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ABSTRACT
Although software development projects increasingly incorporate virtual team members they still fall prey to risks which produce challenges as do co-located projects. Most research performed on project risk was conducted on projects using traditional co-located team members. This paper reports on the results of a survey of over 150 Information Technology (IT) practitioners. One goal of the survey was to identify differences in the degree of impact between risk factors on virtual software projects and those on co-located software projects. Out of fifty-five surveyed risk factors, seven risk factors showed significant differences in impact on the successful completion of projects in these two types of project environments. Additionally, the results showed a greater impact for each of the seven risk factors on virtual rather than co-located software projects. These results can be useful to practitioners who are managing in a virtual environment and need to correctly identify potential risks.

Keywords
IT Project Management, Virtual Teams, Risk Management

INTRODUCTION

Many factors, including advances in telecommunications, globalization and the cost and dangers of business travel (Jones, 2005) have fostered a move away from the traditional co-located project teams and toward use of virtual project teams. However, while the use of virtual project teams is growing (Walther, 2005), the amount of research on this emerging project environment type lags behind the volume of research on co-located projects. This is particularly true in the area of project risk. Prior research has focused on project risk in co-located projects (Wallace, 2004; Barki, Rivard, & Talbot, 1993; Boehm, 1991; Keil, Lyytinen, & Schmidt, 1998) with little attention to virtual projects. This is true despite the fact that risk management on projects has been identified as key to avoiding project problems, failures and even disasters (Addison & Vallabh, 2002) (Cole, Connolly, & Dean, 1995). As early as 1991, Boehm identified risk management to be critical to eliminating or reducing the occurrence of project risk (Boehm, 1991).

Certain aspects of virtual teams, such as trust and communication (DePillis & Furumo, 2006), have been researched in some depth; however there has been no empirical study of the important risk factors on virtual software development projects (Powell, 2004). Are the most important risk factors on software development projects which employ virtual teams the same risks that were previously identified for traditional, co-located projects? Do risks have approximately the same level of effect on the success of both co-located and virtual projects? A study of over 150 IT professionals was undertaken to determine the answers to these questions. The focus of this paper will be the differences in the level of impact or effect of risk factors on virtual versus co-located projects.

This paper begins with a discussion of the research's theoretical foundation and is followed by a description of the research methodology. Next, a discussion of the results illustrates how seven risk factors were found to have a significantly greater degree of impact on virtual software projects than on co-located software projects. The paper concludes with an evaluation of the findings.

THEORETICAL FOUNDATION

Prior literature has theorized on methods of reducing the occurrence of project problems and failures. Many have even proposed the use of risk management techniques to reduce or eliminate project failure (Addison & Vallabh, 2002) (Cole,

Connolly, & Dean, 1995). Within risk management, the first step is risk identification, which is an attempt to identify and document all possible risk factors for a specific project. The identification phase is followed by risk control, which involves devising a strategy to address and control each identified risk. Research by Boehm, Barki, et al., Keil, et al. and Wallace has produced lists of top risks on projects such as resource expertise, team diversity, technology and/or application complexities and unrealistic budgets and schedules to name a few (Barki, Rivard, & Talbot, 1993) (Boehm, 1991) (Keil, Lyytinen, & Schmidt, 1998) (Wallace, 2004). These lists of potential risks are considered to be beneficial in the risk identification phase (Barki, Rivard, & Talbot, 1993). Unfortunately, prior research was conducted on projects involving traditional, co-located project teams. A survey of prior literature reveals no such list exists for virtual software development projects. Therefore, there is a need for research on which risk factors are important to virtual projects. In the absence of a project risk list specific to the virtual environment, the lists of project risks developed for co-located projects have likely been used for all types of project environments. This current research study seeks to identify which risk factors may have vastly different degrees of impact on virtual versus co-located project teams.

Prior literature exists on virtual teams and virtual organizations, much of which focuses on investigating characteristics of virtual project teams such as trust, conflict and communication (Kirkman & Mathieu, 2005) (Jones, Oyung, & Pace, 2005) (Lipnack & Stamps, 1997). Other research identifies differences between virtual and traditional co-located teams. Majchrzak, et al. specifically identified three major areas where virtual teams differ from traditional co-located teams (Majchrzak, Malhotra, Stamps, & Lipnack, 2004):

1) Language and cultural differences
2) Work style differences
3) Problem solving approaches

Damian, et al. in their research found some communication-related benefits in virtual project teams over traditional co-located teams when negotiating requirements among team members with "conflicting perspectives". They felt the lack of verbal cues that occurs without face-to-face communication may have actually been beneficial in resolving differences (Damian, Shaw, & Gaines, 2000). On the other hand Dube and Robey in their research on virtual team paradoxes found a need for face-to-face communication in some instances and benefits to not having face-to-face communication in others. The researchers also pointed out the need for careful team member selection when building virtual teams due to their differences from co-located teams. Virtual teams were in general found to be more flexible and had more ambiguities while co-located teams were more structured (Dube & Robey, 2008).

METHODOLOGY

The methodology for this study was modeled after research methods used by prior researchers, such as Boehm, Barki, and Wallace to identify top risk factors on co-located software projects. The main research method was a survey questionnaire that was modeled after a questionnaire by Wallace (Wallace L. , 1999). The constructs of the questionnaire were the outcome of a number of other methods namely face-to-face interviews and a focus group. First, a review of literature was conducted to identify project risk factors from literature for inclusion in the questionnaire after the interviews and focus group session were completed. Next, face-to-face interviews were conducted with project management practitioners using the first version of the questionnaire. Open-ended questions in the questionnaire were used to identify a list of risk factors from the practitioner point of view and to validate the list from the literature. Additionally, rich data was collected from the practitioners as they described a specific project and the major issues they encountered. This step was followed by an electronic focus group session which was held to identify any risk factors that may have been missed and to validate what was found in the literature review and the face-to-face interviews. The large amount of data collected from these steps was sorted and combined to produce a comprehensive list of fifty-five risk factors. At this point the questionnaire was modified by replacing the open-ended questions with the list of fifty-five risk factors. Survey participants were asked to rate each of the fifty-five risk factors on the degree of impact they had on the successful completion of their particular projects. A three-point Likert scale was used for this rating process where "1" indicated the risk factor had no impact on the project or simply did not occur, "2" indicated the risk factor had a minor impact on the successful completion of the project and "3" indicated the risk factor had a major impact on the successful completion of the project.

The questionnaire was piloted and then the revised version was widely distributed as an online survey. Most survey participants were obtained through a purchased list and through solicitation of the international project management association, Project Management Institute (PMI). Over 150 IT practitioners, i.e. project managers/leaders and systems analysts each working on different projects completed the survey. Survey participants were asked to answer the questionnaire based on a recent virtual software project if possible. If no experience with a virtual software project was

available, a recent co-located project could be substituted. This approach yielded data about both virtual and traditional software projects allowing for some comparisons between project environments.

RESULTS

The survey participants had varying levels of experience and were from a wide variety of industries as indicated in the demographics table below:

Survey Participant Demographics		
Project Environment	Virtual Projects	69%
	Co-located Projects	31%
Project Cost	<$100K	22%
	>$100K to $1M	40%
	>$1M	33%
Project Duration	<1 year	53%
	1-2 years	27%
	>2 years	20%
Project Team Size	1 to 5 people	14%
	6 to 15 people	46%
	>15 people	39%
Firm Size	Large (>20K)	31%
	Medium (1K to 20K)	41%
	Small (<1K)	27%
Industry	IT Services	14%
	Finance/Banking	13%
	Manufacturing	13%
	Business Consulting	8%
	Insurance/Real Estate	8%
Project Manager Experience	<5 years	25%
	5 to 10 years	35%
	>10 years	31%
	Not the Proj Mgr	9%

Table 1: Survey Respondent Demographics

Analysis was performed using Chi-Square statistics. Once analyzed, the results of the survey revealed seven out of the fifty-five risk factors had significant differences in degree of impact when they appeared on virtual software projects versus co-located software projects. The table below shows all seven of the risk factors with the corresponding participant response percentages separated by type of project, i.e. virtual or co-located.

	Virtual Projects			Co-located Projects			
Risk Factors Description	**No Impact or Did Not Occur %**	**Minor Impact %**	**Major Impact %**	**No Impact or Did Not Occur %**	**Minor Impact %**	**Major Impact %**	**p-value**
Insufficient knowledge transfer	31.78	40.19	28.04	61.70	23.40	14.89	*0.0023
Lack of project team cohesion	41.12	41.12	17.76	70.21	23.40	6.38	*0.0034
Cultural or language differences	44.86	41.12	14.02	70.21	23.40	6.38	*0.0143
Inadequate technical resources, i.e. hardware, processing availability	47.66	40.19	12.15	72.34	21.28	6.38	*0.0179
Resource inexperience with company and its' processes	38.32	34.58	27.10	55.32	36.17	8.51	*0.0240
Loss of key resource(s) that impact the project	39.25	28.97	31.78	61.70	19.15	19.15	*0.0360
Hidden agendas impact the project	36.45	36.45	27.10	57.45	27.66	14.89	*0.0453

Table 2: Seven Risk Factors with Significant Differences in Impact on Virtual vs. Co-located Projects

The following sections will discuss each of these seven risk factors, outline the differences, and propose reasons for the observed differences.

Seven Risk Factors

The first risk factor, *Insufficient knowledge transfer* showed the most significant difference in degree of impact (p-value < .003). This risk factor refers to issues related to communication between project members when it involves a transfer of knowledge. Knowledge in this case could refer to situations such as details of a software application, business process procedures or project team workings. Of the virtual project team respondents, 28.40% of them indicated this risk factor caused a major impact on project success while almost half that number of participants on co-located projects (14.89 %) agreed. 61.70% of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects while only 31.78% of virtual project respondents agreed. The results support this risk factor being an issue in a virtual environment since a small percentage of virtual project respondents indicated there was no impact while at the same time a large percentage of co-located project responses concurred. This difference between virtual and co-located project types may have occurred because knowledge transfer methods are destined to be different in these two environments. Lack of face-to-face communication is likely to make knowledge transfer much more difficult in a virtual environment. Dube and Robey (2008) in their research on virtual teams found face-to-face communication to be advantageous in some situations. Simpler methods of communication, i.e. status reporting can easily be accomplished via e-mail or other forms of electronic communication. However, knowledge transfer usually involves a conversation between more than one person as well as sharing of documents. Email does not lend itself to conversational exchanges of complex material and other tools which work better in these situations such as teleconferencing, video conferencing or web conferencing may not be available to virtual project team participants. Damian, et al. (2000) in their research found "multimedia meeting systems" enabled virtual project teams to be more effective especially when there was conflict. Further, knowledge transfer may not be a significant problem on most co-located projects because much of it takes place casually, simply as a result of people being near one another. Jones, et al. (2005) indicate information sharing can be a challenge on virtual teams due to the absence of things like routine face-to-face update meetings which are not available in a virtual environment. It is interesting that other communication-related risk factors in the survey did not show significant differences. This suggests that all forms of communication do not show differences based on project environment. The message here is that all virtual project managers should take extra pains to facilitate knowledge transfer within their environment.

The *Lack of project team cohesion* risk factor showed a significant difference in degree of impact (p-value < .004). This risk factor describes the risk that the project team does not work well together and therefore lacks cohesion. Problems with team cohesion can occur when there is conflict between team members or even when the management of the team does not foster relationships needed to work together as a team. Either of these situations can lead to team member isolation which can contribute to less cohesion on a team. Jones, et al. (2005) indicate a feeling of isolation is one of the most common problems when working on a virtual team. 17.76% of the virtual project team respondents indicated this risk factor caused a major impact on their project success while less than half that number of participants on co-located projects (6.38 %) agreed. More than two-thirds (70.21%) of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects while less than half (41.12%) of virtual project respondents agree. The major impact percentages in the virtual environment were not very high, but together with the minor impact percentages they indicate 58.88% of virtual project respondents felt this risk factor had some impact on the successful completion of the project. More importantly, the difference between the degree of impact in a virtual environment and a co-located environment is significant. This difference may have occurred because co-located teams can form a bond more quickly than virtual teams due to face-to-face contact. Although a virtual project team may eventually form a bond, it is still more difficult for some people to build relationships through the use of electronic communication only.

The *Cultural or language differences* risk factor showed a significant difference in degree of impact (p-value < .02). This risk factor describes the problems that can occur due to differences in language and/or culture among project team members. The team members may speak different languages or they may all speak the designated project language, however, it may not be a native language for some which can lead to misunderstandings. Cultural differences can also occur when team members have a different understanding of a concept like timeliness and neither cultural group is aware a difference exists until a problem or misunderstanding occurs. Cultural differences can be harder to detect than language differences. 14.02% of the virtual project team respondents indicated this risk factor caused a major impact on their project success while less than half that number of participants on co-located projects (6.38 %) agreed. From the opposite angle, more than two-thirds (70.21%) of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects while less than half (44.86%) of virtual project respondents agreed. Over half (55.14%) of virtual project respondents felt this risk

factor had some impact on the successful completion of the project, either major or minor. More importantly, the difference between the degree of impact in a virtual environment and a co-located environment is significant. This difference may have occurred because it is more likely to have team members with different cultural backgrounds on a virtual team since members can be physically located in different cities, states or countries. These findings are in line with Lipnack and Stamps (1997) who indicate virtual teams are certain to have difficulties with differences in culture, custom and languages. Dube and Robey (2008) list cultural differences as just one area creating challenges for virtual team members. Interestingly, Lipnack and Stamps (1997) theorize that cultural differences can be just as severe between team members with different professional backgrounds as those from different countries. Future research could explore this question in more depth by inquiring about the source of the cultural difference, i.e. country of origin or profession. Finally, Majchrzak, et al. (2004) identify language and cultural differences as the first major area of differences between virtual and traditional co-located teams.

The *Inadequate technical resources, i.e. hardware, processing availability* risk factor showed a significant difference in degree of impact (p-value < .02). This risk factor describes the issues that can occur when technical resources required by the project team are not available or have limited availability. For instance, if the team needs to run test cycles on the company's mainframe computer they may run into problems getting enough CPU processing time due to normal daily operations having first priority. 12.15% of the virtual project team respondents indicated this risk factor caused a major impact on their project success while less than half that number of participants on co-located projects (6.38 %) agreed. More than two-thirds (72.34%) of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects while almost half (47.66%) of virtual project respondents agreed. The major impact percentages in the virtual environment were not very high, but together with the minor impact percentages they indicate 52.34% of virtual project respondents felt this risk factor had some impact. More importantly, the difference between the degree of impact in a virtual environment and a co-located environment is significant. This difference may have occurred because some technical resources that are not usually required for co-located projects can be essential in virtual projects such as video conferencing equipment to improve meetings and add a face-to-face communication component. Even smaller items such as scanners might be needed in a virtual environment to aid in the exchange of hand written diagrams and written processes or procedures from users. Since a key component of virtual teams involves the use of technical resources especially telecommunications in order to communicate, the lack of these technical resources could damage the core of a virtual team. Mayer (1998) describes the critical role of connectivity in virtual operations as "ubiquitous connectivity" which requires technical tools. In virtual environments she refers to the need to communicate with anyone in any location at any time (Mayer, 1998). Damian, et al. (2000) in their research also found a need for "multimedia meeting systems" to improve virtual team effectiveness.

The *Resource inexperience with company and its' processes* risk factor showed a significant difference in degree of impact (p-value < .03). This risk factor describes issues that may occur if the project team members are not familiar with the company as a whole, such as its' key goals and objectives or even procedures such as those for implementing software or requesting test cycle runs. 27.10% of the virtual project team respondents indicated this risk factor caused a major impact on their project success while only about a third of that number of participants on co-located projects (8.51 %) agreed. More than half (55.32%) of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects while less than half (38.32%) of virtual project respondents agreed. The difference in degree of impact may have occurred because it is common for virtual team members to work at different company site locations. Within the same company there may be differences in processes and procedures from one work site to another and team members may not realize this unless a problem occurs will trying to complete a task together. On the other hand, team members at the same location may experience some differences from department to department but they may be able to resolve them with face-to-face meetings. Jones et al. (2005) explain these types of problems can occur in decentralized organizations (with many site locations) when no centralized function exists to "mandate standards". Since software development involves many standards for tasks ranging from code creation to implementation, problems on virtual teams in this area are understandable.

The *Loss of key resource(s) that impact the project* showed a significant difference in degree of impact (p-value < .04). This risk factor describes the risk that the project may be thrown off course when an important team member leaves the project before completion. 31.78% of the virtual project team respondents indicated this risk factor caused a major impact on their project success while only 19.15% of participants on co-located projects agreed. Almost two-thirds (61.70%) of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects while less than half (39.25%) of virtual project respondents agreed. Again, the importance of these percentages is the significant difference in the responses from virtual software project respondents as compared to co-located software project respondents. This difference may have occurred because virtual teams have the advantage of being able to recruit the "best of the best" from anywhere in the world unlike co-located teams. If the virtual project team is made up of these types of experts then the loss of a key team member could have a greater impact due to a greater level of expertise that may be very difficult to replace. A greater sense

of team member interdependence and responsibility can occur on virtual teams which may consequently cause a larger gap to fill once a resource leaves the team (Hoefling, 2003).

The *Hidden agendas impact the project* risk factor showed a significant difference in degree of impact (p-value < .05). This risk factor describes the issues that can occur when one or more project team members have a hidden agenda they are trying to accomplish while working on the project. 27.10% of the virtual project team respondents indicated this risk factor caused a major impact on their project success while 14.89% of participants on co-located projects agreed. More than half (57.45%) of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects while more than a third (36.45%) of virtual project respondents agreed. The large percentage of co-located project respondents who felt this risk factor had no impact seems to indicate this risk factor is a non-issue in the co-located environment as compared to the smaller number of virtual project respondents. Hidden agendas at their core are related to trust. When trust exists among team members, a hidden agenda would be a breach of that trust. Trusting team members are not likely to expect fellow team members to have hidden agendas. Trust is also one of the key concerns in virtual teams and Hoefling (2003) indicates trust is the most common barrier for virtual teams. Additionally, these results may have occurred because hidden agendas can be easier to mask on a team where there is little or no face-to-face communication. The lack of non-verbal cues can make a hidden agenda truly invisible to virtual team members as opposed to co-located team members.

DISCUSSION

The graph below in Figure 1 shows a comparison of the participant response percentages for the "No Impact" rating. This is an indication of how many survey participants felt each of the seven risk factors either did not impact the successful completion of their project or simply did not occur on their project. The graph helps to illustrate the significant difference in degree of impact between virtual software projects and co-located software projects for these seven risk factors. In each case, the largest percentage of project participants who indicated the seven risk factors were non-issues worked on a co-located project team while only about a third to a half of virtual project participants felt each of these risk factors had no impact.

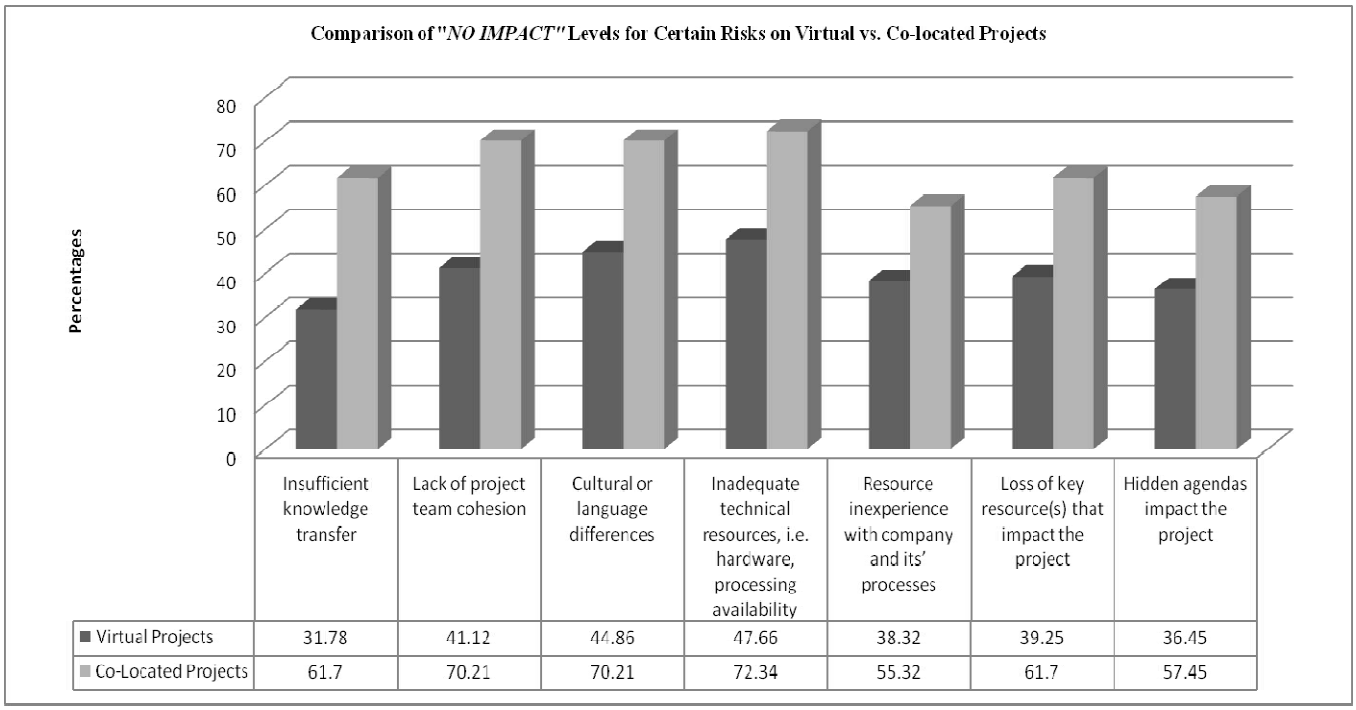

Figure 1: Comparison of "NO IMPACT" Levels for Certain Risks on Virtual vs. Co-Located Projects

The next graph in Figure 2 shows a comparison of the participant response percentages for the "Major Impact" rating. This is an indication of how many survey participants felt each of the seven risk factors had a major impact on the successful completion of their project, possibly changing the outcome from successful to unsuccessful. The graph helps to illustrate the significant difference in the degree of impact between virtual software projects and co-located software projects for these

seven risk factors. In each case, almost twice as many virtual project respondents indicated the risk factor had a major impact as the co-located project respondents.

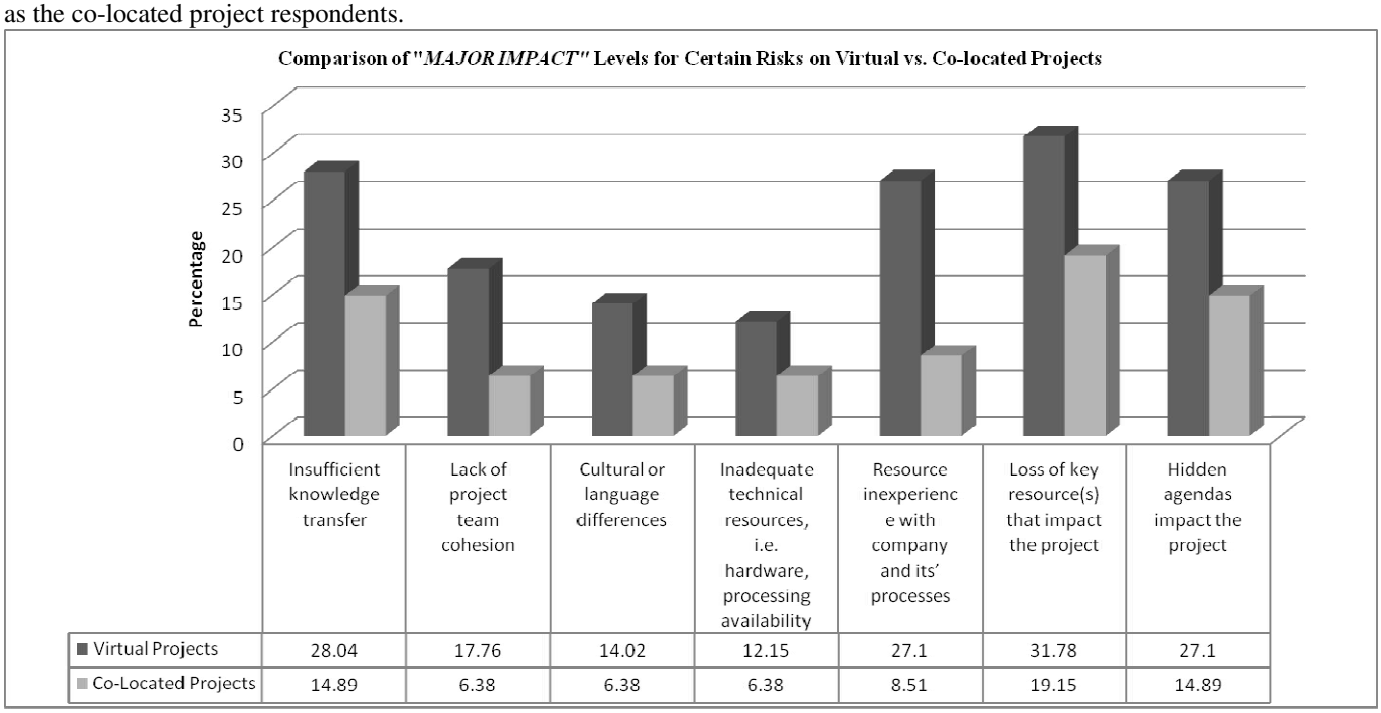

Figure 2: Comparison of "MAJOR IMPACT" Levels for Certain Risks on Virtual vs. Co-located projects

CONCLUSION

These results would be helpful in several ways to project management practitioners who have worked on co-located software projects and are new to virtual software projects. First, the results support the need for a project risk list specific to virtual software projects and the danger in using the traditional, co-located project risk list. Second, these results provide insight into some risk factors that are likely to be more pronounced on virtual software projects and must be monitored more closely in a virtual environment such as:

- Insufficient knowledge transfer
- Lack of project team cohesion
- Cultural or language differences

In conclusion, the survey results indicated seven out of the fifty-five risk factors showed significant differences in the degree of impact on the successful completion of the project for virtual software projects versus co-located software projects. Additionally, in every case, the results for each of these seven risk factors indicated participants felt there was a greater degree of impact on the successful completion of the project on virtual software projects than on co-located software projects. Significant differences were expected, but significant differences pointing to a more severe impact on virtual software projects was unexpected. It is important to note that the participants were not giving general opinions of their views of projects but were answering questions based on actual projects they participated in or led. Future research could further investigate the impact of these seven risk factors on virtual software projects and why the differences in impact occur.

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