentives. Do you think that these four characteristics define the KM-Actors/people construct?" The answers from the panel of experts from the fourth question of the second round with regard to the characteristics of the "KM-Actors/people" dimension revealed that there is a consensus on these four characteristics defining this dimension (see Figure 9 and Table 11).

With regard to the consensus on the four characteristics at the conclusion of the results from the Delphi investigation second round, we noted that, in general, there is a

light consensus (61.54%) on: "KM culture", "KM motivation", "KM rewards", and "KM inciting" as characteristics defining the "KM-Actors/people" dimension. Thus, the analysis of the answers got from the panel of experts for the fourth question of the Delphi investigation second round is synthesized in Table 11. Indeed, the consensus is very strong for the three characteristics "KM motivation" (84.62%), "KM rewards" (84.62%), and "KM inciting" (84.62%) as defining the "KM-Actors/people" dimension, while the characteristic "KM culture" as defining the "KM-Actors/people" dimension got a weaker result (69.23%).

Figure 9
Consensus Observed on the Four Characteristics of KM-Actors/people
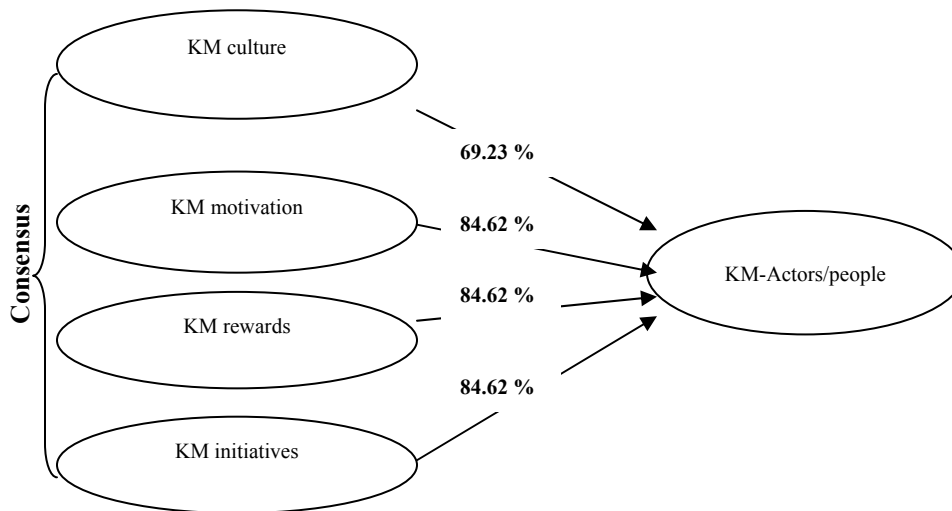
Table 11			
Summary of the Results from the Fourth Question of the Delphi Investigation Second Round			
Constructs/Dimensions	**In agreement (%)**	**In dissension (%)**	**TOTAL (respondents)**
The four following characteristics define the KM-Actors/people dimension: KM culture, KM motivation, KM rewards, and KM inciting	8 (61.54%)	5 (38.46%)	13
KM culture	9 (69.23%)	4 (30.77%)	13
KM motivation	11 (84.62%)	2 (15.38%)	13
KM rewards	11 (84.62%)	2 (15.38%)	13
KM inciting	11 (84.62%)	2 (15.38%)	13

The results of the Delphi investigation second round helped to consolidate the experts' answers by excluding duplications and by unifying the terminology.

Third Round: General Considerations, Identification of the Experts, and Conclusion of the Delphi Investigation

After having obtained the consensus from the panel of experts on the dimensions (constructs) and the characteristics of the KMC concept during the first and second rounds of the Delphi investigation, the third round of the Delphi investigation highlighted the recorded profits making possible to identify the respondents' profile and to conclude on consensus obtained. Thus, the objectives of the third round of the Delphi investigation are: (1) to emphasize the strong points and the limits of this Delphi investigation; (2) to identify the profile of the expert respondents; and (3) to draw general conclusions from the study. Indeed, with regard to the distribution of the questionnaire, we started from a list of thirteen experts of twelve countries (Finland, Portugal, Switzerland, Canada, United Kingdom (England), United States, Thailand, Spain, Estonia, Hungary, India, and Australia) who took part in the second round of the Delphi investigation. Thus, a cover letter to the third round of the Delphi investigation was sent by email. The third round of the Delphi investigation, which has been performed from February 8 to March 28, 2007, aimed at confirming the results and the consensus obtained on some concepts and characteristics of the KMC.

Question 1 of the Delphi investigation third round questionnaire related to the general comments from the expert respondents of this study: question 1 from the Delphi survey questionnaire was the following for the third round: "What are your general comments on the present study?" The answers from the panel of experts to question 1, during the third round of the Delphi investigation, provided the following comments:

(1) *"A useful exercise, but there remain still some considerable differences in opinion about the foundations of knowledge management. There is, for example, an aspect which some experts deem as being essential. But others do not even understand what they mean."*

(2) *"A better way of combining information from experts in the field. But the number of participants should be more because in your case, it is less."*

(3) *"Generally, it seems that you have led a rigorous Delphi process. I suppose that it would have been better to have more than 16 and 13 participants in each step. One of my students recently proposed to make a Delphi study on the future of Web services. I provided him your materials so that he can familiarize himself with it and understand the methodology. I appreciate*

the organization of your documents and processes and I think that they would be an excellent example."

(4) "This Delphi study approached a very difficult and discussed matter in the field of knowledge management, which after 15-20 years of research and practice is always at the research of shared sights. It is why; this makes me think that this study was a true challenge. I first of all appreciated the way in which this study was undertaken, it stimulated me so that I can take part and cooperate with other experts under the wire of the study's author. I think that the central tendency identified by the study gives a very good base for the future investigations in the theory of knowledge management and future practical applications."

(5) "The lack of consensus in some sectors astonished me. In my opinion, sometimes the experts are more concerned with establishing a link or to justifying their own work rather than to help to carry out the consensus. In all events, I certainly appreciated your effort in the research for such a consensus by producing a framework. Moreover, the discussion was refreshing and very didactic for me."

(6) "I found it interesting and I surely appreciated the reports since they clarified the opinions of other colleagues. I still have this idea that the field of knowledge management requires a deep change, in terms of theories that explain the processes of knowledge management in organizations and the methodologies employed to guide the processes. It always sounds a little too much like information management with the dimension of people [quid] to force a little differently the savor. Knowledge is still first of all seen as an "object" which can be controlled by specific processes which can be controlled in parallel or independently of the usual management targets. Its intangible nature is hardly recognized. However, the future will indicate if I am right or wrong..."

(7) "In my opinion, the study was overall well made. The charts and tabular of the results were really helpful in clarifying the results. I wait with interest to see the digested synopsis of this study and I hope that the author will share the latter with us. I would like, however, to present my observations on a question relative to the administration of the study, which is that I think that faster cycle duration in between the rounds (of the Delphi investigation) would help the respondents in keeping subsistence and to remain focused on the subject. Secondly, in the synoptic table of the question 4a, the (characteristic) "KM culture" contains two answers and I think that this seems to be an error."

(8) *"The Delphi study is an excellent method to obtain the reviews and the opinions from experts. In particular on your work, you tried to analyze all the opinions and classified them by category in a completely convincing way. But as we all realize that knowledge is very abstract and differs from one field to another. The functionalities of knowledge change according to its field of study or application. For example, knowledge in the medical field cannot be treated in the same manner as knowledge in technical fields or in arts or sports. Thus the answers which you received from the experts are likely to be linked towards their fields of expertise. Moreover, your interpretation is also likely to be aligned with your field of expertise. My apprehensions about the Delphi studies are: can this polarization be surmounted in interpretation and how can the impartiality are justified? Nevertheless, the recapitulation of the tools and the procedures of analysis are also important."*

(9) *"I found it very interesting. It can also be very useful and an effective way to use the Delphi method with the aim of clarifying terminologies and the relations between the concepts in the field of research which is still very fragmented. My opinion is that the Delphi method helps to identify differences and the polemics in the conceptual framework and the theoretical reasoning and consequently opens the way to finding mutual arrangements on several suitable questions. Moreover, I think that this kind of structured discussion between experts using a facilitator of the Delphi study is very inspiring for the collection of experts' opinions; it stimulates the thought process and directs the attention to the important questions. Always, I've noted that the somewhat clear and tightened expiries were good; (because) I think that research is completely much a process led by "the fall date". Thank you!"*

Question 2 of the Delphi investigation third round questionnaire was the following: "Give information on your identification?" The answers from the panel of experts to question 2 during the third round of the Delphi investigation are summarized in Table 12. We gave pseudonyms to the expert respondents in order to keep their anonymity. In addition, the names of the departments, faculties, and universities are kept in the source languages in order to identify them compared to the country to which they belong.

Question 3 of the Delphi investigation third round questionnaire was the following: "Give the important publications that you have made in journals and conferences with peer review in the fields of knowledge management, organizational capabilities, or KM capabilities and the maturity models?" The answers from the panel of

experts to question 3 during the third round of the Delphi investigation are summarized in Table 13. This synthesis takes some examples from publications made by the expert respondents in the Delphi investigation.

No	Name	Academic status	Department/university/country
Table 12 **Profile of the Respondents to the Delphi Investigation: Identification**
1	Ariane Jean-François	Professor	Department of Business Administration, Lappeenranta University of Technology, **Finland**
2	Andrée Raymond	Assistant professor	Department of Information Systems, School/Faculty: Engineering School, University of Minho, **Portugal**
3	Beneto Benito	Professor/director of the research and consultation department	Swiss Distance University of Applied Sciences (FFHS) **Suisse**
4	John Ricardo	Assistant professor	Department of MIS School/Faculty: Business, San Jose State University, **USA**
5	King Winnie	Professor	Claremont Graduate University, Claremont, CA, **USA**
6	Mike Davidson	Professor of resources and operations of systems and a KM group, editor-in-chief of a KM journal	Aston Business School, Aston University, Aston Triangle, Birmingham, **U.K.**
7	Gandi Gandi	Professor	University Business School, Panjab University, Chandigarh, **India**
8	Sun Swamidaravalli	Assistant professor	Department of Information Technology, Ramrao Adik Institute of Technology, NERUL, New Bombay, **India**
9	Marcel Bonenfant	Professor and scientific director	Service de l'enseignement du management, HEC, Montréal, **Canada**
10	Miguel Donfus	Assistant professor	Departamento de Sistemas de Informaçao, Escola de Engenharia, Universidade do Minho, Campus de Azurem, Guimaraes, **Portugal**
11	Sergio Valencia	Professor	Universidad Politécnica de Valencia, Alicante, **Spain**
12	Gamila Hungay	Professor	MTA Information Technology Foundation, Budapest, **Hungary**
13	Jonson Marley	Professor	Macquarie University, Sydney, **Australia**

CONCLUSION

According to the results of the Delphi investigation, we can conclude that: (1) the "KM capabilities" (KMC) concept is the sum of the whole organizational capabilities related to the KM-Infrastructures, the KM-Processes, and the KM-Actors/people; (2) the KM-Infrastructures are the whole organizational capabilities referring to the KM technological infrastructures and the KM structures; (3) the organizational capabilities related to the KM-Processes are the whole organizational capabilities referring to the KM processes of knowledge generation, the KM processes of knowledge manipulation, and

the KM processes of knowledge application; (4) the organizational capabilities related to the KM-Actors/people (Competences) is the whole organizational capabilities referring to the KM culture, with the KM motivation, the KM rewards, as well as the KM inciting.

Table 13
Profile of the Respondents to the Delphi Investigation: Publications

No	Reviews/conferences	Tackled subjects	Field of studies
1	*European Conference on Knowledge Management*	Knowledge management strategy To allow the management of knowledge by the cognitive engineering of practice and treatment Management and maturity models of knowledge	Knowledge management Maturity Models
2	*International Journal of Knowledge and Systems Sciences*	Management systems for knowledge and processes of businesses	Knowledge management
3	*Diviner*	To tackle the cultural questions in intensive knowledge organizations	Knowledge management
4	*Journal of Social Sciences, Science Publications*	Organizational knowledge: to leave from academic concepts towards the fundamental procedures of management	Knowledge management
5	*International Journal of Knowledge Management*	Knowledge management systems for the state of help preparation: the experiment of consortium from the University of Claremont	Knowledge management
6	*Journal of Information Systems Education*	To design knowledge management systems to teach and learn with from wiki technology	Knowledge management
7	*Electronic Journal of Knowledge Management*	Exchanges of knowledge in the communities online: a duality of participation and culture	Knowledge management
8	*European Journal of Innovation Management*	Capabilities and innovative execution of knowledge treatment: an empirical study	Organizational capabilities Knowledge management
9	*Journal of Knowledge Management*	Management of the creation and knowledge sharing - dynamic scenarios and capabilities in the inter-industrial knowledge networks	Organizational capabilities Knowledge management

In addition, some results observed from our Delphi investigation as a whole as well as the comments received from the experts taking part in the study clearly show that the choice of the Delphi method in this study was suitable in order to get a consensus on the concepts and the key characteristics related to the KM capabilities. Finally, we also observed that, according to the opinions of the experts taking part in the study, the way at which the study was conducted was very rigorous and appreciated from the participants.

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ANALYZE COGNITIVE PROCESS OF INFORMATION REQUIREMENT ANALYSIS

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ABSTRACT

Information requirement analysis is an error prone process, especially for novice information analysts. Empirical studies have shown that lack of knowledge is a major cause for novice information analysts making more errors in requirement specifications. Empirical studies have also shown that there are four characteristics of modeling behaviors that set expert and novice information analysts apart: model-based reasoning, mental simulation, critical testing of hypotheses, and analogical domain knowledge reuse. However, it is unclear how the knowledge of information analysts may influence their modeling behaviors in information requirement analysis. On the basis of the structure-mapping model of analogy from the field of cognition science, this research proposes a cognitive process model that can explain how the differences of knowledge between novices and experts can cause the different modeling behaviors of information requirement analysis. In addition, the implications of the cognitive process model for effective information requirement analysis are also discussed.

INTRODUCTION

Information requirement analysis is the early phase of information systems development. During information requirement analysis, information analysts capture, understand, and translate users' information requirements into requirement specifications (Gibson & Conheeney, 1995; Huang, 2008). The resulting requirement specifications have at least three purposes: (1) facilitating an understanding of the intended system, (2) guiding the process of information system design, and (3) serving as a basis for all communications concerning the information system being developed (Hsia, Davis, & Kung, 1993; Schemer, 1987).

The correctness of requirement specifications is important for the success of an information system development project. An estimation showed that inaccurate requirement specifications might cost in excess of one hundred times what would have been required if the errors were discovered during information requirement analysis (Roman, April 1985; Shemer, 1987). A similar survey done by the Standish Group (1995) also showed that 31.1% of software projects in the United States were cancelled at some point during the development cycle; and inaccurate or incomplete requirement

specifications were identified as the most important contributing cause. Therefore, how to specify correct requirement specifications is a critical issue for information requirement analysis.

Information requirement analysis is an error prone process, especially for novice information analysts. Empirical studies have shown that lack of knowledge is a major cause for novice information analysts making more errors in requirement specifications (Schenk, Vitalari, & Davis, 1998). Empirical studies have also shown that four characteristics of modeling behaviors that set expert and novice information analysts apart: model-based reasoning, mental simulation, critical testing of hypotheses, and analogical domain knowledge reuse (Sutcliffe & Maiden, 1990). However, it is unclear how the knowledge of information analysts may influence their modeling behaviors in information requirement analysis. Therefore, the research question of this research is "What is the cognitive process model of information requirement analysis that can explain how the differences of knowledge of information analysts may lead to different modeling behaviors?"

In this article, a cognitive process model of information requirement analysis is constructed on the basis of the structure-mapping model of analogy. On the basis of the cognitive process model of information requirement analysis, the interactions between the knowledge of information analysts and modeling behaviors are explained from the perspective of the dynamic process of information requirement analysis.

The remainder of this paper is organized as follows. First, this research will review the empirical studies related to the knowledge and modeling behaviors of information analysts. Then this research will discuss Gentner's structure-mapping model of analogy and explain why it is a good choice as a basis for modeling the cognitive process of information requirement analysis. Third, on the basis of the structure-building model of analogy, this research will propose a cognitive process model of information requirement analysis. Fourth, this research will use the proposed cognitive process model to explicate the differences between novice and expert information analysts in information requirement analysis. Fifth, this research will discuss the implications of the cognitive process model for research and practices in information requirement analysis. Finally, a conclusion will be made in the final section.

LITERATURE REVIEW

This section will first review the research studies concerning the influence of the knowledge of information analysts on the performance of information requirement analysis. Then, the review will discuss the literature on the differences of modeling behaviors between expert and novice information analysts. On the basis of the findings,

we will explore the important cognitive processes of information requirement analysis in the following sections.

The Knowledge of Information Analysts

The research into the influence of the knowledge of information analysts on the performance of information requirement analysis has been conducted in two categories: knowledge availability and knowledge organization (Schenk, Vitalari, & Davis, 1998). Knowledge availability refers to various types of knowledge used in information requirement analysis. On the other hand, knowledge organization refers to the ways by which the knowledge is stored in the long-term memory of information analysts.

Knowledge Availability

Domain knowledge and modeling knowledge have been suggested as determining factors for the modeling performance of information analysts. Domain knowledge is drawn upon by both expert and novice information analysts in specifying information requirements (Sutcliffe & Maiden, 1990; Vessey & Conger, 1993). While understanding problem statements, information analysts use domain knowledge to mentally simulate a scenario of the system behavior in order to test the adequacy of the requirement specifications, to add assumptions to increase the completeness of the requirements, to test internal and external consistency of the requirements, and to abstract, summarize, select and highlight important information in the problem statements (Guindon, Krasnar, & Curtis, 1987). Without domain knowledge, even expert information analysts can only specify high-level conceptual models without details (Adelson & Soloway, 1985). With the availability of domain knowledge, novice information analysts can reuse the domain knowledge to achieve almost the same level of completeness of requirement specifications as expert information analysts do (Sutcliffe & Maiden, 1990).

On the other hand, modeling knowledge has long been regarded as an important factor to differentiate expert from novice information analysts. Modeling knowledge can be divided into syntactic and semantic parts (Koubek, et al., 1989). Syntactic knowledge consists of allowable syntax of a specific modeling language. Semantic knowledge, however, consists of modeling principles that are independent of a particular modeling language (Allwood, 1986). Compared to novice information analysts, expert information analysts with richer semantic knowledge can retrieve and apply more relevant modeling principles, make more critical testing of hypotheses, and finally achieve requirement specifications with better quality (Allwood, 1986; Koubek, et al., 1989; Schenk, Vitalari, & Davis, 1998; Vitalari & Dickson, 1983). Modeling knowledge can also be divided into declarative and procedural aspects (Vessey & Conger, 1993). The procedural aspect of a

requirement analysis technique is more difficult to learn than the declarative aspect. However, the procedural aspect of modeling knowledge is more important in determining the quality of requirement specifications (Vessey & Coger, 1993).

Knowledge Organization.

There are basically two features of knowledge organization that can differentiate expert from novice information analysts in information requirement analysis: the size of knowledge unit and the level of abstraction of knowledge. First, expert information analysts store their knowledge in bigger units than novice information analysts do. Empirical studies showed that storing knowledge in bigger chunks gives expert information analysts advantages over novice information analysts in understanding and specifying information requirements. First of all, experts can automate some aspects of the problem solving process because their knowledge can be mapped onto a problem context in a bigger scope. As a result, expert information analysts can have a more efficient process of information requirement analysis. On the other hand, novices have to solve the problem from the first principle due to smaller units of knowledge in the memory. Novice information analysts have to spend much more cognitive resources in identifying the relevant pieces of knowledge and put them together in the right way, leading to an inefficient process of information requirement analysis (Allwood, 1986; Guindon, Krasner, & Curtis, 1987; Guinder & Curtis, 1988). Even worse, smaller units of knowledge may make the process of problem solving more complicated for novice information analysts. As a result, many errors can be caused by novices' inability to map parts of the problem description to appropriate knowledge structures as well as by novices' failure to integrate pieces of information (Allwood, 1986).

The second feature is that expert information analysts use higher-order abstract constructs to organize large amounts of knowledge while novice analysts store concrete objects sparsely in the long-term memory. Research evidence shows that experts use richer vocabulary to categorize problem descriptions into standard abstraction. As a result, experts can retrieve knowledge structure easily, and they can focus more on the semantic structure of problems rather than the surface or syntactic structure (Allwood, 1986; Koubek, Salvendy, Dunsmore, & Lebold, 1989).

Due to the above two important features of knowledge organization, expert analysts can have better performance in information requirement analysis by (1) processing large amounts of information into meaningful chunks; (2) retrieving the knowledge structure easily; and (3) categorizing problems into standard types based on underlying domain principles (Batra & Davis; 1992).

The Modeling Behaviors of Information Analysts

Empirical research on the cognitive process of information requirement analysis has identified a strong association among the activities of gathering information, identifying relevant facts, and conceptual modeling (Batra & Davis, 1992; Sutcliffe & Maiden, 1992). This strong association reflects that information requirement analysis is basically an understanding process.

To account for the better performance of expert information analysts in understanding and specifying information requirements, the research on cognitive process has focused on the differences in the modeling behaviors between expert and novice information analysts. Empirical studies on the modeling behaviors of information analysts showed that four modeling behaviors set expert and novice information analysts apart: model-based reasoning, mental simulation, critical testing of hypotheses, and analogical domain knowledge reuse.

First, expert information analysts use model-based reasoning to model information requirements with the help of various requirement analysis techniques (Sutcliffe & Maiden, 1992; Vitalari & Dickson, 1983). Research evidence showed that model-based reasoning on the basis of requirement analysis techniques could produce more complete solutions than partial or no model-based reasoning behavior. On the other hand, research evidence also showed that novice information analysts could not perform model-based reasoning effectively because they had difficulties in identifying important concepts in the requirement statements by requirement analysis techniques (Sutcliffe & Maiden, 1992). For example, in a research study on the modeling behaviors of novice information analysts in using data flow diagrams, it was shown that the novice information analysts were more successful at recognizing system goals and inputs, while there was poorer recognition of system data stores, processes, and outputs, even though data stores, processes, and outputs were explicitly stated in the problem narrative (Sutcliffe & Maiden, 1992). Therefore, we may conclude that effective model-based reasoning is an important cognitive process that sets expert and novice information analysts apart.

The second feature of expert analysts' modeling behaviors is mental simulation. Mental simulation refers to the cognitive processes of building a mental model that establishes connections among the parts of the system under investigation and of using the mental model to reason about the interactions among the parts of the system (Adelson & Soloway, 1985; Guindon, Krasner, & Curtis, 1987; Guinder & Curtis, 1988). During information requirement analysis, expert information analysts use requirement analysis techniques for mental simulation of information requirements while novice analysts used requirement analysis techniques only for representation (Adelson & Soloway, 1985). Mental simulation makes expert analysts focus on the semantic part of the problem

statement. On the other hand, without mental simulation novice information analysts can analyze only the syntactic part of the representation (Adelson & Soloway, 1985; Allwood, 1986).

Critical testing of hypotheses is the third feature of the modeling behaviors of expert information analysts. By means of mental simulation, expert information analysts can have a clear picture about the structure of the information requirements (Guindon, Krasner, & Curtis, 1987; Guinder & Curtis, 1988). Consequently, experts may be more able to reason about a problem, to create test cases and scenarios for testing hypotheses critically (Schenk, Vitalari, & Davis, 1998; Vitalari & Dickson, 1983). On the other hand, novice information analysts can generate hypotheses only at a general level and make few attempts to test hypotheses because they focus only on the syntactic part of the representation (Schenk, Vitalari, & Davis, 1998).

Finally, analogical domain knowledge reuse makes expert information analysts able to specify information requirements more completely and accurately (Mainden & Sutcliffe, 1992). Expert information analysts tend to use higher-order abstract constructs to organize large amounts of knowledge. As a result, expert information analysts can recognize and assimilate analogies more easily (Batra & Davis, 1992; Vitalari & Dickson, 1983). In addition, expert information analysts tend to keep in memory the details of requirement specifications from their past experience. Consequently, higher quality can be expected because the reused specifications are well tested and validated. On the other hand, novice information analysts have difficulty in identifying the opportunities of analogical modeling because they tend to store concrete objects sparsely in the long-term memory (Batra & Davis, 1992; Sutcliffe & Maiden, 1992). In addition, novice information analysts tend to specify information requirements from scratch because of the lack of reusable specifications in their memory (Vitalari & Dickson, 1983).

THE STRUCTURE-MAPPING MODEL OF ANALOGY

Gentner's structure-mapping model of analogy will be used in this research as the basis for the cognitive process model of information requirement analysis because of the following two reasons: First, the output of the structure-mapping model of analogy is a situation model of the problem context under investigation, which is the same as the output by the cognitive processes of text comprehension and information requirement analysis. Due to the common cognitive goals, the structure-mapping model may be able to shed more light on the cognitive process of information requirement analysis from the perspective of text comprehension. Second, the strength of the structure-mapping model is its ability to explain the differences of analogical reasoning between novices and experts (Gentner, 1983). According to the structure-mapping model, experts use

structural similarity as the basis for analogical reasoning and hence can get better understanding of the target phenomenon. On the other hand, novices use attribute similarity as the basis for analogical reasoning and hence cannot get correct interpretation of the target phenomenon (Gentner, 1983). Therefore, the structure-mapping model may be able to explicate the issue of novice-expert differences better in information requirement analysis. In this section I will discuss the structure-mapping model of analogy from the perspectives of the following four characteristics: (1) the task, (2) the assumption, (3) the mapping process, and (4) the guiding principle for mapping process.

The Task

There are two domains, target domain and base domain, in the context of analogy. The task of analogy is to define a mapping from B, which is a concept in the base domain, to T, which is a concept in the target domain. When the mapping is done, we can conclude the analogy by saying that "T is (like) B". In this analogy, T will be called the target because it is the concept that we want to comprehend. B will be called the base because it is the concept that we know very well and hence that serves as a source of knowledge.

The Assumption

In order to explain the cognitive process of analogy by the structure-mapping model, Gentner (1983, pp. 156-157) made four assumptions about the cognitive environment: (1) "Domain and situations are psychologically viewed as systems of objects, object-attributes, and relations between objects." On the basis of this assumption, Gentner limited the elements of a conceptual structure to three constructs: object, attribute, and relation. (2) "Knowledge is represented as propositional networks of nodes and predicates." This assumption limited the knowledge organization in memory as propositions (Kintsch & Dijk, 1978), rather than schema (Schank & Abelson, 1977) or Neuro-network (Kintsch, 1988). (3) "Two essentially syntactic distinctions among predicate types will be important. The first distinction is between object attribute and relationships. Attributes are predicates taking one argument, and relations are predicates taking two or more arguments. The second important syntactic distinction is between first order predicates (taking objects as arguments) and second- and higher-order predicates (taking propositions as arguments)." The purpose of this assumption is to design a computing mechanism for explicating the process of analogy reasoning. And finally (4) "These representations, including the distinctions between different kinds of predicates, are intended to reflect the way people construe a situation, rather than what is

logically possible." This assumption express the concern of the structure-mapping model is the cognitive process of building a situation model, which is the same as that of text comprehension and information requirement analysis.

The Mapping Process

There are four kinds of domain comparison processes that can determine the mapping from a concept in the base domain to a concept in the target domain: literal similarity, analogy, abstraction, and surface similarity. First, literal similarity is a comparison in which a base structure can be mapped onto the target structure with both object-attributes and structural (or called relational) predicates. For example, Monkey feet are like human feet. In this comparison, monkey's feet are not only similar to human feet in attributes (toe, shape, etc.) but also in structural predicate (for walking, jumping, and supporting body).

Second, analogy is a comparison in which structural predicates, but few or no object attributes, can be mapped from base to target. For example, Cars are like human feet. In this example, cars are different from feet in attributes; but similar in structural predicates (for transportation, for example).

Third, abstraction is a comparison in which the base structure is an abstraction of the target structure. For example, cars are transportation devices.

Fourth and finally, surface similarity is a comparison in which base structure share similar objects and attributes with the target knowledge. For example, we may say that cars are like bricks because of similar shape.

The Guiding Principle for the Mapping Process

While mapping the base structure onto the target structure, a higher-order relation (or predicate) will be more likely to be imported into the target structure than is an isolated relation or object-attribute. It is called the principle of systematicity (Gentner, 1983). This principle is derived from the fact that human beings pursue coherent situation model during their comprehension process. A higher-order relation defines a structure connecting more concepts and lower-level relations together than an isolated relation or object-attribute does. As a result, a higher-order relation contributes higher coherence to the situation model of the problem context and hence provides more satisfaction for the comprehenders.

A COGNITIVE PROCESS MODEL OF INFORMATION REQUIREMENT ANALYSIS

On the basis of the structure-mapping model of analogy (Falkenhainer, Forbus, & Gentner, 1990; Gentner, 1983; Gentner & Markman, 1997), this research proposes a cognitive process model of information requirement analysis to explicate the modeling behaviors of information analysts as shown in Figure 1 (Huang & Burns, 2000). In this section, this research will discuss the mechanism of this cognitive process model. The strength of this model that can explain the interactions between the knowledge of information analysts and different modeling behaviors between novice and expert information analysts will be discussed in the next section.

In this section, we will assume a requirement sentence, "The customer first sends an order to John, the order clerk," in a problem statement of an order processing system as an example to illustrate the cognitive process of information requirement modeling. On the basis of the cognitive process model depicted in Figure 1, the cognitive process of information requirement analysis can be divided into three parts: parsing, modeling, and questioning as follows.

Parsing

A problem statement is the source of target structures that includes concepts and structures of information requirements. The task of information requirement analysis is to construct a model that can connect all concepts and structures of the problem statement into a coherent whole. If a coherent model can be built for the problem statement, then the task of understanding the problem statement is achieved.

Parsing as the first step in modeling translates the example sentence into a target structure in the form of propositional knowledge as follows (Kintsch, 1974):

send (CUSTOMER, ORDER, ORDER CLERK)
send : predicate; CUSTOMER: agent; ORDER: object; and ORDER CLERK: agent.

The translation depends on analysts' knowledge mainly about natural language (in this case, English) and domain knowledge. In this article, we assume that both novice and expert information analysts have the same level of ability to understand English text and necessary domain knowledge about an ordering system. Thus, we can assume that both novice and expert information analysts can come up with a piece of propositional knowledge similar to the above one.

Figure 1. A Cognitive Process Model of Information Requirement Analysis
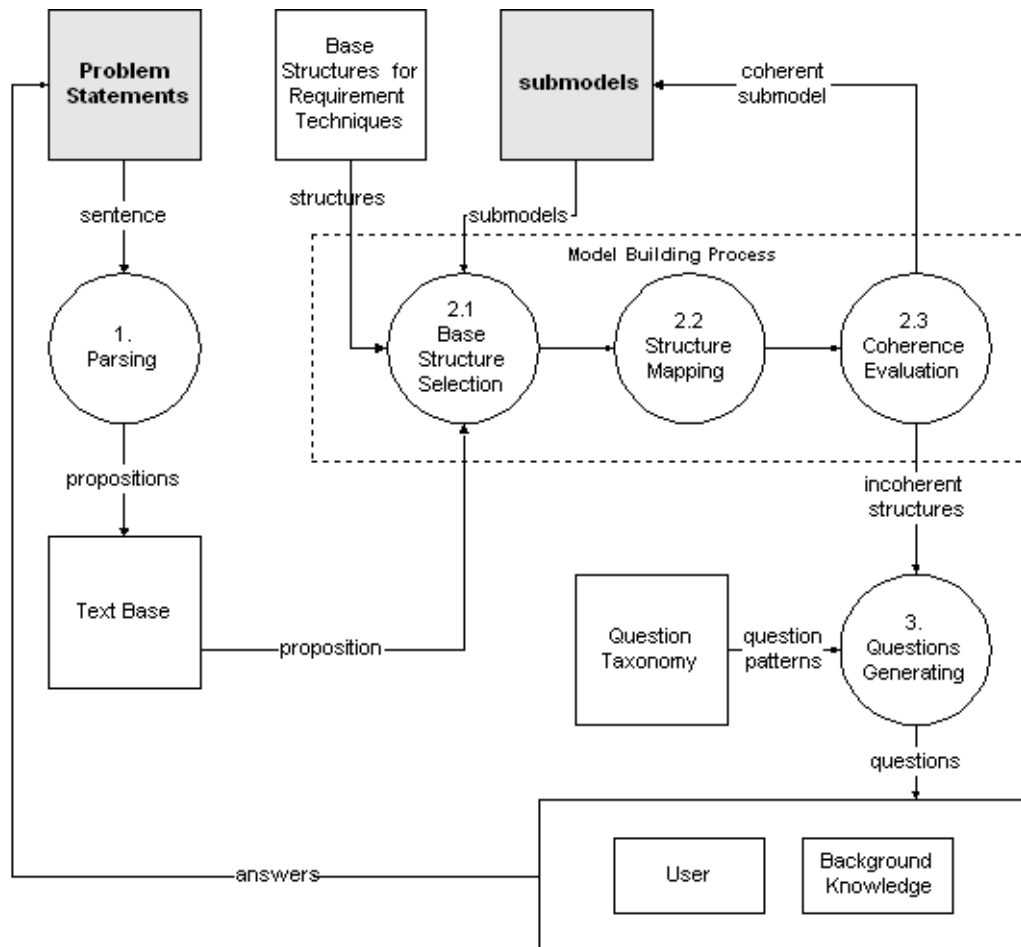
Modeling

Modeling is the process that translates the received target structure into the form of a base structure of a particular requirement analysis technique. In this article, we assume that the selected requirement analysis technique is the data flow diagrams. On the basis of the cognitive process model, the modeling process can be divided into three subprocesses: accessing, mapping and evaluating as follows:

Base Structure Selection

In order to specify the information requirements in the problem statement by a particular requirement analysis technique, information analysts access the base structures of the requirement analysis technique to match the incoming target structure. Basically, two factors are considered while determining which base structure will be selected: the principle of continuity (Zwaan, Graesser, & Magliano, 1995) and the types of similarity (Gentner, 1983). First, on the basis of the principle of continuity, information analysts tend to access the base structure that can be connected to the submodels that have been built so far, especially the most recent one. This principle reflects that information analysts try to build a connected and coherent model for the whole problem statement.

Second, there are four types of similarity between target and base structures that can trigger the access of a particular base structure: literal similarity, analogy, abstraction, and surface similarity. First, on the basis of literal similarity, the information analyst may decide that the order processing system under investigation is like that of company X I analyzed last year. Second, on the basis of analogy, the information analyst may conclude that the order processing system is like the library system he or she analyzed two years ago. Third, abstraction reasoning may make the information analyst use the base structure, inflow (external entity, dataflow, process), from data flow diagrams to model the target structure. Fourth and finally, surface similarity may attract the information analyst's attention and decide too model customer as external entity, and order as data store.

Empirical evidence shows that human knowledge is more likely organized by object-attribute similarity, rather than by structural similarity. Thus, novice information analysts tend to access base structures by literal similarity or surface similarity because both have the feature of object-attribute similarity. Abstraction and analogy are rarely used by novice information analysts to access base structures because the structural similarity is more difficult to identify.

On the other hand, expert information analysts have learned from experience that structural similarity (or even higher-order structure similarity) has better explanation power than object-attribute similarity. Therefore, expert information analysts will prefer abstraction and analogy to surface similarity in selecting base structures. Empirical evidence shows that experts learn from experience to organize their knowledge by abstract relations rather than objects or attributes (Halford, 1987).

For illustration, if the information analysts decide to use the data flow diagrams to model the example sentence mentioned above, the expert information analysts may select a higher-order relational base structure like inflow (external entity, data flow, process). On the other hand, novice information analysts may select an object-attribute base

structure like external entity, data store, and external entity to match the three concepts in the problem statement: CUSTOMER, ORDER, and ORDER CLERK.

Structure Mapping

While mapping the base structure onto the target structure, a higher-order relation (or predicate) will be more likely to be imported into the target structure than is an isolated relation or object-attribute on the basis of the principle of systematicity. For example, if the selected based structure is inflow (external entity, data flow, process), then the information analyst will be able to get the following three results on the basis of model-based reasoning:

CUSTOMER will be mapped as external entity, and ORDER as data flow;

ORDER CLERK cannot be mapped as process. The information analyst may therefore make inferences to decide that the process is what the order clerk does---order processing; and the information analyst may find out by abstraction that the requirement "customer first sends an order to the order clerk" is an input data flow for a high-order structure---an order processing system. On the basis of the principle of systematicity, the information analyst may try to model the whole order processing system by identifying data stores and output data flows from his or her domain knowledge.

Coherence Evaluation

The result submodel will finally be evaluated on the basis of coherence. For example, by using the base structure inflow (external entity, date flow, process) to match the requirement sentence send (CUSTOMER, ORDER, ORDER CLERK), we will find ORDER CLERK can not be matched by process because ORDER CLERK is obviously an agent rather than a process. If the information analyst cannot identify "processing order" as the process by model-based reasoning, then the mismatch between ORDER CLERK and "process" will cause an incoherence. Consequently, the information analyst may decide to abandon the mapping and try another base structure; or he may choose to keep it and solve the incoherence later.

Questions Generating: Asking Questions about the Incoherences in the Submodel

The incoherences in submodels will become the cues for questioning (Huang, 2006). For example, in order to erase the incoherence on the mismatch between ORDER

Clerk and "process," information analysts may ask questions to identify the missing process in the submodel. Example question may be like:

> What task is done by the order clerk? Or more directly, what is the process for the incoming order?

AN EXPLANATION FOR THE NOVICE-EXPERT DIFFERENCES

The purpose of the proposed cognitive process model of information requirement analysis is to describe the modeling behaviors of information analysts. The cognitive process model argues that the differences of knowledge availability and knowledge organization determine the different modeling behaviors between expert and novice information analysts. The different modeling behaviors, in turn, lead to the different levels of correctness of requirement specifications.

The strength of the cognitive process model is its ability to explain an unclear issue related to the performance of information requirement analysis: how the differences of knowledge between novice and expert analysts may lead to different modeling behaviors from the perspectives of four characteristics: model-based reasoning, mental simulation, critical testing of hypotheses, and analogical domain knowledge reuse? The explanation based on the cognitive process model is as below:

First, how does the knowledge of information analysts influence the model-based reasoning? The purpose of model-based reasoning is to identify the concepts for requirement specifications correctly and completely (Sutcliffe & Maiden, 1992). Expert information analysts organize their knowledge by abstract relations. Thus, expert information analysts can make model-based reasoning effectively because they access base structures for modeling target structures on the basis of structural similarity. Consequently, expert information analysts can get fewer errors in their requirement specifications. On the other hand, novice information analysts organize their knowledge as concrete objects sparsely in the long-term memory. Thus, they select base structures on the basis of object-attribute similarity that will be more likely to cause errors or incomplete concepts in the requirement specifications (Sutcliffe & Maiden, 1992).

Second, how does the knowledge of information analysts influence mental simulation? The purpose of mental simulation is to reason about the interactions among the parts of a system and then to establish coherent connections among the parts for a more complete requirement specification (Adelson $ Soloway, 1985; Guindon, Krasner & Curtis, 1987; Guindon & Curtis, 1988). Expert information analysts organize their base structures in bigger units that have higher coherence. The higher coherence will, in turn, provide richer explanation power for mental simulation while modeling the target structures. As a result, fewer errors will be generated in their requirement specifications.

On the other hand, novice information analysts have their base structures in smaller units that will result in many small fragments of requirement specifications. Even worse, many of the smaller requirement fragments may be generated on the basis of object-attribute similarity. As a result, the limited or even wrong explanation power will make the mental simulation difficult and thus many errors will be generated during the integration of requirement fragments into bigger and more complete requirement specifications.

Third, how does the knowledge of information analysts influence critical testing of hypotheses? Critical testing of hypotheses is important to validate the coherence of requirement specifications. On the basis of base structures with higher abstraction and bigger unit, expert information analysts can make critical testing of hypotheses more effectively to derive more important concepts on the basis of the principle of continuity. As a result, more complete requirement specifications can be generated. On the other hand, with a model built from object-attribute similarity, novice information analysts can generate hypotheses only at a general level and make few attempts to test hypotheses (Sutcliffe & Maiden, 1992).

Fourth and finally, how does the knowledge of information analysts influence the performance of analogical domain knowledge reuse? On the basis of the principle of systematicity, expert information analysts can identify opportunities of analogical reasoning more easily because they use abstract concepts to organize their knowledge. In addition, expert information analysts can reuse specifications in bigger units and with higher quality because they store in memory the details of the well tested and validated specifications from their past analysis experience. On the contrary, novice information analysts have difficulty in identifying analogies because they focus on concrete objects and attributes. As a result, they often need to develop requirement specifications on the basis of the first principle.

IMPLICATIONS OF THE COGNITIVE PROCESS MODEL

The cognitive process model has shown that knowledge of information analysts lead to different modeling behaviors and different modeling behaviors in turn result in differences in the correctness of requirement specifications. The cognitive process model suggests that the most basic reason accounting for the differences between novice and expert information analysts is that novice and expert information analysts pay attention to different aspects of a problem statement: experts focus on the structural side of the problem statement but novices on the object-attribute side. Therefore, at least two implications can be identified in this research: first, in order to accelerate the transition from novice to expert information analysts, novice information analysts should be encouraged to learn and to think in terms of structures rather than of object-attributes.

Actually, thinking in terms of structures has also been suggested as an effective way to improve students' reading comprehension (Nix, 1985). Second, novice information analysts can have the same level of performance as expert information analysts have if the target and the base structures share literal similarity that includes both structural and object-attribute similarities. Therefore, domain-specific requirement analysis techniques deserve future research because they use the same concepts and structures as those of the problem statements and hence will improve the productivity of novice information analysts significantly.

CONCLUSION

Using structure-building model of analogy as a reference, this research has proposed a cognitive process model of information requirement analysis. The structure-building model of analogy as a reference model has provided the proposed cognitive process model with two advantages. First, the cognitive model focuses on the process of building situation model for the problem context under investigation, which is consistent with the concern of the cognitive process of information requirement analysis. Second, the cognitive model focuses on the differences between expert and novice in modeling behaviors, which is also the major concern of the research in cognitive process of information requirement analysis.

The cognitive process model proposed in this research has explicated the interactions among the cognitive variables from the perspective of dynamic process of information requirement analysis. In addition, by linking the knowledge of information analysts with the modeling behaviors of information analysts, the cognitive model provides the theoretical explanation about why novice and expert information analysts have different modeling behaviors during information requirement analysis. Finally, the cognitive process model has also shown that the structural similarity between users' problem statements and requirement analysis techniques is an important determinant for the degree of difficulty in information requirement modeling.

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DEVELOPING A PROTOTYPE FOR DETERMINING ALTERNATIVE SOURCES OF NATURAL GAS SUPPLY

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ABSTRACT

The emerging area of management and distribution of global energy resources presents new challenges to businesses, industries, and researchers. This paper describes a prototype used to evaluate the situation and to facilitate rapid decision-making for alternative natural gas supply sources given an unprecedented scenario. It provides a step-by-step approach to determining the best alternative based on cost and risk reduction. It incorporates data about the top exporters and importers of natural gas, their rank order, and the relationship between the importers and exporters of natural gas, as well as the factors guiding such relationships. Results of these relationships are incorporated into a database and examples are chosen to analyze for alternative selection. The solution obtained demonstrates the feasibility of developing an integrated system and its useful implementation for determining alternative sources of natural gas supplies given critical scenarios in the value chain.

INTRODUCTION

Despite its rapid growth in recent years, Liquefied natural gas (LNG) remains a relatively small contributor to world gas demand (under 7% of the total world gas demand in 2005) and even to total internationally traded gas, (about 22% of gas trade) according to the National Petroleum Council (2007). Pipeline gas still dominates international trade most notably supply to Western Europe from Russia, North Africa and Norway and supply to the US from Canada. With regards to regional LNG trade, the Pacific Basin and Asian markets almost double the size of the Atlantic Basin and Mediterranean markets.

By end of 2010, LNG trade is expected to be more than 10 trillion cubic feet (tcf) annually from the recent 6.5 tcf, with the United States expecting most demand followed by Northern Europe, Japan, South Korea, China and India (BP, 2005). Although trade movement is lower in the Pacific, countries in this region supplied 59% of the global

LNG market. In 2006 and 2007 LNG shipment rose by 11.8% and 7.3% respectively; which is in line with historical average considering increased shipments from Qatar and Nigeria (Rühl 2007 & BP 2008). Asia, recorded an incremental average of 10% in LNG imports with Japan and South Korea being the major importing nations (PRLog, 2007), while European imports rose by 20%. In 1995, there were eight LNG exporting countries and nine importing countries (Ogj, 2007). By 2007 the number has increased to 15 exporting countries and 17 importing countries. World trade in LNG reached a total of 211.1billion cubic meters (bcm) in 2006, an increase of 11.7% on figures for the previous year, according to Cedigaz (2008).

In 2002 only 23% of world gas consumption was imported and 26% of that was in the form of LNG (Jensen et al., 2004). Between 2000 and 2020 world demand is forecasted to grow by 1727bcm (IEA, 2002). In the same light the US energy information administration also predicts a similar growth of 54tcf between 2005 and 2030 (EIA, 2008). With the exception of Russia and other countries of Eurasia, natural gas production is expected to represent a significant portion for exports in the Mideast (Qatar) and Africa (Nigeria, Algeria, Egypt and Libya).

Statement of the Problem

The evolution of natural gas trade between Eurasia and its western neighbors cannot be cited without upheavals. In the past, gas importing countries feared an interruption in important gas supplies for a variety of reasons such as contract disputes between Algeria and its customers (Hayes, 2006), political unrest in Indonesia (von der Mehden & Lewis, 2006) and transit country risk such as in Ukraine and Belarus for Russian exports (Victor & Victor, 2006). In March 2008 disputes between Russia and Ukraine accompanied a reduction of Russian supply for 3 days, and Turkmenistan cut supplies to Iran citing technical issues with the pipeline and a breach of pricing contract (EIA, 2008). According to Stratfor (2008), Turkmenistan shut natural gas supplies to Iran (which holds the world's second largest natural gas reserves) at the start of 2008 due to pricing squabbles between the two countries.

Statement of the Objective

The objective of this project is to investigate the present status and trends of natural gas supply and develop a prototype to accommodate planning and implementation by providing the following capabilities: (i) provision of alternative efficient natural gas distribution routes in terms of minimum cost and risk, (ii) identification of the alternative natural gas supply sources given a scenario (supply crisis), and (iii) assess the influence of stakeholders in the selection of alternative sources of natural gas supply. This paper

focuses on the exposition of the prototype components and its features while special emphasis is placed on the contribution of this system in providing integrated solutions to the natural gas supply source problem. The proposed model thus identifies alternative efficient gas supply sources in terms of cost and risk. The Model layer comprises the database that facilitates the decision support system and provides tools to observe time series data, with a linkage to real time data acquisition and monitoring (Ramachandra et al., 2005).

Background

The development of a decision support system (DDS) and applications to provide solutions to problems in natural gas management and logistics has attracted substantial research efforts in the past two decades. Particular examples include the use of analytical hierarchy process as a decision support system in the petroleum pipeline industry (Nataraj, 2005) and applying GIS to provide alternative routes (Kirchner, 2007). Chin & Vollman (1992), describe a methodological framework for developing a decision support model for natural gas dispatch. Queiroz et al., (2007) describe a DSS model to aid designers in the task of elaborating distribution network projects by using optimization and artificial intelligence.

Zografos & Androutsopoulos (2008) proposed a DSS to accommodate the hazardous materials risk management process by integrating vehicle routing and emergency response planning decisions. In particular, they argue that a decision support system for hazardous materials transportation risk management should address the following issues: (i) cost-risk trade off of alternative hazardous materials distribution routes, (ii) Optimum deployment and routing of the emergency response units, and (iii) Optimum evacuation plans.

Ramachandra et al., (2005) introduced a decision support system for regional domestic energy planning. In particular, they argue that a decision support for domestic energy planning should address the following issues: (i) determine fuel consumption patterns in various agro-climatic zones, (ii) provide means for entering, assessing and generating reports and (iii) analyze energy indices and interpretation for sound decision making. They developed a prototype that could transform data into information and help decisions for domestic energy consumption to assess bioenergy potential for Kolar district (Karnataka state, India) using Bioenergy Potential Assessment (BEPA), a spatial decision support system.

Yildirim & Yomralioglu (2007) have developed an interactive GIS-based Pipeline Route Selection by ArcGIS in Turkey. They integrated GIS technology into the decision support system to provide alternative routes and calculate construction and operation cost. Giglio et al. (2004) developed a decision support system for real time risk

assessment of hazardous material transport on road. They focused their study on the risks associated with hazmat road transport by tanker trucks of petroleum products.

Considering the practical issues, requirements, and circumstances involved in natural gas distribution networks, a Decision Support System (Sprague & Watson, 1989) model becomes suitable and appropriate to the problem approached in this project. The prototype has been developed along the lines of Decision-Support System Workbench for Sustainable Water Management Problems introduced by Morley *et al*, (2004) and optimal routing of natural gas developed by SINTEF.

METHODOLOGY

As stated earlier, this research focuses on developing a prototype to study the flow of natural gas supply between consumer (importer) and producer (exporter) countries. Further, the system identifies the degree of interactions among the countries through the use of *certainty* and *dependency* factors. If the relationships among the export and import countries are ever disturbed, these factors, along with data on major suppliers and importers, help to determine the alternatives in the in the natural gas distribution chain.

Data Collection

As major players in the natural gas sector, forty nine countries were selected. Data on these countries was obtained from the Central Intelligence Agency's 2008 publication of World Fact book, and the BP's 2008 Statistical Review of World Energy. Since data was derived from two sources, comparison was made to ensure compatibility between the figures. The data was tabulated using reserve (R), consumption (C), production (P), export (E), and import (I) variables. Net reserve (Nr) was calculated using $Nr = R - C + I - E$.

The selected countries (49) are divided into three categories; Exporting, Self-sufficient, and Importer groups. Twenty eight of them were selected with selection being based on the total volume of natural gas each country holds in that category. This volume ranges from largest to smallest with only the major players (countries that carry high volumes of import or export) categorized as shown in the following table. Aside from political and technical factors, the greater the volume, the greater the influence and role it exerts in natural gas trade flow.

After the data was classified into the three categories, emphasis was placed on the relationship between the major suppliers and importers in terms of quantity of gas distributed, as well as the relational factors that govern the flow of natural gas between these countries (Figure1).

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Table 1: Natural gas importing and exporting countries					
Exporting		**Importing**		**Self-sufficient**	
Country	Capacity (bcm)	Country	Capacity (bcm)	Country	Capacity (bcm)
Russia	237.21	United states	130.30	Colombia	0.00
Canada	107.30	Japan	95.62	Venezuela	0.00
Norway	86.11	Germany	88.35	Azerbaijan	0.00
Algeria	59.40	Italy	73.95	Iraq	0.00
Netherlands	55.67	France	44.56	Iran	0.00
Turkmenistan	49.40	South Korea	34.39	Kuwait	0.00
Qatar	39.30	United Kingdom	29.19	Saudi Arabia	0.00
Indonesia	33.13	Mexico	11.69	Bangladesh	0.00
Malaysia	31.57	Turkey	35.31		
Nigeria	21.21				
Trinidad &Tobago	18.15				

The directions of the arrows indicate the actual direction of flow of natural gas from the suppliers to importers. Based on the number of suppliers destined to each importing country, a *certainty factor* was attributed to each receiving country indicating the degree of assurance for natural gas supply for the importer. The higher the certainty factor, the higher the supply assurance and vice versa. On the exporting side, a *Dependency factor* was defined to determine how many major importer countries depend on each of the exporting countries.

Figure 1: Quantity-based relationships between the major players
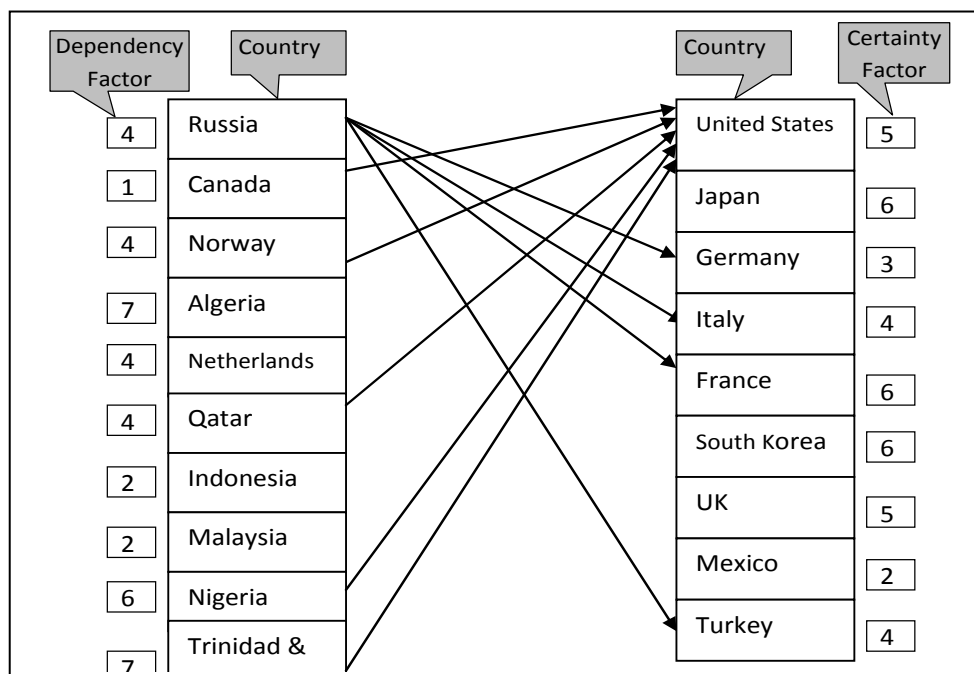
Table 2: Relationship guiding factors between importing and exporting countries									
Importer	**Exporter**								
	Russia	Canada	Norway	Algeria	Nether-lands	Qatar	Indonesia	Malaysia	Nigeria	Trin. & Tobago
United states		PF=3 R=3 Pc=3 Tc=3 Pr=3		PF=2 R=2 Pc=2 Tc=1 Pr=1		PF =3 R=3 Pc=3 Tc=2 Pr=2			PF =3, R=3 Pc=1 Tc=2 Pr=1	PF =3 R=3 Pc=3 Tc=3 Pr=3
Japan				PF =2 R=1 Pc=1 Tc=1 Pr=3		PF =2 R=2 Pc=1 Tc=2 Pr=2	PF =3 R=3 Pc=2 Tc=3 Pr=3	PF =3 R=3 Pc=2 Tc=3 Pr=3	PF =3 R=2 Pc=1 Tc=1 Pr=1	PF =1 R=0 Pc=1 Tc=1 Pr=1
Germany	PF =3 R=3 Pc= 0 Tc= 3 Pr=3		PF =3 R=1 Pc= 2 Tc = 3 Pr=3		PF =3 R=0 Pc = 2 Tc = 3 Pr=3					
Italy	PF =3 R=3 Pc= 0 Tc= 3 Pr=3		PF =3 R=1 Pc = 1 Tc= 3 Pr=2	PF =3 R=2 Pc= 3 Tc= 3 Pr=2	PF =3 R=1 Pc= 1 Tc= 3 Pr=2					
France	PF =3 R=3 Pc= 1 Tc= 3 Pr=3		PF =3 R=3 Pc= 2 Tc= 3 Pr=3	PF =3 R=3 Pc= 3 Tc= 3 Pr=3	PF =3 R=2 Pc= 2 Tc = 3 Pr=3				PF =2 R=3 Pc= 3 Tc= 2 Pr=2	PF =2 R=1 Pc= 2 Tc= 1 Pr=2
South Korea				PF =2 R=3 Pc= 2 Tc= 2 Pr=3		PF =3 R=3 Pc= 3 Tc= 2 Pr=3	PF =3 R=2 Pc= 1 Tc= 3 Pr=3	PF =3 R=2 Pc= 1 Tc = 3 Pr=3	PF =3 R=3 Pc= 2 Tc= 1 Pr=2	PF =2 R=1 Pc= 1 Tc= 1 Pr=2
United Kingdom			PF =3 R=2 Pc = 2 Tc = 3 Pr=3	PF =3 R=3 Pc= 3 Tc= 2 Pr=3	PF =3 R=2 Pc=2 Tc = 3 Pr=3	PF =3 R=3 Pc=2 Tc=2 Pr=3				PF =2 R=1 Pc=1 Tc =1 Pr=1
Mexico									PF =2 R=3 Pc =3 Tc =1 Pr=2	PF =3 R=2 Pc =2 Tc = 3 Pr=2
Turkey	PF =3 R=3 Pc =1 Tc =3 Pr=3			PF =3 R=2 Pc =2 Tc= 3 Pr=3					PF =1 R=2 Pc =3 Tc =2 Pr=1	PF =1 R=1 Pc =1 Tc =1 Pr=2
PF = Political Factor, Pc= Production cost, Tc= Transport cost, R= Reserve, Pr= Production level. The empty cells represent no relationship between the two countries that it intersects									

Apart from *dependency* and *certainty* factors, the relationships (Rs) among the export and import countrie are influenced by several other factors including Political (P_f), Production cost (P*c*), Transport cost (T*c*), proved Reserves (Rp), and volume of Production (Pr). Thus, a more comprehensive relationship can be expressed as: Rs = <P_f, P*c*, T*c*, Rp, Pr>.

In determining the degree of strength of the supply relationship, within the framework of this model, the factors were rated on a scale of 0 to 3, with 3 having a stronger influence on the relationship and a factor with 0 having a weaker influence. In addition the following assumptions were made:

Political relations set the pace for other factors to come in especially the economic factor that includes all costs, and production.

Reserves (*Rp*) and Production (*Pr*) factor ratings are determined by the exporting country's rank order and political influence of the country it supplies natural gas to. Transport cost (*Tc*) rating is determined by distance. The greater the distance the higher the transport cost and the lower the influence on the strength of relationship.

In the light of the above discussions, the relationships among the importers and exporters can be quantified as shown in Table 2.

TESTS AND DISCUSSION

The relationship between countries in the natural gas supply chain is a result of not only the quantity of gas that flows between these countries but also other factors providing a long term certainty/uncertainty of supply to importers. In the event of a dispute that may arise from, for example, the breach of pricing contract (viz Russia and Ukraine in 2008), the relationship becomes fragile, jeopardized by the shutdown of natural gas supply which may lead to the termination of the long term relationship. This creates a "what if" scenario and forces importing countries to seek ways to minimize the consequences from such a situation. These consequences can only be mitigated through a prototype represented by a database which through the process of data mining will enhance the formulation and implementation of a solution as a decision support tool for the planning and organization of the natural gas value chain, helping to decide who will be the best alternative supplier.

In developing the system we followed the classical five stage project life cycle i.e. user requirements identification, functional specifications, system design, prototype development and evaluation. The user requirements will be achieved based on the following:

Determination of alternative routes for the supply of natural gas based on cost and risk minimization;

Determination of alternate supplier;

Computation of scenario probabilities and measure of expected consequences (risk assessment);

Performing an analysis on the number of suppliers available to achieve alternative service for unforeseen scenarios.

Database

As stated, this paper focuses on the development of a prototype to study the effects of different natural gas supply and demand scenarios and provides alternative solutions to the problem of distribution in a cost effective manner and at minimal risk. In order to validate the approach and the characteristics of the prototype, a relational database is designed to analyze and monitor the flow of supplies. This database includes Supplier, Importer, Tanker Truck, and Supply Route. The Supplier table consists of attributes for the name of exporting countries, their regional location and attributes for the factors that may determine the strength of the exporting country in an importer-exporter relationship. Similar attributes are found in the Importer table. The Tanker Truck table contains attributes like the tanker or truck name, their capacity, and commission date. The Supply Route table merely describes the route information (maritime or land) with attributes for distance, route, tanker or truck name that ply the route and tanker, or truck ID for referencing. All the tables have primary key attributes which in our case are auto generated numbers for referential integrity.

In order to reinforce the rule for referential integrity, as well as reduce inefficiency errors, output errors, and redundancies that may lead to data anomalies in our database, a Many-to-Many relationship was implemented between the supplier and importer tables using a *Bridge or Composite entity* (Tanker Truck table). To create this entity, the primary keys of the supplier and importer tables were included into the entity table. The essence of this relationship reinforces the idea that one country can export natural gas to many countries, and at the same time a country can import natural gas from many other countries. Meanwhile a One-to-Many relationship was implemented between the entity table and the supply route table, since a tanker or truck can ply many routes based on cost effectiveness and risk minimization.

As earlier mentioned, the executive decision making process to select an alternate supplier arises based on an unprecedented scenario that may lead to the suppression or total cut of natural gas supply, like the case between Nigeria and the US due to frequent attack by armed groups in the Nigerian oil rigs, contract disputes between Algeria and its customers, the 2006 transit country risk such as Ukraine and Belarus for Russian exports, pricing squabbles between Turkmenistan and Iran, and the March 2008 disputes between Russia and Ukraine. The outcome of a similar scenario was represented by highlighting

and deleting a record from the Supplier table. In our approach the relationship between France and Algeria was elaborated upon as shown in Figure 2

The above scenario was supposedly accompanied by the shutdown of natural gas (LNG) supply from Algeria to France, putting France in a critical situation since more than half of its supplies come from Algeria. As a solution to this problem, stakeholders involved in the Algeria-France gas distribution chain will have to make a query from the database of suppliers as shown in Figure 3 in order to get the best alternative supplier in terms of risk and cost minimization.

Doing this query requires stakeholders to determine the best criteria to be used. Since the sum of factors in each relationship determines the strength of that relationship, the sum of the values of factors was decided to be the best criteria in our case; the higher the sum of factors the stronger the strength of the relationship and vice versa. Since each factor is weighted on a 3 point scale, the maximum sum a relationship could attain is 15 based on our 5 factors. Consequently the criteria *">=13"* was defined for the *Supvalue_sum* attribute to be the best criteria. From the query in Figure 3, the best alternative was decided upon based on the query results as shown in Figure 4.

Figure 2: Scenario representation between France and Algeria

Sup_ID	Sup_name	Location	Imp_name	Tanker_Truck_name	PF-valu	R_value	Pc_value	Tc_value	Pr_value	Supvalue_sum	Sup_rank_order
3	Canada	N. America	United states	Laieta	3	3	3	3	3	15	2
4	Russia	Europe	Germany	Grandis	3	3	0	3	3	12	1
6	Russia	Europe	France	Provalys	3	3	1	3	3	13	1
7	Russia	Europe	Turkey	Excellence	3	3	1	3	3	13	1
8	Algeria	Africa	Japan	Belais	2	1	1	1	3	8	4
9	Algeria	Africa	Italy	Palmaria	3	3	3	3	2	14	4
12	Algeria	Africa	United Kingdom	Scf Polar	3	3	3	2	3	14	4
13	Algeria	Africa	Turkey	Raahi	3	2	2	3	3	13	4
15	Algeria	Africa	France	Edouad	3	3	3	3	3	15	4
16	Trinidad & Tobago	C. America	France	Norman Lady	2	1	2	1	2	8	10
17	Trinidad & Tobago	C. America	South Korea	Gandria	2	1	1	1	2	7	10
19	Trinidad & Tobago	C. America	Mexico	Excalibur	3	2	2	2	2	12	10
20	Trinidad & Tobago	C. America	Turkey	Methane Princess	1	1	1	1	2	6	10
21	Qatar	Middle east	United States	Freesia	3	3	3	2	2	13	6
22	Qatar	Middle East	Japan	Acasia	2	2	1	2	2	9	6
23	Qatar	Middle East	South Korea	Hangin Ras Laffan	3	3	3	2	3	14	6
24	Qatar	Middle East	United Kingdom	Umm Bab	3	3	2	2	3	13	6
25	Nigeria	Africa	United States	Oyo	3	3	1	2	1	10	9
27	Nigeria	Africa	France	Edo	2	1	2	1	2	8	9
28	Nigeria	Africa	South Korea	Technopia	3	3	2	1	2	11	9
29	Nigeria	Africa	Mexico	Granosa	3	2	2	3	2	12	9
30	Norway	Europe	Italy	Maestro	3	1	1	3	2	10	3
31	Norway	Europe	France	The Road Star	3	3	2	3	3	14	3
33	Netherlands	Europe	France	DeLa Soul	3	2	2	3	3	13	5
35	Trinidad & Tobago	C. America	United States	Berge Boston	3	3	3	3	3	15	10
36	Trinidad & Tobago	C. America	Japan	Suez Mathew	1	0	1	1	1	4	10

Figure 3: Query table of best alternate supplier based on sum of factors
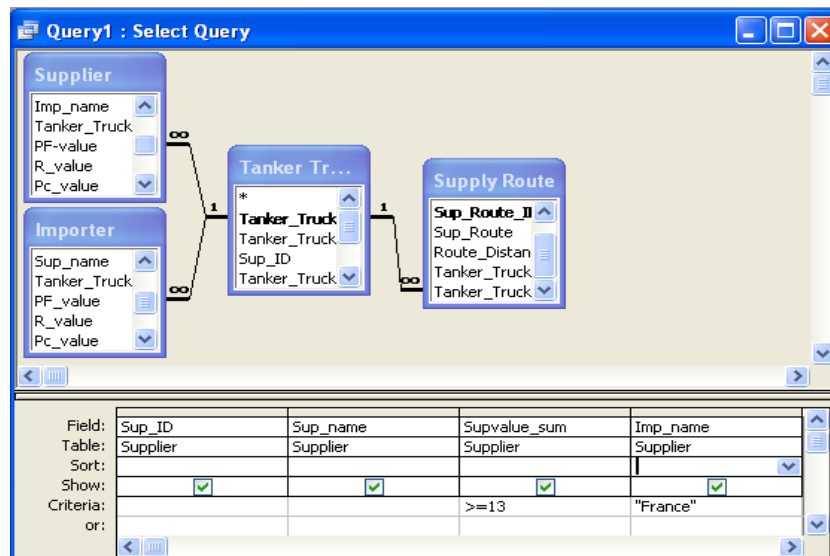
Figure4: Query results of best alternate supplier based on sum of factors

Following our database query results in Figure 4, Norway, with 14 as the sum of values of factors, represents the best alternative for France to import natural gas. However, Russia and the Netherlands also present options for alternate supplies since they fall within the range of our query criteria. The decision for Norway was based on the fact that it had the highest sum of values of each factor. This could be difficult to implement in real world situation, for the simple reason that the most influential factors in a relationship (political and economic) could be lowly weighted over other factors, making the decision for an alternate supplier faulty and misrepresented. Also in the event where the query results are identical-- i.e., the same sum of values of factors and the best alternative; Norway in our case happens to present another difficult scenario to France, the decision to separate the Netherlands and Russia will no more be based on sum of

values of factors since they have the same values, but on the rank order of the supplier in terms of global natural gas production. With this in mind, another query is conducted with supplier rank order as our new criteria which is defined as *"<4"* as shown in Figure 5.

Figure 5: Query table of best alternate supplier based on rank order
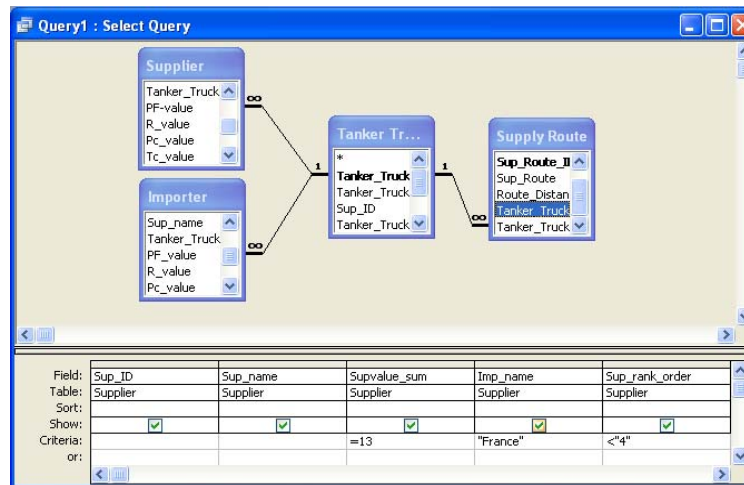
Based on rank order, the best alternative will be determined by position of that supplier in the rank classification of suppliers. From our query results, the supplier with the smallest rank order in this case will present the best conditions and opportunities to be considered an optimum alternative. Therefore Russia, with a supplier rank order of 1 will become the next best alternative to France for natural gas supply after Norway, as shown in Figure 6.

Figure 6: Query results of best alternate supplier based on rank order

Distance represented by transport cost (Tc), economics represented by production cost (Pc), and political factors are very influential in determining the strength of a supplier-importer relationship.

Countries with a high certainty factor (Japan, United States, France and South Korea) are the most dependent on natural gas supply, while those with a low certainty factor (Germany, Mexico, Italy) have the most critical situation. But this dependency does not equal increasing volumes of natural gas that is moved between the two countries since one country can supply more than half the volume of natural gas than any other country in that chain of relationship. This can be exemplified by Russia. According to the BP Statistical review of world energy 2008, The Russian Federation supplied 35.33 bcm of natural gas to Germany, a volume that exceeds supplies from the UK and Norway (26.64bcm) or the UK and the Netherlands (22.03bcm) to Germany.

In this study we found that the proportion of natural gas reserves in a country significantly influences its position as either an exporter or an importer as shown in Table 1. However, contrary to our predictions, the United States exports natural gas to Japan and Canada. The reason for this classification may be due barely to the fact that its actual proven reserves equal its net reserves (*NR)* plus additional imports. Additional imports are then used for export (though a very small volume compared to actual US imports) to Canada and Japan, but unfortunately the US still remains a major importer and consumer of natural gas in the world. In addition the frequency of error was not significant, due to the smaller number of data (2007) that was treated.

The determination of the weight of each factor in an importer-exporter relationship is an outcome of the strength of political and economic factors. Consequently the outcome in this study with the exception of our query results could be generalized with the results representing real world situation.

CONCLUSION AND RECOMMENDATIONS

The overall problem of determining alternative sources of natural gas supply is a complex interdisciplinary problem that should be faced with many view points, one of which is optimal risk-based planning of natural gas routing. This paper presented an integrated multi-scaled prototype for the selection of an alternative supplier of natural gas. The prototype aimed at computing dynamic risk scenario in real-time natural gas supply and it was based on a methodology that determined the critical factors that support the relationship between two or more countries in the natural gas supply chain. It provides a user friendly, model-based environment for determining the best alternate supplier and it establishes supplier-importer relationships while evaluating the factors that govern these relationships. A major feature of the prototype is that it integrates framework and mathematical models, including a relational database that was used to

exemplify stakeholder decision making procedures to determine the best natural gas supplier given an unprecedented scenario between France and Algeria.

Once the decision support prototype is verified on historical and real-time data it should be able to be extended to link with or enhance current scenario planning systems of natural gas supply. However the prototype is general purpose, in the context that it needs to be adapted to suit the scenario environment and conditions it will be applied in.

Recommendations for future studies are both technological and methodological. A technological aspect would be related to the enhancement of information to monitor and control factors that may lead to a possible outcome of a scenario. Methodological aspects could deal with the calibration of the model on a set of historical data and on practical experience of fleet (tanker or truck) and with the integration with scenario planning modules. In addition, further research is required in identifying the input factors of each scenario and undertaking sensitivity analysis. Also, a quantitative comparative analysis of the results of each scenario could be finalized.

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A SURVEY OF INFORMATION SYSTEMS DEVELOPMENT PROJECT PERFORMANCE

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ABSTRACT

This paper presents the results of a 2009 survey of professional IT auditors that explored their perceptions about root psychological and sociological causes of Information Systems (IS) project failure based on the punctuated equilibrium theoretical framework. As predicted by punctuated equilibrium theory, the results of the survey indicate that radical as opposed to incremental organizational changes are more effective in turning around "runaway" projects. The results indicate that IS development project performance is worse in government than in the private sector, and provide support for the continued use of punctuated equilibrium models for research in information systems development project performance.

CURRENT INFORMATION TECHNOLOGY (IT) ISSUES

The rate of information systems development project failure in the 1980s and 1990s was routinely documented to be above 50%, the larger the development; the more likely it was unsuccessful (SIMPL & NZIER, 2000). A 1994 study of IS development projects in the British public sector estimated that 20% of expenditures were wasted, and a further 30% to 40% did not produce perceivable benefits (Wilcocks, 1994). Also in 1994, the U.S. General Accounting Office reported that spending of more than US$200 billion in the previous twelve years had led to few meaningful returns. A 1995 study of over 8,000 IS projects by Johnson revealed that only 16% were completed on time and within budget (Johnson, 1995). The U.S. Internal Revenue Service, with an annual computer budget of US$8 billion, managed "a string of project failures that have cost taxpayers $50 billion a year [mainly defined as revenue forgone] - roughly as much as the yearly net profit of the entire computer industry" (James, 1997). Collins and Bicknell (1997) estimated that public sector failures in the United Kingdom cost £5 billion. The Wessex Health Authority's Regional Information Systems Plan was cancelled after more than £43 million had already been spent, with little achieved (Collins et al., 1997). The New Zealand Police abandoned an IS development in 1999, at a cost of more than NZ$100 million, after years of development provided little more than an e-mail system and a number of terminals run by a 1970s-era mainframe. A study by SIMPL & NZIER

(2000) found that the success rate was only 55% for projects under US$750,000; however, for those with budgets over US$10 million, no projects were successful. A 2001 U.S. Standish Group survey of IS projects found success rates were as follows: 59% in the retail sector, 32% in the financial sector, 27% in manufacturing, and 18% in government. Overall, the average success rate was 26%. In all, 46% of the projects had problems, including being over budget, behind schedule, or delivered incomplete. Another 28% failed altogether or were cancelled, and cost overruns averaged nearly 200% (SIMPL & NZIER, 2000).

The beginning of the 21st century showed little improvement in IS development project performance. In 2002, the United Kingdom's National Health Service initiated the largest-ever public sector project at an estimated cost of £11 billion. This led to the introduction of new information systems in almost every hospital, but it was still considered a failure (Rainer & Turban, 2009). A benefit payment scheme involving the British Post Office, the Department of Social Security, and the computer company ICL was abandoned after three years and a cost of £300 million (The Economist, 2002). An already obsolete air-traffic support system opened at Swanson in the United Kingdom, in 2002, six years late and £180 million over budget (The Economist, 2002). The Canadian Firearms Program increased from initial estimates of C$113 million to more than C$1 billion, an overrun of almost 900% (Auditor, 2002). Georgiadou (2003) found five out of six corporate projects are considered unsuccessful, with one-third cancelled. Of the two-thirds that were not cancelled, price and completion times were almost twice what had originally been planned. Dalcher and Genus (2003) reported US$150 billion was wasted per annum on information and communications technology failures in the public and private sectors in the United States and US$140 billion in the European Union. A 2004 Standish Group report estimated a success rate of 29%, with 53% of the projects having problems, and a failure rate of 18%. The Royal Academy of Engineering and the British Computer Society (2004) found that 84% of public sector projects resulted in failure. Vast sums of money, mostly provided by aid agencies, have been spent on health and other information systems in South Africa, on donor-funded IS projects in China, and on World Bank funded projects in Africa. Overwhelmingly, these projects have resulted in varying degrees of failure (Heeks, 2002, 2004). The Standish Group's 2009 report showed only 32% of all projects succeeded, while 44% were problematic and 24% failed. In the United States the best known IS project failures are the FBI Trilogy Project (Knorr, 2005; US GAO, 2006), the California Motor Vehicles Driver Licensing System (Bozman, 1994), and the Denver airport baggage handling system (Montealegre & Keil, 2000).

In summary, the consensus is that 20% to 30% of all IS development projects are perceived as overwhelming failures, while 30% to 60% are partial failures (Collins et al., 1997; Corner & Hinton, 2002; Georgiadou, 2003; Heeks, 2002; Iacovou, 1999; James, 1997).

IS projects that run wildly over time and budget have been labeled "runaways" (Glass, 1998; Mann, 2003). Runaway projects have been said to take on a life of their own without adding business value (Zmud, 1980; DeMarco, 1982; Abdel-Hamid & Madnick, 1991; Johnson, 1995; Mahring & Keil, 2008). One of the main reported causes of "runaway" projects has been said to be management over-commitment to the project (Keil, 1995). The management behavior that underlies runaway projects resembles what IS researchers have called the process of "escalation of commitment to a failing course of action" (Brockner, 1992; Keil, 1995; Schmidt & Calantone, 2002). The reverse of this process has been defined as IS project de-escalation (Keil & Robey, 1999; Montealegre & Keil, 2000; Royer, 2003; Heng et al., 2003). The literature suggests four general types of determinant factors of project commitment: project, psychological, social, and organizational. (For a good review see Newman & Sabherwal, 1996). The tendency for managers to over-commit to an obviously failing project has lent credence to the strategy that it is sometimes better to radically change the entire organization rather than incrementally improve the immediate project team (Pan et al., 2006a, 2006b). This line of research stems from punctuated equilibrium models that have their roots in biology (Eldredge & Gould, 1972) and are increasingly being proposed in the organizational sciences (e.g., Tushman & Anderson, 1986; Mokyr, 1990; Gersick, 1991).

Most of the research on IS project failure was conducted prior to the age of IT governance practices put in place after the 2002 Sarbanes Oxley Act. IT governance implies a management system in which top management has a much larger influence on IS development project decision-making.   The exploratory research presented here responds to the need for an improved understanding of IS project performance in the post-Sarbanes Oxley environment. The primary purpose of this study was to determine the extent to which, given recent increase in IT governance practices, runaway projects continue to be common and to help determine promising new areas for future research in preventative measures. Another purpose of the study was to determine if, as predicted by punctuated equilibrium theory, radical organizational changes are more effective in withdrawing commitment to runaway projects than are incremental measures.

The remainder of the paper is organized as follows. Next is a review of the literature around the social and psychological causes of "runaway" projects. Then we present our research method followed by a discussion of the results conclusions.

SOCIAL AND PSYCHOLOGICAL CAUSES OF "RUNAWAY" PROJECTS

Management literature identifies four general types of determinantal factors of project commitment: project, psychological, social, and organizational (Newman & Sabherwal, 1996; Keil & Robey, 1999; Pan et al., 2006; Hirschheim, Klein, & Newman, 1991).   Project factors include the costs and benefits as perceived by management.

Projects are considered prone to over-commitment when they involve a large potential payoff, when they require a long-term investment before substantial gain, and when setbacks are perceived as temporary surmountable problems (Keil, 1995; Keil, Man & Rai 2000).

Psychological factors cause managers to believe the project will eventually be successful (Brockner, 1992). Contributing causes include the manager's previous experience, the degree to which the manager feels personally responsible for the outcome (Newman & Sabherwal, 1996), and cognitive biases (Tversky & Kahneman, 1981). Other research has suggested that managers may engage in a kind of "self-justification" behavior committing additional resources to a project instead of ending it and admitting that their earlier decisions were flawed (Whyte, 1986; Staw & Ross 1987; Ross & Staw, 1993). This line of research, known as self-justification theory (SJT), is grounded in Festinger's (1957) theory of cognitive dissonance. Prospect theory focuses on the cognitive biases that influence human decision-making under uncertainty. A derivative of this theory is the so-called "sunk cost" effect in which decision makers exhibit a tendency to "throw good money after bad" (Garland & Conlon, 1998). That research suggests that sunk costs may influence decision makers to adopt a negative frame, promoting risk-seeking (IS project escalation) behavior. Approach-avoidance theory suggests there is a natural tendency for management to over-commit to IS projects because of the "completion effect," which suggests the motivation to achieve a goal increases as an individual gets closer to that goal (Garland & Conlon, 1998; Pan et al., 2006). The completion effect is particularly relevant to software projects, which frequently exhibit the so-called "90% complete" syndrome (DeMarco, 1982; Garland & Conlon, 1998).

Social factors also promote IS project over-commitment (Newman and Sabherwal, 1996; Pan et al., 2006). Social factors include competitive rivalry with other social groups, the need for external justification, and norms for consistency (Brockner et al., 1979; Hirschhem, Klein, & Newman, 1991). Projects are prone to over-commitment when competitive rivalry exists between the decision-making group and another social group, when external stakeholders believe the project will be successful, or when norms of behavior favor persistence (Ross & Staw, 1993). One social determinant of commitment is "the desire not to lose face or credibility with others" (Staw & Ross 1987). The concept of "face saving" is grounded in self-justification theory (Whyte, 1986; Staw & Ross, 1987; Ross & Staw, 1993) and is discussed in the IS project de-escalation literature (Montealegre & Keil, 2000).

Organizational factors in project over-commitment include the structural and political factors that form the "ecosystem" of a project. Information systems researchers (e.g., Keil, Mann & Rai, 2000) have referred to several other organizational factors that may affect commitment to an IS project: top management's knowledge of information

technology (Vitale et al., 1986), information intensity of the organization's value chain (Johnston & Carrico, 1988), and the maturity of the IS function (Sabherwal & King, 1992). Other organizational factors identified in the literature include top management support for the project, administrative inertia in the organization, the extent of project institutionalization, and the extent to which it is perceived as strategic (Johnston & Carrico, 1988).

More recent work on IT project de-escalation suggests projects may be resistant to de-escalation because long periods of organizational "equilibrium" periods are difficult to disrupt because of the constancy of the "deep structure" of the organization (Gersick, 1991; Pan et al., 2006; Orlikowski, 1993). As a result, organizations may be unable to change substantially unless forced by a radical organization change or other crisis (Tushman & Romanelli, 1985; Sastry, 1997). In a number of industries, it has been observed that long periods of unsuccessful "incremental" organizational change tend to be interrupted by short periods of radical change called "revolutionary periods" (Abernathy & Utterback, 1978; Utterback & Suarez, 1993). This pattern termed "punctuated equilibrium," was originally identified in the biological sciences (Eldredge & Gould, 1972) and was subsequently adopted in the management literature (e.g., Tushman & Anderson, 1986; Mokyr, 1990). According to punctuated equilibrium theory, organizations tend toward "equilibrium" because of the permanence of the organization's "deep structure." The *deep structure* of an organization consists of its "alliances, associations and co operations with interlocking interests" (Anderson & Tushman, 1990). This analysis complements Tushman and Romanelli's (1985) identification of "performance pressures . . . whether anticipated or actual" as the fundamental agents of organizational reorientation. Tushman, Newman, & Romanelli (1986) described the scenario of an organization falling into serious trouble before responding by replacing its top management as typical. They found "externally recruited executives are more than three times more likely to initiate frame-breaking change than existing executive teams … Failures caused by inappropriate deep structures are destined to elude the (misdirected) efforts of current system members to correct them. Unless such failures kill the system, they command increasing attention and raise the likelihood that newcomers will either be attracted or recruited to help solve the problems. The newcomer has the opportunity to see the system in an entirely different context than incumbent members, and he or she may begin problem solving on a new path" (Tushman, Newman, & Romanelli, 1986).

The preceding review demonstrates the extreme complexity of the study of information system (IS) development project performance. Existing research demonstrates the presence of many important factors that affect such a project. This raises the question of the most important areas for further IS practice research: Should the focus be on the subtleties of the various indirect psychological and social factors

mentioned above? Or, is it more practical to concentrate on the practice of project management itself? The answers to these questions are the impetus for this study.

RESEARCH METHOD

In order to address these research questions concerning IS development projects a simple questionnaire was developed to survey IT audit professionals. The design of the survey was based on Dillman's (1978) "total design method." Auditors were selected for the study because they are likely to be more objective than other IS project stakeholders, such as managers directly responsible for problematic projects. The sample was designed to select professional IT auditors who would be most likely to be involved in information systems development. The pool of individuals represented approximately one thousand (1000) Information Systems Audit and Control Association (ISACA) members in the Houston, Texas area. The survey was designed to gather data concerning the perceived frequency of problematic IS development projects, the perceived major sources of problems, and the recommended magnitude of corrective actions. A survey is usually the most cost-effective way of collecting data on a large number of IS projects (Mann, 1996). To get a reasonable response rate, the survey was designed to be completed in less than ten minutes. To ensure the survey questions demanded minimal cognitive effort, questions consisted mostly of paired category choices.

The pool of one thousand auditors (1000) was emailed a link to the survey that was posted on the international ISACA web site. The approximately one hundred (100) respondents were asked to consider projects with which they were familiar that fit the definitions of "problematic," "runaway," and "failed" on the survey form. The survey had five sections: introduction, demographics, project performance, corrective actions, and closing. Please see Appendix A for the actual survey questions. The survey was refined through two iterations of pre-testing.

The demographics of the sample are shown in Tables 1, 2, 3 and Table 12 below. Almost half the respondents reported having more than fifteen years experience, while over 40% reported having more than five years experience. Almost 80% reported having the Certified Information Systems Auditor (CISA) certificate; and, about half reported they had been involved with either a problematic or a runaway project (Table 12).

Variables, such as auditor experience, could have affected the results. However, a similar survey of IT auditors showed these variables did not affect overall results (Keil et al., 2000). Thus, to keep the survey brief, we chose not to control for these factors. Furthermore, as was the case in Keil et al. (2000), our method did not allow us to measure non-response bias. To increase the reliability of the survey instrument, three different measures of project performance were operationalized: (1) "failed" projects, (2) "problematic" projects and (3) "runaway" projects

RESULTS AND DISCUSSION

Overall project performance

The results for overall project performance are shown in Table 4. Significantly more of the respondents reported the overall rate for both problematic and failed projects are above 50%. These high frequencies are corroborated by the fact that 40% of the respondents reported having been involved with a "runaway," and 60% reported involvement with a "problematic" project (See Table 12). The findings regarding "runaways" reported here appear to contrast sharply with researchers who contend that software project runaways are rare events (Glass, 1997).

Table 1: Length of Participant Professional Experience		
Question #	Category	Responses
3.1	More than one year experience	87%
3.2	More than 15 years	48%
3.3	Between 5 and 15 years	45%
Table 2: Type of Participant Industry Experience		
Question #	Category	Responses
3.3	Financial Services	22.4 %
	US State Government	4.7 %
	National Government	8.2 %
	Manufacturing	31.8 %
	Trade	14.1 %
	Health Care	10.6 %
	Transportation	8.2 %
Table 3: Participant Credentials		
Question #	Category	Responses
3.4	CIA (Certified Internal Auditor)	28.6 %
	CISSP (Certified Information Systems Security Professional)	23.4 %
	CISA (Certified Information Systems Auditor)	77.8 %
	PMP (Project Management Professional)	26.9 %

Sources of project problems

As can be seen in Tables 6 and 7, the most important sources of problems for both problematic and runaway projects were perceived to be formal attributes of the project team such as size, skills, etc., rather than informal social or psychological attributes of project stakeholders.

Table 4: Perceived Overall Project Performance			
Measurement Construct	Survey Question #	Response Choice	Responses
Project failure rate	2.1	Greater than 50%	62.5%
		Less than 50%	37.5%
Problematic project rate	2.5	Greater than 50%	65.0%
		Less than 50%	35.0%
Problematic projects become runaway	3.5	Greater than 50%	**66%
		Less than 50%	**33%
Rate at which runaways are turned around	3.10	Less than 20%	71.6%
		Greater than 20%	28.4%
Premature project termination rate	3.12	Less than 20%	55.4%
		More than 20%	44.6%
** Indicates that differences in the proportions are not statistically significant			

Table 5: Perceived Causes of Problematic Projects			
Survey Question #	Response Choice	Most likely cause	Least likely cause
2.7	Formal attributes of the project team (size, structure, skills, etc.)	68.0 %	31.7 %
	Formal attributes of the surrounding enterprise (size, structure, skills, etc.)	63%	34 %
	Informal social relationships among the project stakeholders	31.0 %	68.3 %
	Psychology of individual project stakeholders (beliefs, fears, motivations, confidence, etc.)	48 %	50 %

Government versus private sector performance

Table 8 shows significantly more respondents believed that all three project types - failed, problematic, and runaway - are more likely to occur in government than industry. We argue that this result is consistent with that predicted by punctuated equilibrium theory (the argument is presented as an informal theorem in Table 7).

Table 6: Perceived Causes of Runaway Projects			
	Response Choice	Most likely cause	Least likely cause
Survey Question 3.9	Formal attributes of the project team (size, structure, skills, etc.)	75%	25%
	Formal attributes of the surrounding enterprise (size, structure, skills, etc.)	63%	37%
	Informal social relationships among the project stakeholders	27%	73%
	Psychology of individual project stakeholders (beliefs, fears, motivations, confidence, etc.)	45%	55%

Table 7: Punctuated Equilibrium: the "Deep Structure" Theorem	
8.1	If an organizational structure is controlled by elected government officials, its "deep structure" is harder to change than that of private industry.
8.2	If the deep structure" of an organization is relatively harder to change, it will be relatively more likely to produce over-committed projects.
8.3	If management is over-committed to a project, it is more likely to runaway or fail.
8.4	Therefore runaway projects and failed projects should be expected to occur more often in government than in the private sector, all other things equal.

Table 8: IS Project Performance: Government versus Private Sector			
Measurement construct	Survey Question #	Government Sector	Private Sector
Most likely sector for problematic projects	2.6	71.3 %	28.8%
Most likely sector for failed projects	2.3	78 %	21%
Most confident sector	2.2	11.2 %	89%
Most likely sector for runaway projects	3.11	80.0 %	20.0%

The role of "collective belief" in management over-commitment

Another important determinant of management commitment to an IS project has been termed the "collective belief" in the eventual success of the project (Royer, 2002). Our results suggest that government managers seem less confident in their abilities than do private sector executives (See Table 8, question 2.2) and that government is more likely to produce runaways and failures than is the private sector (Table 9, question 3.11). However, these results run counter

to that reported in Royer (2002). There it was found that "collective belief" in the eventual success of the project was a primary determinant of management over-commitment.

	Table 9: Punctuated Equilibrium: the Revolutionary Changes Theorem
9.1	The "deep structure" of an organization consists of more members of top management than of project management.
9.2	The deep structure of an organization is more likely to be changed by a radical (or revolutionary) change than by a more modest (or incremental) change (Gersick, 1991).
9.3	Replacing top management constitutes a more radical organizational change than does educating top management.
9.4	Radical organizational changes are more effective in correcting runaway projects than are incremental changes. (From 8.2, 8.3 and 10.1 – 10.3)

Corrective actions, incremental or radical?

Survey section three (corrective actions) was designed in part to measure whether, as predicted by punctuated equilibrium theory, respondents thought it more effective to apply radical (aka "revolutionary") measures to turn around "runaway" projects than to apply more moderate (aka "incremental") ones (Gersick, 1991). These results are consistent with the punctuated equilibrium argument presented as an informal theorem in Table 9: for "runaway" projects, question 3.8 (See Table 11) respondents believed it more beneficial to choose the radical action of replacing project management rather than the incremental action, simply educate them. However, for "problematic" projects, the respondents reported the opposite conclusion: that an incremental change (i.e., education) is more beneficial than the more radical change, replacing staff (See Tables 11 and 12). Overall though, our results strongly support the conclusion that project factors are more important than organizational factors in determining project failure or success.

Table 10: Correcting Problematic Projects		
Survey Question #	Response Choices	Responses
3.1	Improving top management	39.1%
	Improving project management	60.9%
3.2	Replacing top management	4.3%
	Educating top management	95.7%
3.3	Replacing project management	39.1%
	Educating project management	60.9%

Corrective actions, top management or middle management?

In all cases, our respondents believed it more beneficial to take corrective action at the project management level than at the top level of management (See Tables 11 and 12). These

results suggest the most important causes and remedies for poor project performance have to do more with project management practices than with the structure of the surrounding organization. This does not support the notion that IT governance initiatives introduced by many large organizations early in the 21st century have improved performance of IS development projects.

Table 11: Correcting Runaways Projects		
Survey Question #	Response Choices	Responses
3.6	Improving top management	36.2%
	Improving project management	63.8%
3.7	Replacing top management	18.8%
	Educating top management	81.2%
3.8	Replacing project management	68.1%
	Educating project management	31.9%

Table 12: Perceived Causes of Problematic Projects			
Survey Question #	Response Choice	% Responses	
3.5	Rate that problematic projects become "runaways"	Greater than 50% **60%	Less than 50% **40%
3.12	Premature runaway termination rate	Less than 20% **57%	Greater than 20% **43%
2.4	Percent involved with a "problematic" projects	Yes? **60%	No? **40%
3.4	Percent involved with a "runaway" project	Yes? 38%	No? 62%
** Indicates that differences in the proportions are not statistically significant			

Risk aversion in runaway projects

Another purpose of the study is to help managers decide on an appropriate level of risk aversion in "runaway" projects. On survey question 3.12 (See Table 4) respondents reported an insignificant difference between those that believe managers prematurely kill runaway projects less than 20% of the time, and those that believe mangers prematurely kill runaway projects more

than 20% of the time. Thus, we speculate that managers actually kill projects prematurely about 20% of the time. How managers feel about this likelihood is important to the organization's bottom line. For example, suppose management decides to kill any project at the first sign it is escalating. If so, the organization may often kill good projects prematurely, experiencing loss and committing what Keil and his colleagues (Keil et al., 2000) called a "Type 1" error. On the other hand, allowing too many cases of escalation to be continued on the grounds the project may be incorrectly classified (a "Type 2" error) causes loss by wasting valuable resources. These results suggest that managers tend to be too risk-aversive to runaway projects. Consequently, we believe managers should include this new information in determining an appropriate balance between Type 1 and Type 2 errors.

SUMMARY AND CONCLUSION

Implications for practice

In summary, we believe this study's primary contribution to the practice of IS project management is the evidence it provides concerning the prevalence of project over-commitment in both government and private industry in the 21st century. The results suggest most large IS projects will exceed their original budgets and timelines by more than 50%, and much more often in government than in private industry. Second, the study provides evidence corroborating Keil et al. (2000) that "runaway" projects occur frequently, and new empirical evidence that they occur more often in government. Furthermore, the study supports other research that suggests "runaway" projects should be treated fundamentally differently from merely problematic projects, in that more radical organizational changes are needed to reduce management commitment ((Pan et al., 2006a, 2006b; Wright & Capps, 2010). In addition, the results imply managers should consider being more aggressive in promptly shutting down projects that show signs of over-commitment before they needlessly waste valuable resources. The results suggest mangers prematurely kill escalating projects only about 20% of the time. Finally, the results support the idea that nothing is more important in promoting successful IS development project outcomes than best project management practices.

Our survey respondents consistently rated project management factors more important than top management factors in determining project success. Furthermore they rated formal organizational factors more important than informal social or psychological factors. (See Tables 5 and 6).

These particular results underscore the importance of good monitoring of projects. And as Keil et al. (2000) suggest: "To minimize the problems associated with project escalation, managers would do well to implement early warning systems aimed at detecting escalation as early as possible. One way to minimize budget and schedule escalation is to define the de-escalation trigger points at the outset of the project. In this way, when the cost and schedule begin to approach the predefined trigger points, managers can take steps to de-escalate the project and contain the damage. Another related tactic is defining termination conditions at the outset of the project" (Keil et al., 2000). There is a wealth of information on the best practices in IS

software development published by Carnegie Mellon's Software Engineering Institute (http://www.sei.cmu.edu/) and the University of Texas' software quality institute (http://lifelong.engr.utexas.edu/sqi/index.cfm*)* (See also Wright & Capps, 2008).

To sum up, our study's data does not support a conclusion that IT governance measures implemented by many large organizations in the early 21st century have measurably improved IS development project performance. On the contrary, our results support the Standish Group 2009 report, which indicated that such projects are performing worse than they did in the 20th century.

Implications for future research

The most interesting research questions this exploratory study raises are related to why IS development projects "run away" or fail significantly more often in government than in private industry. The results indicate that all three project types - failed, problematic, and runaway - are much more likely to occur in government than industry. Is this because the deep structure of government organizations is more resistant to change than that of the private sector? Such a result would be consistent with that predicted by punctuated equilibrium theory (See Table 7). Other unanswered questions related to punctuated equilibrium theory are whether government projects are more often "over-committed" than those in private industry; and, what are the conditions under which incremental organizational changes are preferable to radical changes? Our results suggest that under certain conditions an incremental change, education, is more beneficial than a more radical change, replacing staff (See Tables 9 and 10). However, for "runaway" projects, question 3.8 (See Table 11), this pattern was reversed: the respondents believed it more beneficial to replace project management staff rather than simply educate them.

Because project failure is a politically sensitive subject, and thus difficult to study empirically, many more in-depth case studies are needed, with an aim of generating an explanatory theory of project escalation and de-escalation cycles (Pan et al., 2006a, 2006b; Wright & Capps, 2010). Our results support the claim others have made that further insights can and will come from punctuated equilibrium theory (Eldredge & Gould, 1972; Tushman & Anderson, 1986; Mokyr, 1990; Gersick, 1991; Wright & Capps, 2010) as well as from other organizational theories (Sutton, 1987; Eisenhardt, 1989; Ancona, 1990; Isabella, 1990; Pettigrew, 1990; Elsbach & Sutton, 1992; Shenhar, 1998; Cule & Robey, 2004).

What's more we believe there is a need for the IS audit and academic community to join hands in conducting further pragmatic research. Global surveys of IS auditors concerning the frequency, circumstances and characteristics of problematic IS development projects would be helpful. There are several advantages of relying on IS auditors for this type of research. As reported by Keil et al. (2000) these include: "… IS auditors do not have directly vested interests in project outcomes because their careers are unlikely to be made or broken by a project's success or failure; IS auditors can be expected to report more objectively than managers and other project participants; IS auditors have access to objective data on project performance; and IS auditors have experience with multiple projects and formal standards for judging projects" (Keil et al., 2000). Unfortunately, the Information Systems Audit and Control Association in recent years has reduced its support for global survey research.

The outsourcing literature (See Tiwana & Bush, 2007) also promises to be of help in the study of IS development project performance. The relationship between control practices and the project commitment escalation process is an additional promising area for future research (See Kirsch, 1997; Mahring, 2002; Kirsch, 2004; Tiwana & Bush, 2007). Another area for research would be to go beyond the results of Mahring (2002) and Kirsch (2004) to explore whether the constitution and effectiveness of Information Technology Governance is inversely related to management over-commitment to projects. Specifically, it would be of interest to determine if the organization's ability to adapt control practices to the dynamic nature of complex projects reduces the likelihood of escalation periods. The relationship between over-commitment and the requirements determination process is also a promising one for future research (See Kirsch & Haney, 2006).

Limitations of the study

Because our research was limited to proxy measurements consisting of the beliefs of self-reported information systems (IS) auditors, the conclusions drawn herein must be interpreted with caution. Admittedly, this method raises the possibility of bias or an error in the data set. It is conceivable auditors are more likely to be assigned to troubled projects and thus their estimates of the frequency of project problems may be biased upward. Conversely, IS auditors may tend to be employed by organizations more aware of the need for good project management. If so, it is possible that IS auditors' estimates of project problems may be biased downward. Further, this study's data may have been more reliable if it had been gathered from specific individual projects.

However, such an approach was not deemed appropriate or necessary for an initial exploratory study. Because the study relied on self-reported information concerning past events, the results are also limited by possible recall bias. However the same research method has been used in similar research (i.e., Keil et al., 2000) and we know of no effective methods for avoiding subject recall bias. Despite these limitations of the methodology, we believe this study contains important contributions to research and practice of information systems development.

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DESIGN PRINCIPLES OF HELP SYSTEMS FOR DIGITAL LIBRARIES

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ABSTRACT

In this paper we present and discuss a set of principles for the design of help systems for digital libraries. Previously *a user study (Xie and Cool, 2009) was performed by two of the authors in order to identify a number of Help Seeking Situations encountered by novice users of digital libraries. In this paper we continue that work as we examine those help-seeking situations and, based on them, propose a set of principles and guidelines for the design of help systems for digital libraries. Some of the design principles discussed here may have been proposed by other researchers or may have been used in previous user-interfaces but the contribution of this paper is that it validates and connects the design principles with specific help-seeking situations encountered by users observed and categorized in our user study. Further user studies of other digital libraries as well as user interfaces that implement the proposed principles may provide evidence that could be used to modify and refine the design principles*

INTRODUCTION

The problem addressed by this project is that help-seeking situations are not well understood and at the same time, the design of help functionalities has proceeded without the benefit of such knowledge. The consequence is that the standard help features present on most digital library systems, are often not very effective (Xie, 2006; Xie & Cool, 2009) and particularly not helpful for novices.

The first steps of the project were to identify the types of problems novice digital library users experience for which they require help and to better understand the nature of these help-seeking situations. We conducted a user study (Xie & Cool, 2009) in order to identify the Help Seeking Situations (HSSs) encountered by novice users of digital libraries (see section "The User Study"). In this paper we examine the HSSs identified in the study (op. cit.) and propose a set of principles and guidelines for the design of help systems for a digital library (DL) that are intended to address those specific HSSs. Some

of the design principles that we discuss here have been proposed also by other researchers or used in previous user-interfaces. What this paper does is to validate and connect those principles with specific help-seeking situations encountered by users observed and categorized in our user study.

In order to design a usable help system it is necessary to understand what lead users to use help. The user study that we conducted (op. cit.) identifies the kinds of situation that cause users to consult an online help system. The same study also illustrates the cases in which users failed to find the help information they needed. Understanding of users' Help Seeking Situations allows the designer to put effort and resources in the areas that will result in the highest pay-off for users.

In our user study we identify 15 Help Seeking Situations (HSSs). The HSSs and the corresponding user interface features are listed below (see Table 1). For each situation in the list of HSS, the design features that would be relevant are listed.

PREVIOUS WORK

Previous research has evaluated a variety of help features in different types of Information Retrieval (IR) systems. Our approach is to study users first, in order to understand the help-seeking situations that give rise to help-seeking interactions and then, based on those situations, propose a set of design principles and guidelines to build online support systems.

Several collections of design guidelines and principles for the design of user interfaces have been proposed. For example, Shneiderman offers a list of principles in his book (Shneiderman, 1997). Other examples are the MITRE design guidelines (Smith & Mosier, 1986) and similar documents from Apple (Apple Inc., 2009), Microsoft (Microsoft n.d.), and Yahoo (Yahoo!, 2010).   The latter is an example of a growing trend to publish user interface design patters, in this case for web pages. These documents present recommendations to application developers. Their dual purpose is to make user interfaces more usable as well as the, sometimes conflicting, purpose of specifying the look and feel expected in the corresponding environment. The guidelines proposed by these documents may be the result of the experience, taste, and, in some cases, user studies performed by the corresponding organizations. The document from Apple emphasizes the need to "involve users in the design process", "analyze user tasks", "build prototypes" and "observe users". It encourages developers to "see where people have difficulty using [their] product and then use that information to improve [the] product". This is not unlike this paper, were we describe the specific problems that novice users of a digital library encounter when trying to use the help system, and then propose guidelines to design better help systems.

The principles we propose here are based on observations of how novice users behave when seeking help while using digital libraries. The user interface design principles proposed in this paper apply specifically to the design of the help system's user interface of a digital library.

Table 2: DESIGN FEATURES FOR EACH HELP SEEKING SITUATION	
HSS (Help seeking situation)	Design features
Inability to get started	
HSS1: unclear about the topic, HSS2: unfamiliar with digital libraries	Multiple access methods to the help system, Question answering, Help information content, Context-sensitive help, Integration of help and search system, Query by example
Inability to identify collections	
HSS3: inability to identify relevant collections	Don't make users choose between collections, Context sensitive help, Query by example
Inability to browse	
HSS4: inability to browse information	Browsing tools, Help information content
Inability to create search statements	
HSS5: inability to use appropriate query syntax	Query by example
HSS6: inability to select appropriate query terms	Context-sensitive help, Query by example, Browsing tools, Implicit and explicit feedback
HSS7: inability to limit searches to certain fields	Integration of help and search system, Query by example, Context-sensitive help
Inability to refine searches	
HSS8: inability to refine searches for different aspects of the search topic, HSS9: inability to identify other approaches for information, HSS10: inability to refine searches in general	Interactive search agent, Implicit and explicit feedback mechanisms, Identify common Help-Seeking situations, Query by example
Inability to monitor search	
HSS11: inability to monitor search	Don't force users to interrupt their task to seek help, Avoid having different states
Inability to evaluate results	
HSS12: inability to identify relevant documents	Better surrogates, Better ranking algorithms
HSS13: inability to identify specific information	Better surrogates, Browser independent navigation and search controls, Open document in most relevant section
HSS14: inability to compare items retrieved	Better surrogates
HSS15: inability to verify authority and accuracy of retrieved documents	Context sensitive help, Better surrogates, Help information content

Some of the earliest help-system designers recognized the need to understand the help-seeking situations users encounter when using the system. In an early paper about help interfaces published in the first hypertext conference (1987) Walker (1987) described the Document Examiner (DE), a help system based on hypertexted documents. DE offered searching capabilities that were based on consideration of the strategies that people use in interacting with paper documents. As is often the case, Walker designed the interface providing features she thought would be useful to users and then ran some user surveys. One of the main drawbacks of the system from the point of view of the users was performance. Even though the documents took only 10MB (a significant size at the time) some look up operations could take as long as 10 seconds. The system provided enough advantages that users were still willing to put up with a performance that today's users would find intolerable. This fact also illustrates the fact that user behavior and user expectations may change significantly over time as the skills of the average user change, the technology itself changes, and the expectations of the average user change.

Borgman (Borgman, 1996) argued that online catalogs are difficult to use because their design does not incorporate sufficient understanding of user searching behavior. In several papers (Borgman, 1987; Borgman, 1987b) she examined studies of information retrieval systems searching for their implications for online catalog design.

Cool and Xie (2004) reported that people tend to use help mechanisms infrequently because of inadequacies in the interactive capabilities of these systems in their support during help-seeking situations.

Dworman and Rosenbaum (2004) suggested that users failed to use even help systems that did contain useful and well-organized information because of how they perceived and accessed help systems. They listed several reasons for users' inability to use help:

Cognitive blind spots: users appear to simply not see help even when the delivery mechanism is right in front of them.

Distraction aversion: users often are unwilling to leave their current task to start a help-seeking task.

Fear: users may be afraid to suffer the potentially dire consequences of leaving their current task.

Refusal to admit defeat: users insist that they can figure out a solution and don't need to look it up.

The word "help" itself: users may access hints, tips, and quick-reference guides, but refuse to click on something called "help."

It is argued that people seldom find the answers to their questions when they try to use the help of search systems (Haas, Brown, Denn, Locke, & Shneiderman, 2006). Not surprisingly, the panelists agreed that there are problems with help systems. Locke, one of the participants, said that before we can design a help system we need to know who our users are and what brings them to help. Fundamental divisions of the help system may start with the distinction between definitions and procedures that relate to the software interface and those that relate to the content the interface presents.

Shneiderman argued (op. cit.) for multi-layered interface designs which enable first-time and novice users to begin with a limited set of features at the first layer. Users can remain at the first layer, then move up to higher layers when needed or when they have time to learn further features. He pointed out that there are still interesting design problems in how to define the layers (consider, for example, layering by function or by application or task), it is a very promising strategy that needs further exploration and testing.

Denn (op. cit.) made the distinction between interface help and content help, defined as support for the use of the content and concepts contained within an information system. She discussed the methodological issues of designing studies to explore interactions between user and task characteristics. She pointed out the importance of defining the kinds of metrics that we can use to measure them, as well as how to apply the results to the design of integrated interface and content help.

According to Jansen (2005) searchers seldom make use of the advanced searching features that could improve the quality of the search process because they do not know these features exist, do not understand how to use them, or do not believe they are effective or efficient. His study suggests that search effectiveness could be improved by suggesting or implementing assistance automatically.

Krull, Friauf, Brown-Grant, & Eaton (2001) reported studies of help systems that never were overwhelmingly successful in enabling users to complete tasks. The two consistent problems they identified were that the organization of help information was not clear to users and that help topics were expressed in product-specific vocabulary rather than user vocabulary.

In the analysis of our user study (Xie & Cool, 2009) we find evidence of many of the problems mentioned above. In this paper we propose principles and mechanisms to address them.

THE USER STUDY

Two of the authors of this paper (Xie & Cool, 2009) address the following questions in a study of novice users of digital libraries:

What are the typical types of HSS experienced by novice users of digital
libraries?

How do novice users use Help in digital libraries? Specifically, which Help
features are used to address what types of problems?

One hundred and twenty novice participants from Milwaukee and New York
representing general public with various ethnic backgrounds, education and literacy
levels, computer skills, occupations, and other demographic characteristics were recruited
to participate in the study. Multiple data collection methods were used for this project:
pre-questionnaires, think aloud protocol, transaction logs, and post-questionnaires. First,
participants were asked to fill out a pre-questionnaire about their demographic
information as well as their experience in using different IR systems and help
mechanisms.

Next, participants were instructed to conduct 3 tasks in two digital libraries
respectively: American Memory (http://memory.loc.gov/ammem/index.html), this digital
library will be referred as LOCDL in this document; New Zealand Digital Library
(www.NZDL.org), which will be referred to as NZDL in this document. They were
instructed to think aloud during their process. The entire search sessions were logged and
recorded unobtrusively by using Morae™ software. The three types of tasks were:

A task that requires the user to explore each digital library. For example: "use
three different approaches to find an 1895 map of Yellowstone National
Park."

A task that requires users to search for specific information. For example: "what
is another name that was used for Bubonic Plague in the nineteenth
century?"

A task that requires users to search for information that has a variety of
characteristics related to content, format (audio clip, video clip, etc.), and
search strategy required. For example: "identify at least four issues
regarding immigration policy in the U.S., using as many sources from the
digital library as you can. Each issue you identify should have a different
source."

Finally, participants were also asked to fill in post-questionnaires that solicited
information related to their experience in using help mechanisms in accomplishing their
tasks.

HELP SEEKING SITUATIONS (HSSS)

The following is the list of the 15 types of Help Seeking Situations (HSSs) identified in the user study that lead novice users to try to use help features of digital libraries. The principles are described in a section below. See Table 2 for a list of the HSSs and their corresponding design principles.

HSS1: inabilityy to get started - unclear about the topic. Some participants could not get started because they felt they needed more domain knowledge. Therefore, they did not know how to start their searches. Some users tried to use the help system in order to find information about the domain. Example: some users tried to ask the help system "where is Yellowstone" when dealing with the task: "use three different approaches to find an 1895 map of Yellowstone National Park."

HSS2: inability to get started - unfamiliar with digital libraries. Users try to get information about the kinds of searches they could do. Example: "find different search strategies supported by the DL (e.g. search by phrases)."

HSS3: inability to identify relevant collections. Users need help choosing which collection to search. Example: "which would be the better collection to search given that the question is about immigration?"

HSS4: inability to browse information. This type of help-seeking situations was mainly caused by lack of system knowledge, poor interface design as well as unintuitive browsing mechanisms.

HSS5: inability to formulate query statements. Users had trouble constructing statements that could be submitted to the system as queries. This led them to try to find information about search features and query syntax from the help system. They tried to construct queries using syntax learned in other systems but which may not work in the digital libraries used in the study. In particular, they tried to use boolean operators, quotes for phrases, and + for the "must be present" feature.

HSS6: inability to select appropriate query terms. Users had trouble finding the right terms to use in their queries due to lack of domain knowledge

HSS7: inability to limit searches to certain fields. Users do not know how to specify the facets of their search, for example: publication year, author, title, format of documents, etc. Problems in the search system design caused some of these situations. Example: "how to search just for maps", "how to specify a date".

HSS8: inability to refine searches for different aspects of the search topic. This situation was often caused because of lack of retrieval and domain

knowledge. Examples: "how to find more than one source for a single issue", "having found different name for bubonic plague, tried to find countries and cities impacted by the epidemic." "I am overwhelmed by the amount of the results. I don't want to read all the results to identify multiple issues of immigrant policy."

HSS9: inability to identify other approaches for information. One of the study tasks asked participants to apply three different approaches to find the same information. This situation is often caused by lack of users' knowledge about the system as well as the domain. Examples: "Let me try browse through the collection [another approach] and see if I can find the map." "I'm trying to think of another collection besides conservation or maps that would include a map of Yellowstone."

HSS10: inability to refine searches in general. After their query fails, users need help to create a new one. Example: users tried to re-write their queries after the original query submitted did not retrieve any documents, retrieved too many documents, or all results seemed irrelevant to the user's question.

HSS11: inability to monitor search. Study participants sometimes were lost. Either they did not know where they were (they had lost track of how they had reached the state they were in and could not tell what to do next) or they wanted to return to a previous state (for example to start again) but they did not know how. Participants were often confused about how to move between the main digital library site and its help site as well as between the digital library site and other sites such as the home of the browser. Several participants tried to use the search mechanism from the help document describing it by trying to click on an image used as an example in the help document. Other users unsuccessfully tried to use the browser navigation buttons to navigate in the digital library site: "I click home, get out of the site to MSN. How do I go back to American Memory site." "How do I get here? Is this the beginning the homepage. I'll try help."

HSS12: inability to identify relevant documents. Participants were often unable to recognize relevant documents from the long lists of document surrogates presented by the search system. Example: "Many results, unable to identify the relevant answers"

HSS13: inability to identify specific information. This situation was observed when participants were asked to find specific answers to questions. For example: "find how many people have been affected by HIV in Uganda." Users did not know which tools to use, or whether any was provided by

the system, in order to find specific information within the documents found. Example: "how do I search within one of the documents retrieved?"

HSS14: inability to compare items retrieved. This situation was observed when participants wanted to compared two of the documents retrieved. Some pairs of items made participants suspect the documents were the same, even though the surrogates presented by the system were slightly different, but they thought the only way to decide was to actually compare the documents. This situation was caused by several reasons: the surrogates presented by the digital library did not contain the information necessary, and the users lacked enough domain knowledge. Examples: "... this looks like the same thing if I take the time to read..." "are these two retrieved items actually the same?"

HSS15: inability to verify relevant documents. When participants found multiple answers or confusing results in topics about which they lacked enough domain knowledge, they did not know how to decide which answer was more authoritative and accurate than the others. Example: "There are many answers for the question HIV in Uganda, but I am not sure which result is correct."

OVERVIEW OF THE DESIGN PRINCIPLES

In this section we suggest a list of principles for the design of help systems for digital libraries (DLs) based on the help seeking situations identified in the user study.

Support systems can be categorized as follows:

online tutorials
online documentation
online help

The differences between the three are determined by the way in which they are intended to be used.

The three kinds of online support systems may contain some combination of descriptive text, examples, and interactive features such as hands-on experimentation.

Online tutorials are systems designed to teach users about features and tasks. Users may use tutorials to learn about the system not necessarily while they are using it but perhaps in preparation to use it. Tutorials represent an investment in time and effort that few casual users may be willing to spend. Online documentation is intended to be used more like a reference than a learning tool. Online help is meant to support users

who must solve problems that they encounter while they are using the system. Online help should be fast, efficient and provide support within the context in which the Help Seeking Situation arises.

This paper deals mostly with online help but we propose that a full support system should include also what is called above "online documentation" and "online tutorials". The study we conducted on which we base the design principles described here focused on users trying to solve problems they encountered while using digital libraries. Such users needed the kind of help we called "online help" above. It is interesting to note that some systems we have studied (such like the LA Public Library online system as of 2009) seem to offer "online documentation" in lieu of "online help". The experience we gathered while conducting the user study suggests such help is probably not very effective.

What follows is the list of design principles for help systems. In the following sections each principle is described and, for each, the relevant HSSs are listed.

General principles: apply the same general design principles that would apply to any user interface

Reduce users' cognitive load, make all interfaces as simple as possible, consistent, easy to learn, and easy to use

Increase effectiveness

Reduce defects of the main search system that cause the user to seek help.

Search engine: better ranking algorithms, implicit and explicit feedback, and question answering.

Main search interface: better surrogates, browser independent navigation and search controls, browsing tools, avoid having different states, open document in most relevant section, and don't make users choose between collections

Access to online help

Don't force users to interrupt their task to seek help

Provide multiple access methods to the different layers of the help system (menus, text search).

Integrate help and search system

Provide context sensitive help

Identify common Help Seeking situations and offer relevant help.

Help tools

Provide effective browsing tools

Provide interactive search agent

Do not force the user to learn a query language. Help users build queries instead of expecting them to learn any more or less formal query language.

Help information content and style
Help information should include information about the content of the digital
        library as well as how to use it.
Include definitions of all specialized terms.
Include examples, tutorials and demos.

GENERAL PRINCIPLES

The user interface for an online help system must follow the same design principles of any user interface. Several researchers have proposed rules and principles for the design of user interfaces. Shneiderman's golden rules for dialog (Shneiderman, 1997) are a good example:
Consistency. Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent commands should be employed throughout.

Enable frequent users to use shortcuts.
Offer informative feedback.
Design dialog to yield closure. Sequences of actions should be organized into
        groups with a beginning, middle, and end. The informative feedback at the
        completion of a group of actions gives users the satisfaction of
        accomplishment.
Offer simple error handling.
Permit easy reversal of actions.
Support internal locus of control. Experienced operators strongly desire the sense
        that they are in charge of the system and that the system responds to their
        actions.
Reduce short-term memory load.

We focus here in principles that facilitate the use of help systems. For example: reduce user's cognitive load, and make the user interface simple, consistent, easy to learn, easy to use, and effective.

The design principles described in the following sections include some of these general principles and also some new ones that are specific to online help systems. The principles proposed specifically for online help systems are based on the lessons learned in our user study.

An important design principle applicable to help system interfaces is the need to reduce the user's cognitive load. In order to achieve that goal everything that is not essential to help users enter their query should be removed from all interfaces. If you are

designing a help user interface, consider each element of the main interface, if it doesn't directly help the user to enter a more effective query delete that element from the interface. Users are overwhelmed by too many choices or too much information. The main search page of the DL system must eliminate all unnecessary clutter. Any user interface element that does not directly contribute to help the user find the information they are looking for actually hurts the effectiveness of the system.

The following items represent some of the elements a help user interface should include. Anything else should be added only after careful consideration:

> a banner that identifies the website
> a prominently displayed text box where the users can enter a query or question (preferably on the top left of the page or in the center).
> text that invites users to enter a query or question: this can be a link next to the text box that offers users examples of queries that can be entered (addressing HSS2: users unfamiliar with digital libraries). This is also an example of applying context sensitive help.
> buttons for each of the formats (images, maps, documents, sound, etc.) offered by the DL
> a button labeled "Advanced Options" that takes the users to a query by example (QBE) page.
> a button labeled "about this Digital Library" that takes users to the help documents that describe the DL: its history, its contents, its authority, etc.
> a button labeled "Help" that takes the user to the main help system.

The LOCDL violates the simplicity principle in many ways. It offers "Collection Highlights" and "today in history" information on the main page (as of Jun 2, 2009). Actually less than half of the interface is actually about searching information. The rest is what would be considered "promotions" in a commercial site (e.g. "Teachers: use American Memory in the classroom"). This adds to the clutter on the page and does not help the user to search for information. It would be better to separate both aspects completely so users could find a page that has no other purpose but to help them find what they are looking for. All the "promotional" stuff could be in a different page containing information "about us". The search page should be as simple as possible.

REDUCE DEFECTS OF THE MAIN SEARCH SYSTEM THAT CAUSE THE USER TO SEEK HELP

Several of the Help Seeking Situations described in the user study are the result of shortcomings or defects of the search system. The better the main search system is

designed the less help-seeking situations will occur. No redesign of the help system should be used (or can be used) to overcome what are really problems of the main search system. The help system cannot be used to make effective a search system that is not.

Listed below are several examples of problems or defects of the search systems used by the DLs used in our study that were found to cause the user to seek help.

Question answering. At least simple (and common) questions should be parsed automatically and transparently into good queries for the search system (see HSS1 (unclear about the topic), HSS2 (unfamiliar with digital libraries), HSS5 (inability to formulate query statements), HSS6 (inability to select appropriate query terms)). Google does this quite effectively. For instance if users want to find out the name of their representatives they can simple enter "who is my congressman and senator?" and find websites that contain the answers. This as opposed to trying to figure out what kind of documents might contain the desired answer.

Improve surrogate presentation. The document surrogates are difficult to evaluate (see HSS12 (inability to identify relevant documents)). It is not clear to the user which surrogates actually stand for the same document (see HSS14 (inability to compare items retrieved)).

Avoid having different states, e.g. the state where the user can enter queries, the state where the user can look at surrogates (see HSS11 (inability to monitor search)).

SEARCH ENGINE

Some defects of the search engine itself cause users to seek help. Some of the Help Seeking Situations observed in the study were caused by defects in the search engine. Some areas in particular that could be improved in order to reduce Help Seeking Situations are: the ranking algorithms, use feedback to reformulate queries, and question answering.

If the ranking algorithms are not very good, it will be harder for users to find relevant documents at the top of the list of hits retrieved. Users feel that they are overwhelmed by too many irrelevant documents (see HSS12 (inability to identify relevant documents)).

QUESTION ANSWERING

At least simple queries should be translated automatically, and transparently, into appropriate queries for the Digital Library. For example, queries such as "Where is

Yosemite?", "What is Bubonic plague?", "Who is my representative" should be "understood" by the system, i.e., translated into queries that are likely to return documents that contain the answer to the question. Several users in our study thought they needed to learn some specific facts about the domain. For example, in order to find a map of Yellowstone, as require by one of the study tasks, they tried first to find out where is Yellowstone from the DL. Some users did not know how to proceed and tried then to use the help system to answer such questions. It should be clear from the user interface and from the help available at the point where users must enter a query (context-sensitive help), that it is possible to enter simple questions as queries.

Users may have trouble figuring out how to start a search (HSS1 (unclear about the topic), HSS2 (unfamiliar with digital libraries)). From a "getting started" button (located right next to the search box) users should be able to get information about how to create a query. On the pop-up help window the user should be told that one possibility to start a query is simply to "ask a question". It should not be necessary to learn a special syntax, nor should it be necessary to choose between collections. The system should be able to do at least some very simple parsing of users' queries in order to identify simple questions (such as "what is implicit feedback", "where is Yellowstone") and retrieve documents that may contain the answers.

The surrogates presented should be built in such a way that the answer is likely to be shown in the surrogate (see for example Figure 1). This might work simply showing the fragment of the document most relevant to the query.

The users' experience would have been completely different if instead of using a DL they were using the Web for the following reasons:

> in the Web, users don't use a help system to ask questions about the domain, they consult the web itself
>
> often Web search engines, such as Google, are designed to parse simple questions such as "where is ...", "what is..." When such queries are used, documents likely to be relevant will appear at the top
>
> the document surrogates of a Web search engine are very likely to actually contain the answer to the question, so the results are easy to evaluate. This is because the Web, due its size, contains many variations of answers to a large number of questions, and search engines, such as Google, do a good job building useful surrogates to present to users. See examples of surrogates in Figures 1, and 2.

Figure 1: information shown for first hit of query "where is Yellowstone" by Ask.com
Yellowstone National Park. Established in 1872, Yellowstone National Park is America's first national park. Located in Wyoming, Montana, and Idaho, it is home to a...More
Go To: Official Site, Map, Directions, Activities, Campgrounds Search For: Camping Reservations Nearby Airports: Jackson Hole, Idaho Falls

Figure 2: surrogates shown for first hit of query "where is Yellowstone" by Google
Where is Yellowstone National Park? Yellowstone National Park... is in the northern Rocky Mountain Range. Located mostly in Wyoming, the park crosses into Montana to the north and Idaho to the ... www.yellowstonejobs.com/whereisyellowstone.html - 11k - Cached - Similar pages

On the other hand, in the LOCDL:

users think they may find information about the domain using the help system queries such as "where is ..." may not be parsed appropriately. For example the question "Where is Yellowstone?" in the LOCDL, retrieves documents that contain "Yellowstone" but that are not necessarily likely to contain information about its location (see Figure 3).
The LOCDL surrogates are not very good.

Figure 3: surrogates for query "where is Yellowstone" from LOCDL
1. Lamar Buffalo Ranch, East of Tower Roosevelt on Northeast Entrance Road, Canyon Village vicinity, Park County, WY Built in America
2. DCM 0876: Anonymous, North American Indian (Sioux) / Courting Flute (Vertical Whistle Flute) Miller Flutes
3. U.S. Statutes at Large, Vol. 39, Part 1, Chap. 408, pp. 535-36. "An Act To establish a National Park Service, and for other purposes." H.R. 15522, Public Act No. 235 Conservation

MAIN SEARCH INTERFACE: SURROGATES

Users need better surrogates (see HSS12 (inability to identify relevant documents)). The surrogates provided by the LOCDL (see figure 3) are particularly bad. LOCDL shows only the titles of the documents. Unfortunately the titles of government documents are infamously bad at providing clues about their content. The surrogates provided by the system should include the titles but also keywords in context, collection the document comes from, dates and authors. Some of the information provided in the

document surrogates should be made mouse sensitive so the user can reformulate the query by restricting the search to those dates, that collection, those authors, etc. Also the terms in context should be clickable so the user can jump directly to the relevant passages in the documents. The fact that the LOCDL surrogates are hard to evaluate cannot be solved by a better help system but by providing better surrogates.

Figure 3 shows the first few hits for the query "Where is Yellowstone?" as shown by the LOCDL. From the text shown to the user in the document surrogates it is hard for them to tell whether any of these documents may be relevant to their information problem.

Figures 1 and 2 show examples of surrogates generated by Ask.com and Google respectively in response to the same query. Google's surrogates include the title of the document as well as document text that is presented showing the keywords the user entered highlighted. This kind of surrogate makes it easier for the user to evaluate the relevance of the document without having to actually look at it. Better designed surrogates would address HSS12 (inability to identify relevant documents) and HSS13 (inability to identify specific information).

HSS13 (inability to identify specific information) could be addressed by presenting in the surrogate the text from the document that is most relevant to the query. See Figure 2 for an example of how Google does something similar.

HSS14 (inability to compare items retrieved) would be addressed by detecting duplicates automatically (as Google does) or other relationships between docs such as one being a superset of the other, etc. For example Google uses indentation to indicate that some surrogates belong to the same website.

HSS15 (inability to verify relevant documents) would be addressed by having the surrogate itself display information about the source such as name of the document, name of the collection, dates, and authors. Each of the document characteristics should be linked to more information about them that helps users evaluate the document. For example: information about the institution or publication sponsoring the document, information about the author, etc. From the surrogate it should be possible to open a window containing a different kind of surrogate: a summary built (automatically) from the contents of the document as well as the meta-information about the document. The summary would contain information about the genre of the document, the kind of information it has, etc. Summaries should be designed to help users evaluate documents without having to actually look at them. Some of the possible information for a summary could be used to answer questions such as "does it contain statistics?", "does it contain information about numbers of casualties?", "does it mention countries or geographical regions?", etc.

BROWSER INDEPENDENT CONTROLS

In order to address HSS11 (inability to monitor search) the DL system should provide full navigation within the system without having to rely on browser's buttons. This means: (1) the designer has more control over the user experience, (2) the user experience depends less on the browser the user happens to be using, (3) the user is not confused (as happened to participants of the study) between the browser navigation controls and the system's.

Navigation controls should include a way to show users how they got to where they are as well as a way to go back to any point in the search process. This can be achieved by using breadcrumb devices (see Figure 4). The breadcrumb technique displays the search history on the same window and allows the user to jump to any previous stage. Another way, would be to present the search history on a different window (for an example of how Google does it see Figure 5).

Figure 4: bread crumbs example from Altavista
Directory >Arts> Design Arts >Architecture >Architects > Masters > Meier, Richard (b. 1934)

Figure 5: search history example from Google
May 19, 2009, 5:38pm Searched for java programming example; Viewed 1 result Java Programming Examples - idevelopment.info
5:28pm Searched for java tutorial sun Microsystems; Viewed 1 result The Java Tutorials - sun.com

In order to address HSS13 (inability to identify specific information) provide a search mechanism within the DL site. The DL site should provide its own tools to search within documents. Most browsers offer this feature but, if it's provided by the website itself, it will be homogeneous no matter what browser is being used. If the DL system provides the feature it can be made more powerful and friendly than what the browser uses.

BROWSING TOOLS

HSS6 (inability to select appropriate query terms) arises when users have trouble selecting appropriate query terms due to (1) lack of domain knowledge, (2) lack of experience using online search engines, and (3) lack of experience formulating queries for the search engine of that particular digital library. When users are not sure what terms to choose, or in the very common case when they are not quite sure what they need

to know from the help materials, browsing tools can help (Rice, McCreadie, & Chang, 2001).

The case of browsing tools is also a good example of the case in which the help device will not be as effective if it is not integrated into the user's workflow. If the user has to consult a separate help system he may not even know how to look for relevant help. An example of this problem are Digital Libraries with interfaces similar to the one offered (as of Jan 2009) by the Los Angeles Library online catalogue. The only apparent help offered to the user is a button labelled "Help". When the user clicks on the button a new window (at least it is a different window!) opens showing all the help available in the form of a manual of the system. The user would have to find in this document explanations (if any) about how to build queries and select terms. The Digital Library user will seldom have the patience or time to explore this manual.

A solution is to integrate browsing and information exploration tools into the search process. Browsing tools have been used by librarians even before the advent of Digital Libraries (see (Anderson & Perez-Carballo, 2005) chapter11: displayed indexes). A browsing tool is a tool that displays to the user some level of the structure of the topics covered by the documents. In the case of Digital libraries a browsing tool should be seen as an alternative to the search box, where the user just enters the query that she hopes will retrieve the documents relevant to her information problem. Instead of the user having to come up with appropriate query terms connected with the appropriate query operators, a browsing tool allows the user to navigate through the structure of topics offered by the system. This allows users to explore the contents of the Digital Library and discover solutions to their problems. There are numerous research and development opportunities in this area (see for example (White, Kules, & Drucker, 2006)).

An example of a browsing technique, deeply rooted in the best traditions of library science, is the use of facet classifications (Stoica, Hearst, & Richardson, 2007). In a facet classification each category groups one aspect of the topic. The use of facets helps the user explore the information contained in the Digital Library. Several studies (e.g. (Hearst, 2006), (Venkatsubramanyan & Perez-Carballo., 2007)) suggest that interfaces that present results organized into categories or faceted hierarchies meaningful to users may help them make sense of their information problem as well as the information system itself.

AVOID HAVING DIFFERENT STATES

HSS11 (inability to monitor search) describes situations in which the users got lost navigating the search system. Changing the users' environment to a different state contributes to them getting confused and lost. Whenever possible it is better to display help information on a pop up window than to change the state of the user to a help mode.

OPEN DOCUMENT IN MOST RELEVANT SECTION

HSS13 occurs when users have trouble finding specific information inside of the documents they retrieve. One possibility is to open the document in the area deemed the most relevant by the system (e.g. the fragment that contains the most terms from the query). It would also be possible to offer to the user several points of access to the document. One for each fragment that contains possible answers to the information problem represented by the query terms used by the user.

DON'T MAKE USERS CHOOSE BETWEEN COLLECTIONS

Do not force users to choose between collections or make other unnecessary choices at the top level. Offering the choice or even forcing the users to select a collection is completely unnecessary and reduces the ability of users to find relevant information. Choosing between collections may have made sense when collections were physically distinct in brick and mortar libraries. In a digital library, a user can search all collections at the same time effortlessly. Choosing between collections must be an "advanced" choice.

Design guidelines about choosing collections:

Provide information in the help system about the content of the different collections.

Parse the user's query and offer to user the possibility of learning about specific collections, restricting search to some collections.

By default search all collections. Show surrogates indicating which collection they come from.

Relevant HSS: HSS3 (inability to identify relevant collections).

ACCESS TO ONLINE HELP

The purpose of the principles described in this section is to make help information easily accessible and highly visible. Help should be transparent and always available. It should not feel to the user as a separate system, and should never feel like an interruption or diversion.

DO NOT FORCE USERS TO INTERRUPT THEIR TASK

Requesting help should not put users in a different mode or otherwise interrupt the flow of their interaction with the search system. As much information as possible should be already on the main interface. Help screens should open on a different window so users can continue their search process at the same time that they consult the help system. Whenever possible the help system should offer help on topics that may be relevant to the current state of the users' interaction. This can be achieved by a help pane that displays one or two relevant help topics at any time. This device doesn't need to be cute, annoying or distracting like some previous implementations of this idea have proved to be (e.g. Microsoft's infamous animated paper clip). Another possibility is to have the special help topics pane appear also on the main help screen that opens when the users request help. Relevant HSS: HSS6 (inability to select appropriate query terms), HSS7 (inability to select appropriate query terms).

PROVIDE MULTIPLE ACCESS METHODS TO THE DIFFERENT LAYERS OF THE HELP SYSTEM

The user should be able to access the help system through a variety of methods: menu bar, tool bar, help buttons on dialogs, help messages triggered by hovering over certain elements, etc.

All elements on the interface should be set to provide help just by hovering on them or by clicking on a nearby link. For example: hovering on the "images" button tells users that selecting this option retrieves only images. Hovering over the text box describes its purpose and provides links to query examples. Each one of the elements of the query by example (QBE) interface should have its own direct access to the help system, both by hovering over the appropriate element, and/or by clicking on a nearby link that would lead to several layers of help information (from fast and concise to deeper information, examples, tutorials, etc). Help documents and messages should open on their own window as opposed to changing the mode on the user.

Whenever a dialog window is open there should be a help option on it. If the user clicks on it the system provides information about that specific window and its choices.

If help documents are organized as a hypertext collection of documents, it should contain a table of contents and a search function. There should be a FAQ page (frequently asked questions) with links to the more popular questions and the most useful answers.

It must be possible to jump directly to the relevant situation in the system described in the document. For example: when describing how to use a query by example interface, the user should be able to open it by clicking a button. In general,

moving from a search situation to the corresponding relevant document or from a document to the corresponding relevant search situation should always be only one click away.

One of the access methods may be a "help" button from the main search interface that provides access to a general help system. Relevant HSS: HSS2 (unfamiliar with digital libraries), HSS4 (inability to browse information).

INTEGRATION OF HELP AND SEARCH SYSTEM

Help should be integrated into the system as much as possible. The user should not be expected to click on "Help" and navigate to a document that answers their questions. If the user needs help searching the digital library the last thing they need is the additional challenge of navigating its help system. Using the LOCDL interface as it was as of June 2, 2009, the user would have to follow at least three clicks to reach help topics about "Search All Collections" (Help - Search Help - Search All Collections) or "How to Format Search Terms." (Help - Search Help - How to Format Search Terms).

In the aforementioned LOC interface the search box is on the top right, perhaps not as visible as it could be. Ideally the search box should be in the most visible place of the page, on the left hand side. Right next to the search box there should be a link labeled "examples of questions". When users click there they are taken to a page showing examples of questions that can be entered in the system.

The next paragraphs show suggestions of how the integration of help and search system can be used to address specific help seeking situations.

In order to address HSS1 (unclear about the topic), and HSS2 (unfamiliar with digital libraries) the help and search systems should be integrated. Buttons on different points of the user interface should display appropriate help information to the user. There should always be a link to appropriate help information from several points on the search user interface. As the users read the help information displayed on the pop-up help window they should be able to jump back to the search system easily. An example of integration between help and search system can be seen in the "Spotlight" search feature of Mac OS X. If users click, for example, on "Open Spotlight Preferences" on the help page, the appropriate preferences window opens allowing users to set preferences as explained on the help page they are reading.

HSS7 (inability to limit searches to certain fields): from the search interface users should be able to go directly to help documents showing examples of queries. From the help documents users should be able to click on the example and start a query like the one being explained.

HSS3 (inability to identify relevant collections): topics covered by the DL should be linked to the corresponding collections. If a user wants to choose a specific collection

they should be able to browse through their names and descriptions, or through the topics covered by the DL. Each collection should have a help button next to it that links to information about it, its description, and examples of questions that could be answered by it. For example: "if you are looking for ... you could try collection ..."

HSS3 (inability to identify relevant collections): help user choose collection. Given the query entered by the user, the system may help the user choose collections using a variety of methods. One possible method: each collection is associated with a set of words that represent their content (lets call this "signature"). Depending on which signature the query matches better, the user is offered a list of ranked collections to choose from. Another possible method: collections can be ranked according to the number of retrieved documents that belong to each collection. For example, the collection to which most documents retrieved belong to would be ranked first, etc. When results are presented the system would offer to restrict the search to the collection (or collections) it guessed may be most relevant to the users' query.

HSS1 (unclear about the topic), HSS2 (unfamiliar with digital libraries): There should be a direct link to information about how to start. A "getting started" button takes user to examples of tasks and corresponding queries. There should be direct access to tasks such as "asking question", "looking for a map", "looking for a biography", "looking for a specific answer". For each case, help documents show tips and strategies to build an effective query.

As the user is typing in text in the search box the system displays information about it. Google exhibits a similar behavior. This is particularly useful on a small mobile device without a full size keyboard. There are many examples of search systems that do this. For example, while the user is typing "yellow" in the search window of the Safari browser, the system displays in a near window a list of clickable relevant queries under the label "Suggestions" such as: "yellow pages", "yellow book", "yellowstone national park", "yellow freight", "yellow", "yellow fever", "yellowstone volcano", "yellowstone earthquakes", "yellow freight tracking", "yellow lyrics." At any time the user can stop typing and select any of the choices offered by the system.

HSS6 (inability to select appropriate query terms): when users are creating a query they can click on the words they have entered and get suggestions about synonyms, more general terms, more specific terms, or related terms.

HSS7 (inability to limit searches to certain fields): provide direct connection from the point where the user needs to create a query to help documents that offer examples on how to limit queries to certain fields or facets.

HSS15 (inability to verify relevant documents): links or buttons on the appropriate places in or next to the surrogate display allows users to investigate details about the source of the information. This context sensitive link should take users directly to help information about how to evaluate the quality of retrieved documents and that

specific source. From there, users could find out more information about sources and how to evaluate them. Another link on the surrogate opens a window containing a summary of the document designed to help the user evaluate the document retrieved easily and efficiently (see section on surrogates for the desired characteristics of the summaries).

HELP SHOULD BE CONTEXT SENSITIVE

Helpful information should be incorporated into all screens and dialog boxes of the main search interface.

Each screen of the user interface should show to the user what functions are available. The functions available at any point during the search interaction should be visible to the user instead of hidden inside of menus. The user should be able to tell what functions are available just by scanning the search interface in front of him. This should allow the user to get help on what they need with a minimum number of clicks or navigation.

The system should present to users the operations they may want to use at each stage of the interaction. For example: when showing a document, the system identifies the user's browser and provides a reminder about how to search within the document (e.g. ctr-F in Internet Explorer under windows, command-f in safari under Mac OS). Also, offer appropriate points of entry into the help system to help user with the choices offered in this context. Relevant HSS: HSS7 (inability to limit searches to certain fields).

The main interface should make clear to the user what kinds of questions can be asked. The users in the study did not understand (see HSS1 (unclear about the topic), HSS2 (unfamiliar with digital libraries)) what kinds of questions/queries could be submitted to the search system (looking for content) and which to the support system (look for help information).

Help seeking situations HSS1 (unclear about the topic) and HSS2 (unfamiliar with digital libraries) are situations in which users had difficulty starting the search process because they felt they did not have enough information about the domain (HSS1 (unclear about the topic)) or about the kinds of questions they could submit to the system (HSS2 (unfamiliar with digital libraries)).

IDENTIFY COMMON HELP SEEKING SITUATIONS

The help system should be able to identify common Help Seeking Situations and offer relevant help. For example: if the number of retrieved items is too small or zero, the system may parse the query entered and suggest to the user changes, This is similar to the suggestions offered currently by Google in that situation:

Make sure all words are spelled correctly.
Try different keywords.
Try more general keywords.
Try fewer keywords.

For each situation there should be a point of entry to relevant documents in the help system. The help system documents could, for example: explain ways to make the query less specific, or explain different strategies to build a query. Relevant HSS: HSS6 (inability to select appropriate query terms).

HELP TOOLS

As mentioned before in the section about browsing tools for the general search system (section 7.7), browsing tools help users when they are not sure what they want. Since users may be even more confused about what they want or need when they are looking for help, this kind of device would be particularly useful in help seeking situations. Consequently, one of the ways to access help should be in the form of browsing tools similar to the ones recommended earlier for the full system.

INTERACTIVE SEARCH AGENT

Allow the possibility to interact with the user trough a dialog (HSS8 (inability to refine searches for different aspects), HSS9 (inability to identify other approaches), HSS10 (inability to refine searches in general)). It is important to implement this in as unobtrusively as possible. The agent should not interrupt the users' task or put them in a different state. On a different window the agent may offer context sensitive help depending on the results of the search and some characteristics of the query. For example, if the number of documents retrieved is too large, the agent may decide that it is because the query is too short (one or two words) or the query terms are too general. It may then suggest to users ways of making their searches more specific. In other cases the agent may decide the query is too specific (e.g. no documents retrieved) and may suggest ways of making the query more general.

DO NOT FORCE THE USER TO LEARN A QUERY LANGUAGE

The user should be able to get good results without having to learn the syntax of a special language. A possibility is a Query by Example interface (QBE). A QBE interface uses a query template or form that helps naive users create complex queries. In that sense

it is part of the help system. The main interface should assume the most useful defaults for query construction. The user should be asked only to enter a question or a few words. More advanced users should be able to enter directly complex queries. Most other user choices should be delegated to an "advanced page" which should be reachable from the main page with a single click. There, users can use a query by example form (QBE) in order to create more complex queries

In order to help users get started with the search process a query by example QBE interface is always available. QBE guides the user suggesting sets of possible values for the different facets of the search. This can be done without changing modes, like Google, which offers QBE as an advanced option (this is relevant to HSS1 (unclear about the topic) and HSS2 (unfamiliar with digital libraries))

A query by example interface facilitates the creation of the query as well as its modification and refinement (relevant to HSS: HSS2 (unfamiliar with digital libraries), HSS3 (inability to identify relevant collections), HSS5 (inability to formulate query statements)).

HELP INFORMATION CONTENT AND STYLE

This section discusses the help documents themselves: the different styles, organizations, and kinds of help documents. Help seeking situations HSS1 (unclear about the topic) and HSS2 (unfamiliar with digital libraries) have to do with the inability to get started. Users that found themselves in HSS1 (unclear about the topic) had trouble starting because they felt they needed more information about the domain.
A help system must include information about the information contained in the digital library. In keeping with the principle of keeping the interface simple, users should be able to enter questions about the domain in the same text box they would use to enter questions about the interface.

DEFINITIONS, EXAMPLES, TUTORIALS AND DEMOS

Help documents should include an overview of search strategies implemented by the DL. For example: when to use browsing, when to use "keyword" search. The documents should be written using concrete examples of common user tasks. For example: "asking a specific question", "if you know words that may appear in the documents you are looking for", "exploring the topics covered by the DL", "looking for a map". From the explanation on the help documents it is always possible to go directly to performing the task (see Integration of help and search system) (relevant to HSS1 (unclear about the topic), HSS2 (unfamiliar with digital libraries)).

It would be useful to have at least a very short demo of how to use browsing tools. This can be in the form of a very short movie or animation. Must be on demand and it should be possible to interrupt it at any time. It should appear on its own pop-up window. It should be available at any point the user can browse (relevant to HSS4 (inability to browse information)).

Give examples of when browse helps and how to do it (relevant to HSS4 (inability to browse information)).

Information about how to assign credibility or authority to the different sources contained in the DL should be provided (relevant to HSS15 (inability to verify relevant documents)).

HELP DOCUMENT STYLE

The documents should be written by a professional writer in plain language, without obscure acronyms or technicisms. They should be concise, short, and provide links to other help documents when necessary. Most help documents should contain links to related topics, as well as more general, and more specific ones.

The documents should include definitions of all specialized terms. There should be examples of different kinds of queries and information problems. There should be tutorials and step by step examples for different kinds of users. There should be help documents at different levels of detail and complexity in order to address the needs of users at different levels of competency, from the most naive to experts.

CONCLUSIONS AND FUTURE WORK

Designing help systems that will effectively support people in their information seeking goals is not an easy task, for a variety of reasons. During the course of an information search session, people often encounter a variety of problems, or help-seeking situations, that help systems are not uniformly designed to address. Typically, system design has preceded user studies, leading to poorly designed help systems. In this paper we describe a program of research that is grounded in analysis of users first, the kinds of help they need in a variety of contexts, which we identify as help-seeking situations, and from this empirical grounding we have suggested design principles to respond to these HSSs. Many of these principles are novel but others have already been incorporated into the interfaces of some internet search engines or certain operating systems. Very few have found their way yet to the interface of Digital Libraries. The next step in our research is to implement these design principles into the interface of a Digital Library and evaluate the outcomes. Our premise in pursuing this course of research is based on a belief that users ought to be considered designers and actively brought into the design

stage of system development. In our own study, participants were not directed to comment on help features during their searches, although they offered many spontaneous comments. As a next step, we suggest that users be given an active role in participatory design of future help systems. Results of our work thus far suggest several fertile areas for follow up research. Some of the questions that warrant further investigation include the following:

Do HSSs identified by us vary across novice/expert differences?

To what extent are there gender differences in using system help, and at what point during the search. We have learned from studies of social behavior that males are more reluctant than females to ask for help from a stranger. Does this finding hold true within the context of human-computer interaction?

How do searchers respond to help mechanisms in different modes of presentation? That is, what differences in help-seeking behavior might we find under conditions in which help is offered by an anthropomorphic agent; or a speech activated device?

Quite importantly, we need to remember that our classification of HSSs is based on user experiences with two digital libraries. Clearly, advancement in this area of research will require replication of the experiment with other digital libraries.

While beyond the scope of this paper, a larger goal of our research is to identify prototypical patterns of help-seeking behaviors over the course of an entire search.

Finally, the high level goal of our research program is to develop help systems that can act as interaction partners with users. A next step in this direction is to identify interaction strategies that precede use of help and facilitate the implementation of automatic help assistance. This is a challenging problem which we look forward to addressing.

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USING DECISION TREE ANALYSIS TO PREDICT WOMEN'S ENTREPRENEURIAL CHOICES

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ABSTRACT

If pre-entrepreneurial perceptions precede entrepreneurial behavior, then entrepreneurship researchers should benefit from perception-based research in entrepreneurship. This paper investigates the role of women's pre-entrepreneurial perception on their satisfaction levels and the impact this in turn will have on their choices of pursuing or not pursuing entrepreneurial endeavors. Using data from female graduates of a Liberal Arts College in Upstate New York, the perception of job satisfaction levels are analyzed on a comparative basis with their counterparts across gender lines. The data allows us to demonstrate that women view their satisfaction levels differently when gender is accounted for. In addition, the paper offers a unique analysis of female college graduates' job satisfaction levels, college education satisfaction levels and their relation to entrepreneurial choices. The paper is unique in its application of a decision tree analysis to answer this major question, as well as others.

INTRODUCTION

Theorists often claim that factors that lead to entrepreneurship participation are based on three main perspectives: (1) the characteristics of the entrepreneur; (2) how the entrepreneur uses knowledge, networks and resources to construct firms; (3) the environmental forces at different levels of analysis (people, population, society), (Low and MacMillan, 1988; Aldrich and Martinez, 2001). All three areas have received reasonable focus over the last four decades of concentrated attention paid to entrepreneurship and entrepreneurial orientation. The latter distinction has been made in the past, but was made most recently by Limpkin and Dess (1996) who saw the former concept as a broad perspective on the subject and the latter as encompassing methods, practices and decision making styles used by the entrepreneurs.

This paper merges the economic and the psychology domains of entrepreneurship with the goal of determining what psychological factors help to determine certain entrepreneurial choices. The paper assesses various facets of career related perception as key determinants of entrepreneurial choices, behaviors and, ultimately, success. The failure of past entrepreneurial research that clearly highlights the role of earlier

perceptions on later entrepreneurial choices has created a vacuum within the entrepreneurship literature that has been waiting to be filled. With this deficiency in mind, we examine the role of career related perceptions on the entrepreneurial choices made by women when engaging in entrepreneurial behavior.

Over the last five decades, the influx of women into the workforce has occurred at an unprecedented pace, resulting in a 46-48% rate of workforce participation level (Jones and George, 2009). Despite their labor force participation rates, numerous studies reveal that women continue to face stereotyping, struggle with bias in hiring, promotion, training and salaries and are forced to reconcile serious work/life conflicts. One area that has received an adequate focus is the level of job satisfaction women experience when compared to their male counterparts. However, no known study has looked at the link between job satisfaction levels and the level of satisfaction with the skills and training received from females' college education.

Job satisfaction has been defined as a positive feeling about one's job resulting from an evaluation of its characteristics (Robbins and Judge, 2011). The topic of job satisfaction is important because of its implications to other job related variables, such as job performance, job involvement and motivation (Robbins and Judge, 2011; Danielson and Bodin, 2009), Moreover, various studies have shown that job satisfaction is positively related to motivation, job involvement, organizational citizenship behavior, organizational commitment, life satisfaction, mental health and job performance and negatively related to absenteeism, turnover and perceived stress (Janssen, 2001; McCue and Gianakis, 1997, Judge et al, 2001; Spector, 1997). As such, the various disciplines of economics, sociology, psychology, psychiatry and various fields of business have shown an appropriate interest in workers' job satisfaction levels.

The level of job satisfaction among women is also an important aspect of their work experience because it may signify their potential long-term commitment to the world of work, as well as their ability to simultaneously address work/family conflict issues (Andrisani, 1978; Hodson, 1989; Mcelwain et al, 2005; Stevens, Kiger and Riley, 2006).

The principal purpose of this study is to examine a number of aspects of job satisfaction for female graduates, such as job advancement and compensation levels in a context of comparison with counterparts across gender lines. A secondary purpose is to look at the graduates' job satisfaction and look back to their satisfaction with their college education to determine the relationship between the two areas. More specifically, the study involves three major questions. First, will the women from the same graduating cohort express varying job satisfaction levels when viewing from a varying gender perspective? Second, will the women from the same cohort express varying job satisfaction with job advancement and compensation again when looked at from varying

gender perspectives? Third, what will be the link between satisfaction with college education obtained and job satisfaction levels for the said group of women?

LITERATURE REVIEW

The literature review for this paper is divided into two distinct sectors. The first looks at women entrepreneurs and the impact that perceptions have on their choices. The second literature review section looks at the satisfaction levels of women. In so doing, the literature presentation allows the reader to analyze and decipher the framework for the decision tree analysis that is done in the results section.

Literature Review on Women's Job Satisfaction Levels

Satisfaction with one's job is said to be a standard for assessing the quality one's work experiences (Bokemeier and Lacy, 1986; Auster, 2001). Job satisfaction for women has been studied from various perspectives. This paper does so from five major streams: job satisfaction and performance; job satisfaction across various occupations; job satisfaction across countries; job satisfaction as related to work/family conflict and job satisfaction in varying gender composition groups.

Job satisfaction as related to job performance are detailed in the following key studies. The first looks at sex differences in job satisfaction and was explored utilizing data from the National Opinion Research Center (NORC) General Social Surveys, using information from the years 1974-1982. While the study confirms that women receive less job rewards than men, they do not show any difference in job satisfaction levels when compared to their male counterparts (Bokemeier and Lacy, 1986).

Earlier studies suggest that the gender composition of an employee's work group may in fact affect their job satisfaction levels (O'Reilly et al, 1989; Smith, 1992; Tsui, Egan and O'Reilly, 1992). This has been affirmed in more recent studies by Fields and Blum (1997) and even more recently from Bender at al (2005). In the case of Fields and Blum (1997), the authors found that both men and women working in gender balance groups have higher levels of job satisfaction than those who work in homogenous groups (Fields and Blum, 1997). They further concluded that employees working in groups containing mostly men have the lowest level of job satisfaction, with those working in groups containing mostly women falling in the middle (Fields and Blum, 1997). In the same vein but with differing results, Bender et al (2005) found that women report higher job satisfaction levels than their male counterparts, especially in workplaces that are dominated by fellow female workers. However, in a divergent set of results, the authors found that gender composition of the workplace plays no role in determining the job satisfaction levels of women (Bender et al, 2005).

There are many interesting parallels between gender relations and the work/home divide in regards to job satisfaction. Managing work and family responsibilities is an increasing problem in today's society, due in part to the changing roles of men and women in the workplace and at home. Not only are women now working outside the home, but various studies have found that women continue to engage in the majority of the housework at home (Duxbury et al, 1994; Leo, 2003; Greenhaus and Beutell, 1985). Using questionnaire data from 320 participants, Mcelwain, Korabik and Rosin (2005) found no significant gender differences for the relationship between Work Interfering with Family (WIF) and family satisfaction. In addition, the relationship between Family Interfering with Work (FIW) and jobs satisfaction was significantly stronger for men than for women (Mcelwain, Korabik and Rosin, 2005). In a related study, women's job satisfaction levels are higher for women with more job flexibility with their work and greater levels of family cohesion (Stevens, Kiger and Riley, 2006).

Job satisfaction levels of women and the central paradox of why women's job satisfaction is not always lower than that for men has been investigated across countries (Kim, 2005; Remennick, 2005; Sousa-Poza and Sousa-Poza, 2000). Sousa-Poza and Sousa-Poza (2000) found that in countries where women are much more satisfied than men, work-role outputs tend to be higher for women than for men.

Working women in Israel showed no differences in their job satisfaction levels when compared to their male counterparts (Remennick, 2005), while women in Korea from a survey of 5,128 public employees defied the central paradox and indicated that women are more satisfied with their jobs than are men (Kim, 2005).

Issues related to women's job satisfaction levels and different types of occupations have been researched through a number of studies. Environmental health professionals in North Carolina were evaluated, with significant differences found between job satisfaction with salary and career advancement among regions (Zontek, Duvernois and Ogle, 2009). Salary inequities identified for women with 6-15 years of experience, overall job satisfaction levels did not show any differences across age, gender or years of practice for the respondents in this said occupation (Zontek et al, 2009). The preceding results were echoed in studies by Jurik and Halemba (1984) who looked at correctional officers and McDuff (2001) who looked at clergies. Both studies showed that women's job satisfaction levels were higher than that for their male counterparts (Jurik and Halemba, 1984; McDuff, 2001). The prior results are in contrast to results from Price and Wulff (2005) and Blau and Tatum (2000), where women for the most part showed lower job satisfaction levels when compared to their male counterparts. The former article analyzed television newscasters, while the latter looked at medical technologies.

Two articles simultaneously looked at job satisfaction and occupations but did so across countries with different socioeconomic statuses. While holding occupation

constant, Ssegana and Garrett (2005) and Sabharwal and Corley (2009) looked at faculty members teaching at colleges and universities in Uganda and the United States respectively. Sabharwal and Corley (2009) focused on analyzing job satisfaction by gender across disciplines, while controlling for a variety of demographic, institutional and career variables across all disciplines. The authors concluded that female faculty members expressed lower levels of job satisfaction when compared with male faculty members in the United States (Sabharwal and Corley, 2009). No such difference in job satisfaction levels were found across gender lines for faculty members in Uganda (Ssesanga and Garrett, 2005).

Literature Review in Related Women Entrepreneurs' Areas

Entrepreneurs in general and women entrepreneurs in particular are important facilitators of economic growth and development (Gorman and Sahlman, 1989; Jome, Donahue and Siegel, 2006). They are said to contribute to the development and introduction of new products, services and technologies and subsequently create the majority of new jobs, solidifying their role as a critical component of a nation's economy (Proimos and Murray, 2006). However, the area of women entrepreneurship, which has taken an increased focus in the last two decades, has not been thoroughly explored with all facets of the subject area intricately investigated. One area that has not been afforded the attention it deserves is the role perception impacts the type of businesses that women entrepreneurs enter into. Very few researchers thus far have attempted to examine the role of career perception in predicting the type of entrepreneurial ventures pursued or the role of varying perceptions on entrepreneurial success.

The entrepreneurial cycle has four phases – conception, gestation, infancy and adolescence (Aldrich and Martinez, 2001). This paper focuses on the perception that takes place at the conception stage (while someone is thinking about starting a business but probably working for someone else) and the impact that has on the gestation stage (the type of business started) as well as the impact that has on the infancy and adolescence stage (while the business is operational).

Within the multidisciplinary tradition of entrepreneurship research, theories that attempt to explain the relationship between the entrepreneur and new venture formation stems from several fields: economics, personality, psychology and strategy (Mitchell, Busenitz, Lant, McDougall, Morse and Smith, 2002) from an economic perspective, theories of entrepreneurship view the contribution of the entrepreneur to be a creation of new enterprise (Mitchell et al, 2002; Brown, Davidson and Wiklund, 2001). While the trait based or personality grounded psychological approach gives credence to the contributions of the individual themselves (Mitchell et al, 2002; Sarasvthy and Dew, 2008; Stewart and Roth, 2007). Tthe strategic management perspective in most recent

decades have attempted to link new venture performance to entrepreneurial activities (Ireland, Covin and Kutatko, 2009).

It is true that all perspectives have merit from an entrepreneurial research view and each faction makes a significant contribution to a further understanding and exploration of the entrepreneurial literature. However, questions remain that demand answers. To this end, this paper explores a sector of the psychological literature focusing on perception and the role it plays in the entrepreneurial process. This research will shed light on two key areas. First, whether there is a relationship between women's perception of their feminine roles, compared to other women or men and the types of businesses she started. Second, whether their majors in college or types of degrees impacted the success of their businesses. Third, whether their majors or types of degrees pursued in college impacted the types of businesses they started.

There is no doubt that an individual's perceptions dominate their thoughts and their behavior as human beings (Robbins and Judge, 2008). This perceptual focus is critical when entrepreneurial studies are conducted, since the individual is a key component of what defines and entrepreneur (Smith-Hunter, 2006; Doucouliagos, 1995). In addition, the role of perception is a critical focus when the entrepreneur is analyzed (Weber and Hsee, 1998; Keh, Foo and Lim, 2002; Sitkin and Pablo, 1992). For example, a number of authors have analyzed the impact of risk on an individual's behavior (Weber and Hsee, 1998; Weber and Milliman, 1997; Limpkin and Dess, 1996; Sine, Haveman and Tolbert, 2005). Risk is said to be dependent on one's perception (Robbins and Judge, 2008). Weber and Hsee (1998) concluded that individuals across various countries differed on their risk preference. In a similar vein, Weber and Milliman (1997) concluded that an individual's risk perception would be altered based on situational factors. Our perceptions area is said to dominate our thoughts and impact our behavior as human beings (Robbins and Judge, 2008). It is these same perceptions that alter our behavior in relation to risk. The importance of perception to an entrepreneur's behavior cannot be understated. In fact, Keh, Foo and Lim (2002) indicate that an individual's evaluation of existing opportunities (which is a direct link to the pursuit of entrepreneurial behavior) is mediated by opportunity evaluation.

The previous perspectives raise intriguing questions about the role of perception in impacting entrepreneurial behavior. Perceptions are shown to differ across cultures (Lau, Shaffer and Au, 2007; Hayton, George and Zahra, 2002), as well as different stages of an individual's life (Cameron and Whetten, 1981) and across genders (Fagenson and Marcus, 1991). In a direct relation to the current study, females' perceptions of their own evaluation differed when asked to compare it to differing gender contexts (Fagenson and Marcus, 1991). The current study also assesses females' perceptions of various factors in differing gender contexts as related to their career success.

The concept of personality has been said to have an impact on the start-up configuration of a business venture. This was done most recently by Korunka, Frank, Lueger and Mugler (2003) who investigated the impact of personality and other factors such as personal resources, environment and organizational activities on business start-ups. The authors were able to show that personality factors (such as need for achievement, internal locus of control and risk) did indeed impact the type of business start-up the entrepreneurs engaged in (Frank et al, 2003). With successful entrepreneurs showing high scores on the former factors and medium scores on the latter factor (Frank et al, 2003). A later article by Stewart and Roth (2007) confirmed that entrepreneurs score higher on the need for achievement when compared to managers.

The role of intentions (Kuehn, 2008; Vandekerckhove and Dentchen, 2005; Shepherd and Krueger, 2002; Townsend and Hart, 2008) has also been used to explain entrepreneurial behavior, acting as an umbrella to more specific variables, such as perceptions or risk propensity. Intentions are said to be specifically focused on the entrepreneur's state of mind, directing their attention, experience and action towards a business concept and is thus related to the literature of this paper, since it sets the form and direction of organizations at their inception (Bird, 1988).

First Set of Hypotheses:

Based on the preceding detailed literature review, the following hypotheses will be analyzed:

> *H1:   Women who express lower levels of satisfaction for meaningful jobs are more likely to engage in entrepreneurial choices.*
>
> *H2:   Women who express lower levels of satisfaction for their college education and more likely to engage in entrepreneurial choices*

Children, Marriage and Job Advancement:

Earlier studies have shown that one reason for embracing entrepreneurship is the lack of advancement women experience in the mainstream labor market beyond a certain point (usually mid to upper level management). This "glass ceiling" effect results in a sense of frustration for the women entrepreneurs in leaving to start their own business (Moore and Buttner, 1997; Smith-Hunter, 2006).

Much of the studies on women entrepreneurs have returned results with certain constants. Two such constants are related to marital status and having children. A multitude of studies have shown that women entrepreneurs are more likely to be married and have an average of two children. Such results have been found in the United States

(NWFBO, 1999; NFWBO, 2000), with women entrepreneurs across racial lines (Smith-Hunter, 2006), in Ghana, where the average number of children is found to be slightly higher at 4 children (Dzisi, 2008, in Oman (McElwee and Al-Riyani, 2003) and in Turkey (Hisrich and Ozturk, 1999). A rare study to have found differently was conducted by Delmar and Davidson (2000). The authors found that marital status and number of children were unrelated to the probability of becoming a nascent entrepreneurs (someone trying to start a business), Delmar and Davidson, (2000). The studies that have found marital status to be related to increased entrepreneurial ventures cite the additional income from a spouse as a security to propel women start their own business. The nature of entrepreneurship is also such that the increased flexibility allows women to combine work and family life. Another reason that has been put forward as to why women with children start their own business is to provide a source of wealth for their children. One could thus extend this reasoning and posit that women who are unmarried with children might be more potently inclined to take the risk and engage in business ownership.

Based on the above discussion, the following hypotheses are proposed:

Second Set of Hypotheses:

H3: *Women with children are more likely than their counterparts to start a business.*

H4: *Women who are married are more likely than their counterparts to start a business.*

H5: *Women with children who are unmarried are more likely than their counterparts to start a business.*

H6: *Women who had high levels of job advancement are more likely than their counterparts to start a business.*

DATA AND RESEARCH METHODOLOGY

The research methodology section of this paper is divided into the following sections: sample data, statistical analysis and research instrument.

Sample Data:

The sample for this study was derived from alumni women of a private, undergraduate college, located in upstate New York. The college was originally established as a male commuter school in 1937. It remained a single sex institution until 1969, when the first female students were admitted. By 2009, the female population at

the institution had grown to 56%. The alumni that participated in this study graduated between 1984 and 1989. This specific cohort was chosen since it was felt that they would have participated in the mainstream labor market (worked for someone else) for some time before possibly embarking on an entrepreneurial venture. A total of 1836 female alumni were originally contacted. The overall response was 596 (32.5%). There were 445 (74.6%) of the females who worked in the mainstream labor market for someone else. The other 151 (25.4%) were entrepreneurs who operated their own business.

Statistical Analysis

One key analysis that will be undertaken in the current paper is a Decision Tree. Unlike other studies on this topic that have employed regression analyses or correlation tables, use of s decision tree vaults the analyses to premium level and thus contributes significantly to the research in this area.

A decision tree method in statistical analysis has been described as a general approach to a wide range of operations and supply chain decisions (Oliver et al, 2009). It is particularly valuable for evaluating different capacity expansion alternatives when demand is uncertain and sequential decisions are involved (Oliver et al, 2009). It is sometimes called a sequential decision tree and then simply defined as a graphical method for analyzing decision situations that require a sequence of decisions over time (Russell and Taylor, 2009). A decision tree is a schematic model of alternatives available to the decision maker, along with their possible consequences (Oliver et al, 2009). The name derives from the tree-like appearance of the model. It consists of square nodes, representing decision points, that are left by branches, which read from left to right, representing the alternatives (Oliver et al, 2009). The probability of each chance event is shown above each branch. The probabilities for all branches leaving a chance node, must sum to 1.0 (Oliver et al, 2009).

After drawing a decision tree, it is solved by working from right to left, calculating the expected payoff for each node (Oliver et al, 2009). For an event node, the payoff of each event branch is multiplied by the event's probability and then added to get the event node's expected payoff (Oliver et al, 2009). For the decision node, the alternative that has the best expected payoff is picked (Oliver et al, 2009). If an alternative leads to an event node, its payoff is equal to that node's expected payoff (Oliver et al, 2009). The branches not chosen are pruned, the decision node's expected payoff is the one associated with the single remaining unpruned branch(Oliver et al, 2009). The process is continued until the leftmost decision node is reached.

Research Instrument

A questionnaire was mailed to the participants, soliciting their responses. It was designed to assess the perceptions of the female graduates as they related to the quality of their career experiences and whether they had a subsequent entrepreneurial engagement. In the questionnaire, participants were asked to respond with varying degrees of intensity in regards to their perception on the issues of: their human capital characteristics; their business related knowledge; and the difficulties they experienced.

The former students were also asked to assess their satisfaction levels with their education at the college on a scale ranging from "very dissatisfied" to "very satisfied." They were also asked to assess the perception of their satisfaction levels on their jobs in terms of its meaningfulness, advancement potential and financial compensation.

The results from the current study are presented in three different but related sub-areas in order to aid clarity and to answer the questions posed at the beginning of this paper in a clear and concise manner.
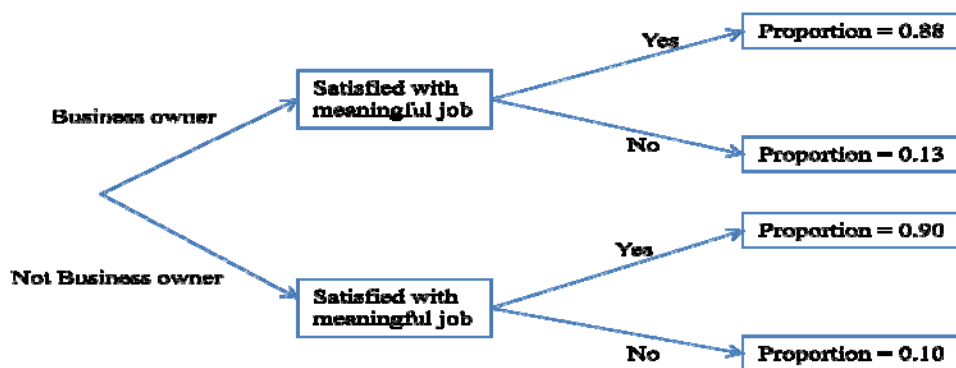
RESULTS AND ANALYSIS:

First hypothesis:

> *H1:* *Women who express lower levels of satisfaction for meaningful jobs are more likely to engage in entrepreneurial choices.*

Crosstabulation#1: Business owner * Meaningful Job					
			MeanJob_D		
			0	1	Total
OwnBus	0	Count	44	400	444
		Expected Count	46.7	397.3	444.0
	1	Count	17	119	136
		Expected Count	14.3	121.7	136.0
Total		Count	61	519	580
		Expected Count	61.0	519.0	580.0

Computed Chi-Sq. value = 0.742,
The tabulated value of chi-sq distribution:
Notation: OwnBus = 1 means that the person is a business owner: = 0 means that the person is a not a business owner.
MeanJob_D = 1 means the person is more than satisfied from his /her ability to secure and maintain a job he/she felt was meaningful,; = 0 means less than satisfied.

$$\chi^2{}_\alpha = 2.706, \quad 3.841, \quad 5.412, \quad 6.635 \quad for \quad \alpha = 0.10, \quad 0.05, \quad 0.02, \quad 0.01$$

The chi-square test is insignificant. That means the proportion of business owners who were satisfied with meaningful jobs (or, not satisfied) were homogeneous with the proportion of non business owners who were satisfied with meaningful job (or, not satisfied). So, the relative proportions of people who were satisfied with meaningful job for these two categories cannot distinguish between business owners and non business owners.

The following decision diagram shows the proportion of people who were satisfied with the meaningful job from two categories (Business and non-business):

Because of homogeneity of relative proportions of people with meaningful job satisfactions between business owners and business non-owners, the hypothesis "*Women who express lower levels of satisfaction for meaningful jobs are more likely to engage in entrepreneurial choices*" is false.

H2: Women who express lower levels of satisfaction for their college education and more likely to engage in entrepreneurial choices

The chi-square test is insignificant. That means that the two categories: business owners and non business owners are homogeneous based on their satisfaction levels with the broad education that they received at the college. This result shows that the satisfaction levels of their "broad education" received at the college cannot determine their decision to start a business. The decision diagram below shows the proportions of the satisfaction levels at the broad education levels received at the college are homogeneous between two categories of populations: Business owners and Business non-owners. More proportions of Business owners (also, Business non-owners) were satisfied

with the broad education that they received, and the chi-square test shows that the two categories (Business owners and non-owners) are homogeneously distributed.

Crosstabulation#1: Business owners x Broad education received					
			BrdEd_D		
			0	1	Total
OwnBus	0	Count	21	423	444
		Expected Count	23.6	420.4	444.0
	1	Count	10	128	138
		Expected Count	7.4	130.6	138.0
Total		Count	31	551	582
		Expected Count	31.0	551.0	582.0

Computed Chi-Sq. value =1.322 ,
The tabulated value of chi-sq distribution:
Notation: OwnBus = 1 means that the person is a business owner, = 0 means that the person is a not a business owner.
BrdEd_D = 1 means the person is more than satisfied from the broad education she received at the college   = 0 means less than satisfied.

$$\chi^2{}_\alpha = 2.706, \quad 3.841, \quad 5.412, \quad 6.635 \quad for \quad \alpha = 0.10, \quad 0.05, \quad 0.02, \quad 0.01$$
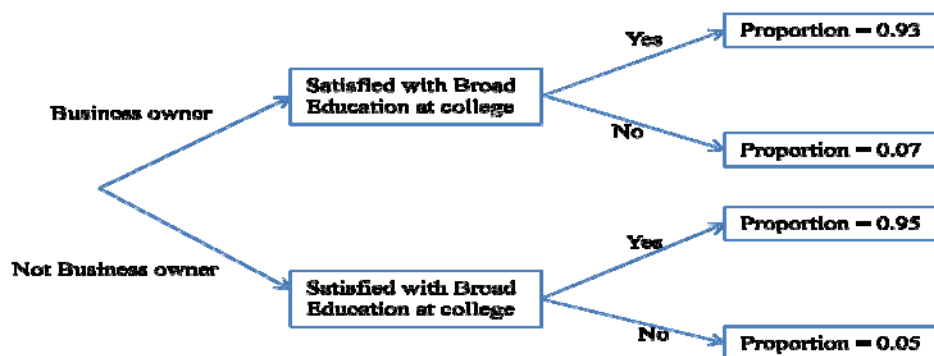
So, this decision theoretic approach states that : The satisfaction levels of the broad education received at the college <u>cannot</u> distinguish between people who start a business vs. who does not start a business
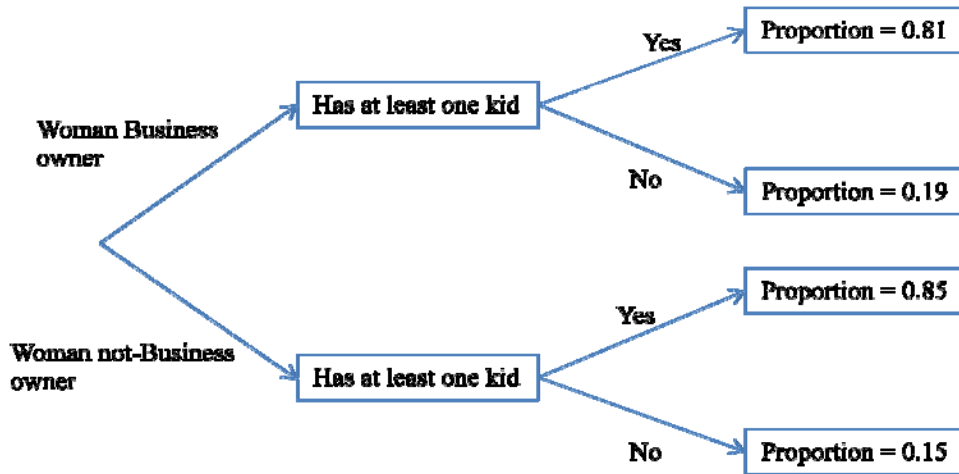Third hypothesis:

H3: *Women with children are more likely than their counterparts to start a business.*

Crosstabulation#13: Business owner x have children					
			Chil_Dm		
			0	1	Total
OwnBus	0	Count	67	374	441
		Expected Count	70.7	370.3	441.0
	1	Count	26	113	139
		Expected Count	22.3	116.7	139.0
Total		Count	93	487	580
		Expected Count	93.0	487.0	580.0

Computed Chi-Sq. value = 0.968 ,
The tabulated value of chi-sq distribution:
Notation: OwnBus = 1 means that the person is a business owner, OwnBus = 0 means that the person is a not a business owner.
Chil_Dm = 1 means the woman has at least one kid, Chil_Dm = 0 means she does not have any kid.

$$\chi^2{}_\alpha = 2.706, \quad 3.841, \quad 5.412, \quad 6.635 \quad for \quad \alpha = 0.10, \quad 0.05, \quad 0.02, \quad 0.01$$

The chi-square test is insignificant. That means the categories business owners/non-owners are homogeneous groups based on if they have kids or does not have any kids. So, just looking into these two variables makes us reject the hypothesis "*Women with children are more likely than their counterparts to start a business.*".

The decision diagram below shows the relative proportions of the women business owners and not business owners have at least one kid and does not have at least one kid. The relative proportions look similar among two categories woman business owner and woman non-business owner. This confirms chi-square test of homogeneity results that we obtained above.

So the above decision diagram shows that the hypothesis "*Women with children are more likely than their counterparts to start a business*" is false.
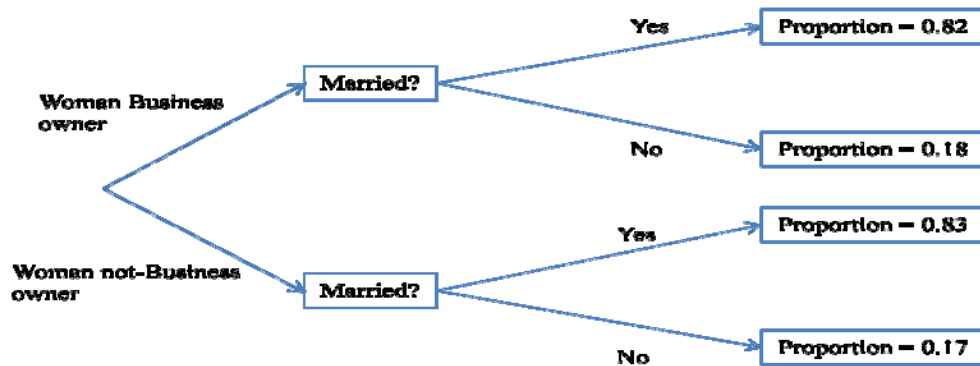
Fourth hypothesis:

> *H4: Women who are married are more likely than their counterparts to start a business.*

			Mar_St_Dm		
Cross tabulation# 4: Woman business owners vs. Marital Status					
			0	1	Total
OwnBus	0	Count	72	361	433
		Expected Count	73.1	359.9	433.0
	1	Count	24	112	136
		Expected Count	22.9	113.1	136.0
Total		Count	96	473	569
		Expected Count	96.0	473.0	569.0

Computed Chi-Sq. value = 0.077 ,
The tabulated value of chi-sq distribution:
Notation: OwnBus = 1 means that the person is a business owner, OwnBus = 0 means that the person is a not a business owner.
Mar_St_Dm = 1 means the woman is married, Chil_Dm = 0 means she is not married

$$\chi^2{}_\alpha = 2.706, \quad 3.841, \quad 5.412, \quad 6.635 \quad for \quad \alpha = 0.10, \quad 0.05, \quad 0.02, \quad 0.01$$

The chi-square test is insignificant. That means proportion of married (or unmarried) women among women business owners is homogeneous with the proportion of married (or unmarried) women among women non-business owners. So, the hypothesis "*Women who are married are more likely than their counterparts to start a business*" is false based on our data.

The decision diagram above shows the relative proportions of the women business owners and not business owners who are married and who are not married. The relative proportions look similar among two categories woman business owners and woman non-business owners. This confirms chi-square test of homogeneity results that we obtained above and effectively stating that our hypothesis "*Women who are married are more likely than their counterparts to start a business*" is false.

Fifth hypothesis:

> *H5:   Women with children who are unmarried are more likely than their counterparts to start a business.*

The chi-square test shows that whether they are unmarried with children or not, women business owners and not business owners are homogeneously distributed. That effectively nullifies the hypothesis "*Women with children who are unmarried are more likely than their counterparts to start a business*".

The decision diagram below shows the relative proportions of the women business owners and not business owners who are married with at least one kid (or, not) are similarly distributed.

Crosstabulation#5: Woman Bus-owner * Unmarried with Children					
			UnMrd_Chil_Dm		
			0	1	Total
OwnBus	0	Count	399	34	433
		Expected Count	398.8	34.2	433.0
	1	Count	125	11	136
		Expected Count	125.2	10.8	136.0
Total		Count	524	45	569
		Expected Count	524.0	45.0	569.0

Computed Chi-Sq. value = 0.008 ,

The tabulated value of chi-sq distribution:

Notation: OwnBus = 1 means that the person is a business owner, OwnBus = 0 means that the person is a not a business owner.

UnMrd_Chil_Dm = 1 means the woman is unmarried and has at least one child, otherwise UnMrd_Chil_Dm = 0.

$$\chi^2{}_\alpha = 2.706, \quad 3.841, \quad 5.412, \quad 6.635 \quad for \quad \alpha = 0.10, \quad 0.05, \quad 0.02, \quad 0.01$$
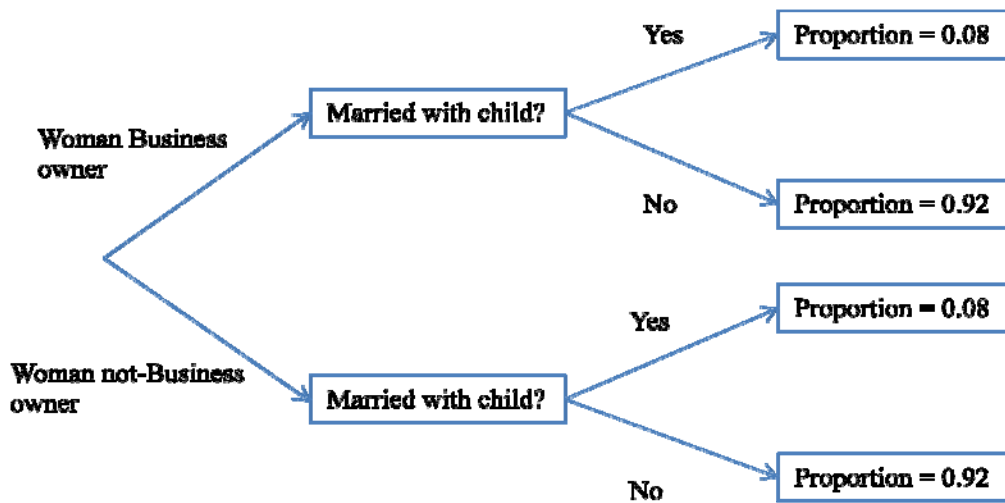
As the proportion of "married with children" (yes or no) are similar between two categories: woman business owners and woman not business owners. This evidence says that the hypothesis "*Women with children who are unmarried are more likely than their counterparts to start a business*" is false.

Sixth hypothesis:

> *H6:* *Women who had high levels of job advancement are more likely than their counterparts to start a business.*

This hypothesis can be looked from two different angles:

Part I of *H6:* *Women who had high levels of job advancement <u>at a pace equal to the men</u> are more likely than their counterparts to start a business.* And
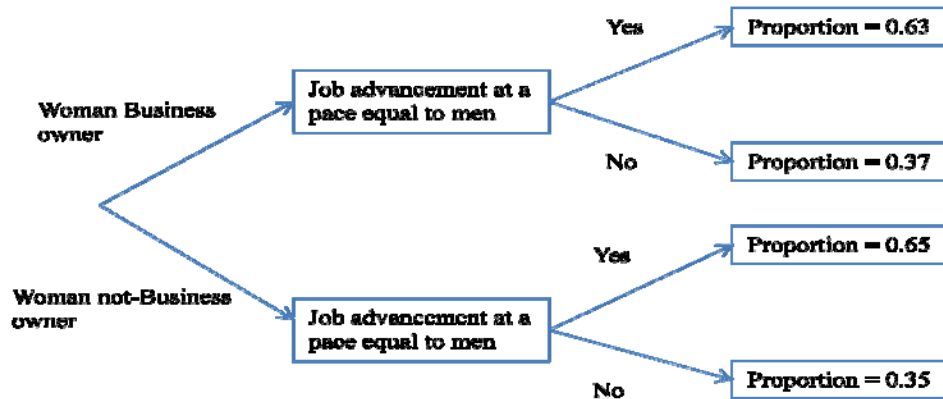
Part II of *H6:* *Women who had high levels of job advancement <u>at a pace equal to the women</u> are more likely than their counterparts to start a business.*

Part I of *H6:*

Crosstabulation#6 Part 1: Woman business owners * JobAdvMen_D					
			JobAdvMen_D		
			0	1	Total
OwnBus	0	Count	157	287	444
		Expected Count	158.5	285.5	444.0
	1	Count	50	86	136
		Expected Count	48.5	87.5	136.0
Total		Count	207	373	580
		Expected Count	207.0	373.0	580.0

Computed Chi-Sq. value = 0.089,
The tabulated value of chi-sq distribution: Notation: OwnBus = 1 means that the person is a business owner, OwnBus = 0 means that the person is a not a business owner.
JobAdvMen_D = 1 means the woman is satisfied with the ability to secure job advancement at a pace equal to the men
JobAdvMen_D = 0   means the woman is not-satisfied with the ability to secure job advancement at a pace equal to the men

$$\chi^2{}_\alpha = 2.706, \quad 3.841, \quad 5.412, \quad 6.635 \quad for \quad \alpha = 0.10, \quad 0.05, \quad 0.02, \quad 0.01$$

The chi-square test of homogeneity rejects the hypothesis. The decision diagram below shows the relative proportions of the women business owners and not business owners who were satisfied (or, not) with the job advancement at a pace equal to men.

And it clearly shows that the proportions are homogeneous between two categories women business owners and non-business owners.

So the hypothesis "*Women who had high levels of job advancement at a pace equal to the men are more likely than their counterparts to start a business.* " is false.
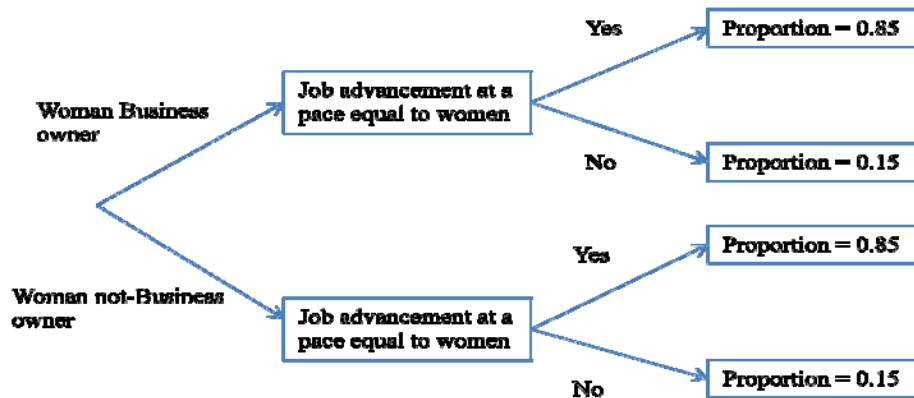
Part II of *H6: Women who had high levels of job advancement at a pace equal to the women are more likely than their counterparts to start a business.*

Crosstabulation#8: Women business owners * Job_Adv_Wm_D					
			Job_Adv_Wm_D		
			0	1	Total
OwnBus	0	Count	66	378	444
		Expected Count	65.8	378.2	444.0
	1	Count	20	116	136
		Expected Count	20.2	115.8	136.0
Total		Count	86	494	580
		Expected Count	86.0	494.0	580.0

Computed Chi-Sq. value = 0.002 ,
The tabulated value of chi-sq distribution:
Notation: OwnBus = 1 means that the person is a business owner, OwnBus = 0 means that the person is a not a business owner.
Job_Adv_Wm_D = 1 means the woman is satisfied with the ability to secure job advancement at a pace equal to the women
Job_Adv_Wm_D = 0 means the woman is not-satisfied with the ability to secure job advancement at a pace equal to the women

$$\chi^2{}_\alpha = 2.706, \quad 3.841, \quad 5.412, \quad 6.635 \quad for \quad \alpha = 0.10, \quad 0.05, \quad 0.02, \quad 0.01$$

The chi-square test of homogeneity rejects the hypothesis. The decision diagram shows that the relative proportions of woman business owners who were satisfied (or, not) at job advancement at a pace equal to woman are similar to those with woman not-business owners.

The decision diagram too shows that the hypothesis: "*Women who had high levels of job advancement <u>at a pace equal to the women</u> are more likely than their counterparts to start a business*" is false.

The Probit Analysis:

So far we have considered each variables one by one to see if that single factor affects to become (or, not) a business woman. The effect could be different if we look into all the factors simultaneously.

Let us now look into all the variables together in a multivariate probit equation to see which factors may contribute to the probability in making a business woman.

The dependent variable in the probit analysis is: OWNBUS that means if the woman interviewed owns her own business or not (OWNBUS = 1 implies the woman interviewed owns her own business).

	Probit Estimation:		Dependent Variable: OWNBUS					
Method: ML - Binary Probit (Quadratic hill climbing)								
Sample: 1 584								
Variable	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	0.11	0.89	0.06	0.94	-0.22	0.73	0.11	0.83
YR_SINC_GRAD	-0.09	0.54	-0.09	0.51				
Broad Education	-0.12	0.47	-0.12	0.50				
Think Analytically	0.22	0.12	0.23	0.11	0.14	0.18		
can learn on own	0.04	0.74						
developed writing skills	0.09	0.38	0.12	0.20	0.08	0.37		
developed oral comm	-0.12	0.34	-0.12	0.32	-0.13	0.26		
knowledge skills	-0.06	0.48	-0.06	0.48				
# company worked	0.02	0.92						
Has advanced degree	0.09	0.57	0.12	0.30				
Job adv at pace with woman	0.12	0.41	0.11	0.22	0.16	0.02	0.17	0.01
Job adv at pace with man	0.01	0.97						
compen at pace w wmn	-0.01	0.95						
compen at pace w men	0.09	0.68	0.05	0.81				
Marital_Satus_dummy	-0.52	0.08	-0.51	0.08	-0.48	0.09	-0.49	0.08
Has Children_Dummy	0.51	0.00	0.52	0.00	0.53	0.00	0.53	0.00
Akaike info criterion		0.69	0.68		0.66		0.66	
Schwarz criterion		0.82	0.78		0.72		0.69	
Hannan-Quinn criter.		0.74	0.72		0.68		0.67	
Avg. log likelihood		-0.32	-0.32		-0.32		-0.32	
McFadden R-squared		0.26	0.26		0.25		0.24	
Obs with Dep=0		81	82		82		82	
Obs with Dep=1		453	453		459		461	
Total obs		534	535		541		543	

The independent variables are:

YR_SINC_GRAD: year since she graduated
Broad Education: Satisfied with receiving a broad general education at college (scale 1 to
     5 with 5 being very satisfied)

Think analytically: satisfied with the developed ability to think analytically while at college (scale 1 to 5 with 5 being very satisfied)

Can learn on own: satisfied with the ability to learn on her own developed while at college (scale 1 to 5 with 5 being very satisfied)

Developed writing skills: satisfied with the written communications skills developed during college (scale 1 to 5 with 5 being very satisfied)

Developed oral comm.: satisfied with the oral communications skills developed while at college (scale 1 to 5 with 5 being very satisfied)

Knowledge skills: satisfied with knowledge and skills applicable to a career gained during college (scale 1 to 5 with 5 being very satisfied)

Companies worked: # companies worked since graduating from college

Has advanced degree: Has advanced degree, 1 if yes, and 0 if no

Job adv at pace with man: satisfied with the ability to secure job advancement at a pace equal to the men with whom she have worked (scale 1 to 5: very satisfied)

compen at pace with woman: satisfied with the ability to secure job advancement at a pace equal to the women with whom she have worked (scale 1 to 5: very satisfied)

Marital_Satus_dummy: Marital status = 1 if married, = 0 otherwise

Has Children_Dummy: it takes value = 1, if she has any child, else takes value = 0

CONCLUSION

The women who were the focus of this study—585 graduates of a private, undergraduate institution who received degrees between 1984-1989—had very clear and differing perceptions of their workplace experiences when comparing themselves to both women and men they had worked with. In turn, the women's perception of their satisfaction levels both in and out of school were used to determine which what impact those satisfaction levels had on them becoming or not becoming entrepreneurs. We saw this from three angles, first by chi-square test of homogeneity. That is similar to the two variable decision theoretical approach. We then looked to the hypotheses through Probit equation. Probit looks at it by taking all the variables simultaneously. Under these various methods most of our hypotheses turned out to be false.

Research investigating women entrepreneurship has often highlighted the motivational factors leading them to start, as well as the key factors leading to the continuation of their businesses. Observations on these associations often have a tendency to treat entrepreneurial women as an undifferentiated group, failing to recognize heterogeneity therein. The preceding discussion and subsequent statistical analyses recognized that this was not the case and have brought forth three significant results.

First, we found that a married female is less likely to be a entrepreneur than an unmarried female. We found that, in a multivariate set up, if the woman is married, that has negative significance on her being a business woman. Research has shown that married women may not be as anxious to earn a living since their husband may be the income earner in the family (Remmenick, 2005; Kim, 2005).

Second, we found that a female with a child (ren) is more likely to be a female entrepreneur. In essence, if the woman has child(ren) then she is more likely to have a business of her own. This is evidenced in the literature. Maybe the mother wants to gain more wealth for her children by starting a business (Smith-Hunter, 2006).

Third, one other variable was significant, that is if a woman is happy with the job advancement at a pace with her women colleague around her, she is more likely to start a business. This also has evidence in the literature. The literature concluded that employees working in groups containing mostly men have the lowest level of job satisfaction, with those working in groups containing mostly women falling in the middle (Fields and Blum, 1997). In the same vein but with differing results, Bender et al (2005) found that women report higher job satisfaction levels than their male counterparts, especially in workplaces that are dominated by fellow female workers. One could extrapolate and make the argument that women working in such female dominated groups achieve the self-confidence that translates into giving them the impetus to start their own businesses.

Overall, these findings are probably not surprising in their basic underlying results. However, the unique statistical analyses applied to this study makes for significant findings. Given that our operationalization can be confirmed from other literature and research findings, we can have confidence in the results. Our results have several implications for future research. Future studies could analyze broader samples of women entrepreneurs, as well assessing entrepreneurs across genders to see if the results still hold up with these additional analyses.

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