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Using Embedded Mixed Methods in Studying IS Phenomena: Risks and Practical Remedies with an Illustration

Xiaodan Yu
University of International Business and Economics

Deepak Khazanchi
University of Nebraska at Omaha, khazanchi@unomaha.edu

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Xiaodan Yu, Ph.D.
School of Information Technology and Management,
University of International Business and Economics,
P.R.China
yxd.xiaodanyu@gmail.com

Deepak Khazanchi, Ph.D.
College of Information Science and Technology,
University of Nebraska at Omaha, USA
khazanchi@unomaha.edu

Abstract:

Drawing on lessons learned from a mixed method research project, we illustrate how mixed research approaches are fruitful in studying the complexities and interactions inherent in IS phenomenon. This is particularly relevant in instances where the phenomena under investigation is relatively new and "messy" in that many opportunities for errors and omissions are possible. Mixed method research designs can also prove to be valuable in exploratory or new areas of research and provide empirical evidence from multiple sources and types of data that can be truly triangulated. The key contribution of this paper is a detailed discussion of the risks associated with using a specific mixed method research strategy, embedded mixed method design, and the practical remedies we used to address them. This discussion provides operational guidance to researchers interested in adopting mixed research designs to study emergent IS phenomenon.

Keywords: mixed methods; IS research; embedded mixed research design; shared mental models

1 Introduction

Mixed methods research or mixed research (MM) is the class of research designs where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study for the purpose of breadth and depth of understanding and corroboration (Creswell & Clark, 2010; Denzin, 1970). Historically, mixed methods were first proposed for seeking convergence of findings or cross-validation (Campbell & Fiske, 1959). Mixed research designs became popular in social science studies for their many other advantages including the ability to leverage the strengths of varied methods, provide richer insights into phenomena of interest that cannot be fully understood using only quantitative or qualitative methods, address research questions that call for real-life contextual understanding, multi-level perspectives, and cultural influences (Johnson & Onwuegbuzie, 2004; Johnson, Onwuegbuzie, & Turner, 2007; Morgan, 1998; Venkatesh, Brown, & Bala, 2013; Venkatesh, Brown, & Sullivan, 2016).

Mixed methods have recently started receiving closer attention by IS researchers. For example, Venkatesh et al. (2013) suggests that a mixed research approach is particularly useful when researchers want to get "a holistic understanding of a phenomenon for which extant research is fragmented, inconclusive, and equivocal (p.36)."

> If IS researchers continue to publish single method papers from mixed methods programs, they are likely to miss the opportunity to discover, develop, or extend a substantive theory in richer ways than possible with single method papers. A mixed methods approach, particularly the associated meta-inferences, offers mechanisms for discovering substantive theory by allowing researchers to not only unearth components related to a phenomenon, but also unveil interrelations among these components and boundary conditions surrounding these interrelations (Venkatesh et al., 2013, p.31).

Despite the potential benefits of adopting a mixed method (MM) approach, conducting mixed research studies can be challenging (Creswell & Clark, 2010; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 2003; Venkatesh et al., 2013). A mixed methods approach is generally considered to be technically challenging compared with single threaded approaches. This is because of two main reasons: (a) researchers have to either be adept at multiple methods or collaborate with others who specialize in complimentary methods; and (b) researchers need to know how to mix multiple methods appropriately (Creswell & Clark, 2010). Additionally, compared with traditional qualitative and quantitative methods, graduate students do not receive much training on the use of mixed methods (Jick, 1979). This is exemplified by Bryman's study, wherein he reported conducting a series of interviews of mixed method researchers and found that most of them were unable to locate or could not remember any exemplars of mixed method research (2007).

Venkatesh et al. (2013, 2016) propose high level guidelines for conducting mixed methods research in IS, provide an integrative validation framework for mixed methods approaches, and also suggest how IS researchers can be flexible in adopting mixed methods approaches to suite their research purpose. However, we believe that given the many potential opportunities to use a variety of techniques in conducting mixed method research, it would be very useful to learn from IS studies using mixed research about the specific challenges and potential opportunities of such approaches. Thus in this paper, we explicitly focus on practical experiences and lessons learned from conducting a specific mixed method research study (refer Appendix A for a detailed description of our illustrative study). As suggested by Venkatesh et al. (2013, 2016), researchers should only consider the use of mixed methods when the research question, objective, and context require such an approach. Based on the exploratory nature of our illustrative study and the difficulties of measuring the constructs, we chose a mixed methods research design for two purposes: completeness and corroboration.

In view of the above, the overall goal of this paper is to illustrate how mixed method approaches offer a rich research design strategy for studying emergent complexities and interactions inherent in IS phenomenon and, in particular, provide guidance to researchers on ways to address the challenges of mixed method research designs. We achieve this goal by discussing our trials and tribulations in operationalizing a specific mixed research design to address our research questions and the ensuing challenges that had to be addressed. Thus, our hope is to help researchers learn from our experiences in conducting MM research and suggest ways to ameliorate challenges that often crop up in such studies. The goals of our paper are also in line with Creswell and Clark's (2010, p.273-275) call to mixed method researchers to not only report on completed domain specific mixed research studies but to also "contribute or extend" mixed methods literature by writing a methodological article. We heed their advice and follow their proposed structure for such a paper in this effort.

In their seminal book, Creswell and Clark (2010) propose four major types of mixed methods research designs: convergent (parallel or concurrent) design, embedded (or nested) design, sequential (explanatory sequential or exploratory sequential) design, and multiphase designs. In this paper, we illustrate the use of an **embedded mixed method (EMM)** research design. Embedded mixed method designs are described by Creswell and Clark (2010, p.90-93) as follows: "… the researcher combines the collection and analysis of both quantitative and qualitative data within a traditional quantitative research design or qualitative research design…. The collection and analysis of the secondary data set may occur before, during, and/or after the implementation of the data collection and analysis procedures traditionally associated with the larger design… in an embedded mixed methods case study, the researcher collects and analyzes both quantitative and qualitative data to examine a case."

Accordingly, our particular illustrative study belongs to the EMM research design strategy, where a complementary quantitative study is embedded within a primarily qualitative study (Creswell & Clark, 2010; R. B. Johnson & Onwuegbuzie, 2004; R. B. Johnson et al., 2007). In this approach, mixing of the quantitative strand within the primacy of a qualitative approach occurs during data collection, data exploration, data analysis and data visualization. This mixing of strands in a research study can be emergent or fixed (Creswell & Clark, 2010); our illustration in fact falls in the emergent category. Emergent approaches utilize mixed methods when issues develop during the process of conducting the research requiring adjustments to the research strategy, rather than being predetermined at the outset of the study. In contrast, fixed designs are mixed methods studies where the use of quantitative and qualitative methods is predetermined and planned at the start of the research process, and the procedures are implemented as planned.

Our key contributions in this paper include: 1) a detailed illustration of how EMM studies can be implemented and reported, 2) brief discussion of the paradigmatic issues with mixed methods research, 3) detailed analysis of the particular challenges faced in the various stages of conducting mixed research and potential tactics and guidance to ameliorate them, and 4) a description of techniques or practices that are useful to mix, analyze and visualize data for sense making and to draw meaningful insights.

2 A Brief Aside: The Paradigm Debates of Mixed Methods

> Mixing paradigms is indeed a risky business, but this should not be confused with combining methods within a clear-headed understanding of paradigms. If a particular paradigmatic stance provides the framework for a project, then the selection of an appropriate method or combination of methods does become a largely technical task (Morgan, 1998, p.363).

There have been intense debates over the epistemological issues associated with the mixed methods approach. Some researchers argue that by blending two research approaches together, the qualitative and quantitative approaches, researchers have mixed world views in terms of the nature of knowledge and the way we get the knowledge (Venkatesh et al., 2013).

In contrast, we concur with Sechrest and Sidani (1995) who argue that there is no epistemological conflict between mixed methods approaches. They assert that "…quantitative and qualitative methods are, after all, empirical, dependent on observation. Although empirical inductivists and phenomenologists (also empiricists) differ in their philosophical assumptions and, consequently, the ways in which they go about collecting and making sense of their data, their ultimate tasks and aims are the same: describe their data, construct explanatory arguments from their data, and speculate about why the outcomes they observed happened as they did. The differences, in our view, have to do with the details, with exactly "what is observed by whom (Sechrest & Sidani, 1995, p.78)." In addition, we agree with their contention that the only key difference between qualitative and quantitative researchers is in their preferences for numerical precision.

In this vein, we contend along with other researchers that mixed method researchers should adopt a philosophy of *pragmatism* for designing and conducting mixed dualisms. Ontologically the mixed research approach adopts a belief in *fallible realism* (i.e., "all theories are approximations") where researchers "recognize the existence and importance of the natural or physical world as well as the emergent social and psychological world (Johnson & Onwuegbuzie, 2004, p.18)." Furthermore, this thinking incorporates methodological pluralism or eclecticism, which frequently results in superior research compared to mono-method research (Johnson & Onwuegbuzie, 2004; R. B. Johnson et al., 2007). Epistemologically, findings are generated through interaction between researcher and data utilizing a logic of inquiry that includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one's results) (Johnson & Onwuegbuzie, 2004). Axiologically, mixed method researchers are value-neutral making no distinction between applied and basic research.

According to Johnson and Onwuegbuzie (2004), the fundamental principle of mixed research design is that researchers should collect multiple data using different strategies, approaches, and methods in such a way that the resulting mixture or combination is likely to result in complementary strengths and non-overlapping weaknesses. These authors further argue that the effective use of this principle is a major source of justification for mixed methods research because the product will be superior to mono-method studies. Additionally, the mixed research approach allows one to explore the meaning of a construct or phenomenon from more than one perspective (Johnson & Onwuegbuzie, 2004).

3 Risks and Remedies

To illustrate how the operationalization of an embedded mixed method (EMM) research design can be done in practice, we summarize in Appendix A our research project in the domain of “virtual teams” research (Yu, 2013). Figure 1 below illustrates the EMM research design procedure utilized for the study. Drawing on this study and prior literature on mixed methods research, we have identified nine risks or challenges in using EMM research designs (Figure 2). In addition to elucidating these challenges, based on our specific experience, we propose remedies and strategies to address these challenges. Risk 1 addresses a general challenge associated with mixed method research designs. Risks 2 through 4 relate to data preparation in mixed research designs. Risks 5 through 8 relate to problems with data analysis and interpretation problems in mixed research design. Risk 9 is associated with how mixed method findings are reported. Appendix C shows a summary of all the identified risks and remedies.

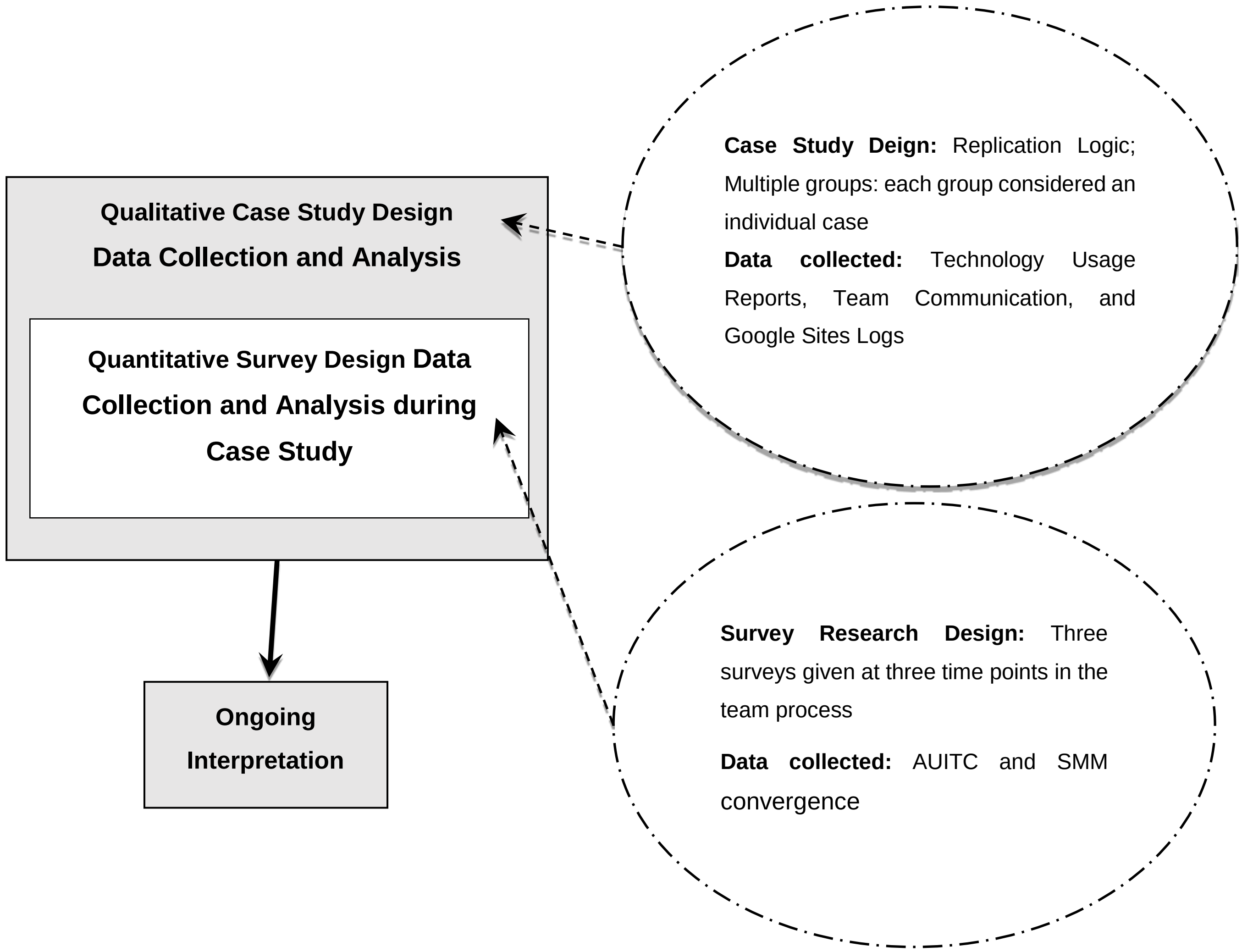

Figure 1: Embedded Mixed Methods Research Design Procedure

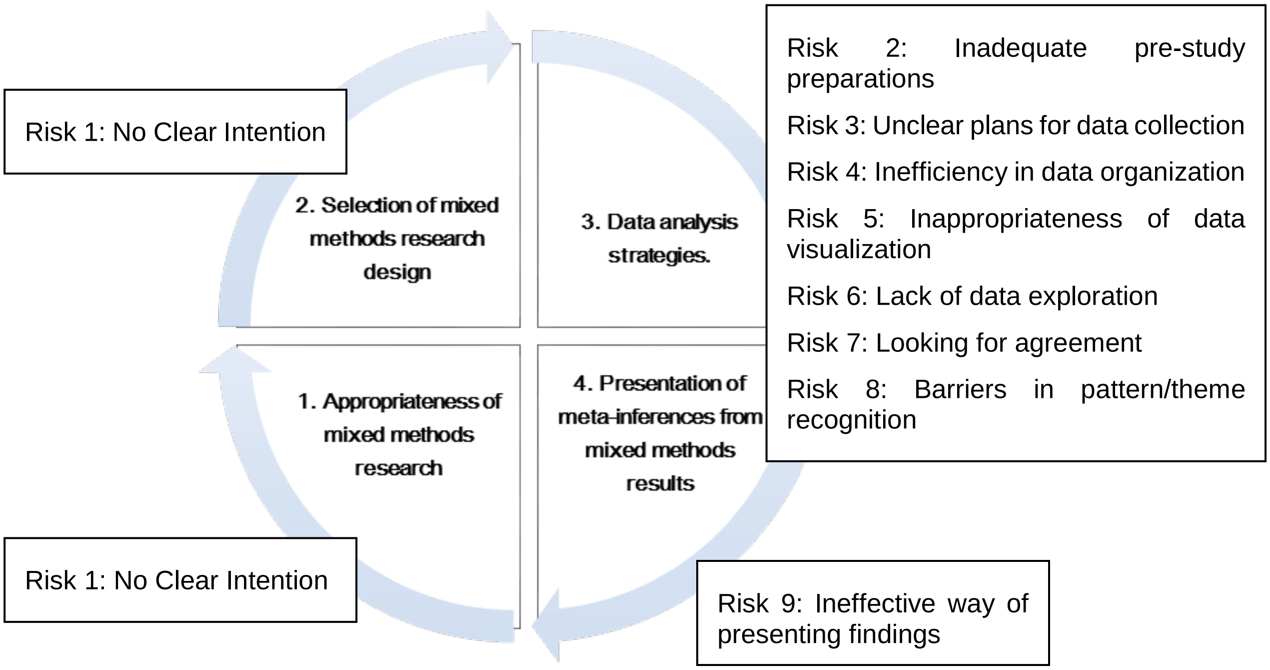

Figure 2 Risks and Research Cycle of Mixed Methods Study

3.1 Risk 1: No Clear Intention

Every mixed method study begins with a good reason or reasons; researchers using mixed methods tend to struggle with keeping that reason or reasons in mind during the conduct of their research. Many researchers report findings from different methods in parallel (or independent of each other) with little effort to "genuinely" combine their findings (Jick, 1979). One reason is because researchers can get immersed and then lost in the complex process of conducting mixed methods and analyzing the data in various forms (Venkatesh et al., 2013). For example, the data we collected in our "virtual teams" research study was both messy and voluminous. The concurrent (not sequential) occurrence of all these types of data added more complexity to the overall research process (refer Table A3 in the Appendix). These type of complexities in mixed method research pose significant cognitive challenges to researchers to process information and make meaningful interpretations from the data collected.

Another reason why researchers of mixed methods tend to lose their direction and initial intent for using them is that there are a variety of benefits that these methods can offer; researchers try to do much more than their original intention resulting in a greater cognitive overload (Bazely, 2002; Bryman, 2007; Collins, Onwuegbuzie, & Sutton, 2006; Johnson et al., 2007; Sechrest & Sidani, 1995). Creswell and Clark (2010, p.60, 61) discuss this opportunistic expansion in the following terms: "… one data source alone is insufficient, results need to be explained, exploratory results need to be further examined, a study needs to be enhanced through adding a second method, a theoretical stance needs to be advanced through the use of both types of methods, and a problem needs to be studied through multiple phases of research that include multiple types of methods." Thus, researchers of mixed methods may start mixed method studies with a purpose and then realize the additional potential of using mixed methods along the way while conducting the study. These new "emergent" intentions of doing mixed methods, though appropriate, may add to the cognitive overload and result in confusion about the approach to analyze the data and report findings. In this vein, Bryman (2006, p.99) correctly assert that "[W]hile a decision about design issues may be made in advance and for good reasons, when the data are generated, surprising findings or unrealized potential in the data may suggest unanticipated consequences of combining them."

For example, in our example study, we *emergently* chose an embedded mixed method because there wasn't a consistent way of assessing both the adaptive use of IT capabilities construct and the construct of shared mental models in the virtual teams context. For the construct adaptive use of IT capabilities (AUITC), some researchers assess IT use with quantitative surveys (e.g. Sun, 2012), and others use a qualitative approach to measure IT use, such as coding the communication messages, assessing the actual usage behaviors or recording the usage logs in technologies. Regarding the construct of shared mental models (SMM), a recent review of the SMM literature conducted by Mohammed et al. (2010) has shown that while quantitative approaches (e.g. pathfinder to operationalize team mental models and surveys) seemed to be the primary approach for assessing SMM, to gain richer understanding of the context where teams develop SMM, researchers still explored qualitative approaches such as open-ended interviewing or communication message analysis, to measure the similarity of SMM among team members. Considering the purpose of our study, we also abandoned our initial design of using a *purely quantitative approach*, i.e. surveys. We decided to not just use mean scores and correlations to describe the interplay between the constructs of interest. We realized that mixed methods not only provide a richer explanation to the research question by combining both the qualitative "stories" and the quantitative "data" but also helps us achieve a balance between time and effort rather than using a multi-method type of research design. In addition, using a mixed methods approach allowed us to observe the important interplay between teams' adaptive use of IT capabilities and shared mental models during the team process and over time. Despite the fact that this change in our thinking added substantive cognitive load, once we decided to use the EMM research design, we premeditatedly developed a plan and conducted a second pilot to verify our intentions.

In conclusion, with regards to this risk, we recommend that MM researchers should plan to review and audit the research design during the study and just remind themselves of the intention of choosing a mixed methods research design. Also, if the MM design emerges during the process of research despite different intentions (like in our case), we would advise that researchers assess what value this approach would provide them and evaluate the design through an additional pilot. Another recommendation is to try being explicit about why (purpose, reason, value-added) of MM in taking the maximum advantage of mixed method designs thus avoiding the challenges of cognitive overload. Having a clear, parsimonious goal in mind can help guide researchers to conduct, analyze and mix the methods "genuinely" while balancing the amount of effort with potential outcomes. We should also admit that the issues discussed here are not unique to MM research design. However, our experience with the EMM approach has shown that using mixed method approaches requires one to pay closer attention to the issues discussed here due to the inherent complexities of implementing this research design.

3.2 Risk 2: Inadequate Pre-Study Preparations

It is not uncommon for researchers to start their studies without pre-study preparations, i.e. pilots (Dubé & Paré, 2003). This could pose risks in answering research questions using the study findings; in addition, issues that arise in pilots can be used to clarify and better operationalize elements of the research process for the full study.

One fundamental principle in the pre-study preparation for mixed research is that researchers need to see if the various data collection methods do complement each other's weakness. For example, in our study, we collected both team members' technology usage activities through technology logs and survey questions to assess users' adaptive use of IT capabilities during the team process. During the second pilot, consistent with our intent, we found that the data collected through these two methods provided both contexts of members' technology usage, i.e. timing, frequency, content, the specific technology capability used, and the numerical rating of members' AUITC behaviors (assessed by surveys). Further, in our study, we found that the qualitative approach provided us a means to assess the "explicit" SMM, i.e. what specific shared knowledge and understanding has been established among the members; while the survey items were useful in helping us see the "tacit" SMM, i.e. whether or not virtual teams have smooth team interaction with infrequent harmful conflicts.

Also, the pre-study preparations are essential for researchers to get a sense of the data that will be collected. We collected users' technology usage logs in Blackboard, Gmav, and Google Site. Before the full study, our pilot studies allowed us to clearly understand the format of the data logs for the different technology capabilities, the accessibility of these data, and the volume of data that may occur with each type of technology. The lessons we learned from the pilot studies helped us decide the means to organize and present our data for effective analysis. Further, pre-study preparations give researchers a chance to think of the potential ways of combining data together. Even though researchers often carefully develop their research plans before study, not everything happens as anticipated. When researchers see the actual data generated, they may discover interesting results or certain unanticipated consequences of combining them (Bryman, 2006). For example, in our study we intended to collect users' Google Site activity logs to assess how frequently and intensively they used Google Site. This was needed to better understand team members' AUITC behaviors. In the pilot studies, we found Google Site activity logs can also be helpful in assessing team members' SMM when salient patterns of using particular Google Site features were identified. In one of the teams, we found that each member would make updates to task management (a feature in Google Site) after they finished some web-page editing activities. This pattern shows the agreement among members and illustrates the way members interact with each other to share the progress of critical tasks. Therefore, the use of Google Site activity logs was a good means of corroborating findings we obtained from other SMM assessment techniques such as communication logs and responses to the technology usage reports.

3.3 Risk 3: Unclear Plans for Data Collection

In EMM research designs, researchers potentially will collect qualitative and quantitative data together to develop an understanding about their questions of interest (Creswell & Clark, 2010; Sieber, 1973). "By using a variety of sources and resources, the evaluator observer can build on the strengths of each type of data collection while minimizing the weaknesses of any single approach (Patton, 2002, p.306)."

This means that careful planning of data collection would be helpful for researchers "(a) to obtain convergence or corroboration of findings, (b) to eliminate or minimize key plausible alternative explanations for conclusions drawn from the research data, and (c) to elucidate the divergent aspects of a phenomenon (B. Johnson & Turner, 2003, p.299)."

However, such data collection plans are not often made explicit in researchers' reports of their embedded research design as suggested by Creswell and Clark (2010). According to Creswell and Clark, for embedded research design, researchers should describe "the rationale for embedding one form of data, the timing of the embedded data, and how to address problems that may arise from the embedding (p.190)." For example, in our research study, we had to decide on the following issues. (1) What is the rationale for embedding a survey? The first pilot showed that surveys and qualitative approaches have complementary roles in our study. Qualitative data analysis provided us with a rich study context, an opportunity for making inferences, and also a chance to tell stories. Surveys helped corroborate our findings and also were powerful in facilitating finding interesting insights when surveys and qualitative data analysis results were different or contradictory. (2) What are the timing of conducting the surveys? To be able to catch potential changes in AUITC and SMM during the virtual team process, we decided to administer surveys at the end of each milestone of the team project. (3) How to develop the strategy for dealing with the convergence and divergence problems with embedding? In our research we decided that we will use case study data as the primary resource for data analysis and the survey data as a complementary source (Creswell & Clark, 2010). This is because we believed that the correlations derived from survey data analysis were too simple to describe and explain the interactions between AUITC and SMM development in virtual teams. Therefore, choosing a qualitative method as the primary method and survey method as the embedded research approach rather than the reverse was more helpful in uncovering the unknown complexities between AUTIC and SMM in virtual teams.

When developing plans for data collection, one should also be aware of, and identify the limitations of each kind of data collection technique. For example, in our study, an important limitation with the technology logs data was that it was variable in format, quality and completeness. The logs we used for our study did not necessarily capture all team members' interaction activities through technology (e.g. chat over Google Talk). In addition, limitations of survey data we collected included possibly distorted responses due to personal bias, anger, and anxiety, etc. (Patton, 2002). Considering the limitations of the study, when making inferences, we carefully corroborated our findings from various data sources to ensure the validity of the assessments and inferences.

3.4 Risk 4: Inefficiency in Data Organization

In our EMM study, given the voluminous data and the variety of formats of the data collected, we experienced challenges in figuring out the right approach to organizing the data to engender meaningful comprehension; this was particularly critical for the qualitative data collected.

The purpose of organizing qualitative data in a systematic way is to gather comprehensive, systematic, and in-depth information and represent the data efficiently so patterns of interest can be understood and described (Patton, 2002). It is also recommended that a check of the “inventory” of what researchers have before getting data organized is an important step (Patton, 2002). Identifying an effective data organization approach involves the process of building an initial data display so that researchers can get a full picture of the case and can do exploratory analysis across cases if the study includes multiple cases.

In our study, we chose to organize the qualitative case data based upon their general nature, i.e. technology usage report, communication data, and Google Site activities. For each of these three types of data, we used grids and organized them in order from the first to last case study.

During the second pilot study using the EMM research design, we tried to organize the data by specific cases; we also tried to organize the data by each specific technology feature (e.g. BB discussion board), which was a straightforward way of organizing data. However, in contrast to these approaches, we discovered that organizing data by the three general types of data was more effective in helping us do both within-case and cross-case analysis. In particular, organizing data by specific cases may be the intuitive approach for researchers to take so that they can corroborate and confirm findings across various data sources and be thorough in carrying out within-case analysis. However, such an approach can significantly hinder the process of researchers’ ability to do a cross-case analysis when faced with this information overload.

We therefore recommend that researchers explore multiple ways of organizing the data to determine the best one for understanding, presentation of the data, and therefore engendering the ability to draw focused insights.

3.5 Risk 5: Inappropriateness of Data Visualization

Data generated in EMM studies can be messy given the nature and limitation of human beings’ cognition (Creswell & Clark, 2010). Even though visualization techniques for quantitative data are well established (e.g. graphs and charts), techniques for visualizing qualitative data in variety of formats has less guidance. Data visualization is important because these techniques represent “visual sources of information” and they entail a decision to organize information in a certain way that could have the potential of deriving interesting and meaningful insights (Sandelowski, 2003).

Miles and Huberman (1994) offer some practical approaches to visualizing qualitative data through tables and maps. As we realized in our research study, it is important to note that utilizing such tables and maps requires thoughtful consideration of the purpose of the study and the unique strengths of each kind of qualitative data representation technique.

For example, we wanted to examine the ‘interplay’ between virtual teams’ AUITC and SMM development during a virtual team’s life cycle. We believe that virtual teams’ adaptive use of IT capabilities, the development of shared mental models, and the interactions between these two constructs are all *processes* that can be depicted by “a string of coherently related events (Miles & Huberman, 1994, p.111).” Therefore, for our study, this meant identifying the timing and the content of those salient events and the connections between them. We posited that if we can successfully sort out occurrences of AUITC and occurrences of SMM, while preserving the sequence and showing the salience or significance of preceding events for following events, we would be able to develop a holistic view of the interactions between AUITC and SMM development in virtual teams. So how could we attain this goal from the massive volume and diversity of data we collected? We surveyed the categories of visualization techniques by Miles and Huberman and found that the time-ordered displays are an appropriate means for visualization of collected data and served well the purpose of our study. In particular, considering the multiple constructs and sub-constructs included in our study, we believed time-ordered matrix would be the most useful way for us to attain our goal. Time-ordered matrices not only aid researchers in keeping records of the chronological events during the study, but also allow researchers to keep track of events of different domains, i.e. constructs or sub-constructs. In Table A5, we illustrate the time-ordered matrix we constructed for each team so that salient patterns of interplay of AUITC and SMM could be captured.

Clearly, it is important for mixed method researchers to seek good visualization of their data to create “a sense of order out of chaos” (Sandelowski, 2003, p. 337).” Specifically, we recommend mixed methods researchers pay attention to, and be innovative with the visualization of the qualitative data where standard data visualization methods are still lacking.

3.6 Risk 6: Lack of Data Exploration

Data exploration allows researchers to understand the nature of data collected and examine the quality of the information collected. Skipping the data exploration step could have a potential negative impact in that important patterns or trends may be ignored. Qualitative data exploration involves reading through all of the data to develop a general understanding of the database while quantitative data exploration usually involves "visually inspecting the data and conducting a descriptive analysis (the mean, standard deviation [SD] and deviance of responses to each item on instruments or checklists) to determine the general trends in the data (Patton, 2002)."

Appropriate data organization is only one way to facilitate data exploration. Researchers should employ other visual techniques to help clarify and understand the data collected. For example, in our study, we built charts to see trends of changes on variables of interest over time (Figure A2). We also plotted the survey scores of each pair of variables for all teams on a two-by-two matrix (Figure A3 and Figure A4). These four-cell matrices showed simplified relationship between variables. In general, visualization of survey data was useful in enhancing the efficacy of our qualitative data analysis, especially when there were differences between the two approaches and we took a deeper look at the data to draw insights. Therefore, we recommend that MM researchers employ appropriate data exploration techniques that align with their research questions.

3.7 Risk 7: Focusing on Agreement

The conventional purpose of utilizing mixed methods research is to look for concurrent or convergent evidence for supporting findings across methods or to provide the corroboration of findings by leveraging the strengths of various techniques (Rossman et al. 1985). According to Rossman et al. (1985, p.633), "[Q]uantitative techniques are the most appropriate source for corroborating findings initially noted from qualitative methods. Likewise, qualitative methods are best used to provide richness or detail to quantitative findings, but should precede quantitative ones when clarifying the direction of inquiry."

Despite the importance of looking for "agreement" in mixed methods, "disagreement" in findings should not be overlooked and can also provide valuable insights into phenomenon under study. Jick (1979, p.608) argues that the "… process of compiling research material based on multi-methods is useful whether there is convergence or not. Where there is convergence, confidence in the results grows considerably. Findings are no longer attributable to a method artifact. However, where divergent results emerge, alternative, and likely more complex, explanations are generated."

For example, in our research study, the communication log data, Google Site activities data, and survey data suggested that two of the three distinct patterns identified appeared to describe the interplay between AUITC and SMM development in virtual teams (refer Table A7). These two patterns were generally distinguished by how early and actively teams initiated interactions among themselves when accomplishing their task. That is, the earlier the teams engaged in interactions using information technology capabilities, the better the team's ability to develop SMM convergence. However, there was one particular team that did not fall into either pattern. This particular team started their team interactions earlier but did not converge on their shared mental models as quickly and as well as the other teams. When we looked deeper into the qualitative data, we found that this team had been struggling with coordination among the conflicting schedules of members and a majority of the team was not positively addressing the difficulties that occurred in team coordination. After further analysis of that particular teams' context we concluded that a third type of pattern of the interplay between AUITC and SMM development in virtual teams was necessary to describe these findings; we called it the "Struggle Pattern" (Table A7).

In conclusion, it is important that mixed method researchers be open to the idea of divergent findings and be willing to revisit and/or modify their initial theoretical assumptions or hypothesis or conclusions and to potentially draw on further theoretical concepts that have not yet been applied to the domain in question (Erzberger & Kelle, 2003; Erzberger & Prein, 1997; Fielding & Fielding, 1986).

3.8 Risk 8: Barriers in Pattern/Theme Recognition

Mixed method researchers often face challenges in discovering appealing and cogent themes and patterns from their data due to the volume and diversity of data collected and because of the varying nature of data collected with multiple research techniques. One potential barrier to themes and patterns' discovery is a lack of solid evaluation criterion for identifying "substantive significance" of the findings. This notion is equivalent to the idea of statistical significance in quantitative analysis. Patton proposes four questions to be answered when considering the substantive significance of evidence generated.

- How solid, coherent, and consistent is the evidence in support of the findings?

- To what extent and in what ways do the findings increase and deepen understanding of the phenomenon studied?
- To what extent are the findings consistent with other knowledge
- To what extent are the findings useful for some intended purpose (e.g., contributing to theory, informing policy, summative or formative evaluation, or problem solving in action research) (Patton, 2002, p.467)?

In mixed research, evidentiary interpretation requires "researchers (to) work back and forth between the data or story (the evidence) and his or her own perspective and understandings to make sense of the evidence. Both the evidence and the perspective brought to bear on the evidence need to be elucidated in this choreography in searching of meaning. Alternative interpretations are tried and tested against the data (Patton, 2002, p.477, 478)."

In our study, qualitative data told stories of how teams' mental model development may interplay with the adaptive use of IT capabilities (refer Appendix A). For example, we discovered that two virtual teams may reach agreements on the same general topic at the same time point in time but use different technology capabilities. In another finding, two virtual teams developed teamwork mental models about the use of Google Site for team interaction during different phases of their project. Through the time-ordered matrix we built (refer Table A5), we observed certain links between the usage of particular technology capabilities and the similarity of mental models, i.e. level of agreements among team members regarding the team's shared mental models development. We also observed the influence of certain categories of SMMs on virtual team members' preferences for technologies used. These observations of the linkages between AUITC and SMM, piece by piece, formed the solid, coherent, and consistent evidence base to achieve our final findings. Using Patton's (2002) four criterion of assessing the significance of findings, we tried alternative ways to interpret the interactions between AUITC and SMM from the evidence. We tried to explain the complexities of the interactions through the three dimensions of AUITC, inclusiveness, fit, and usage experience; we also tried to see if the dimensions of SMM could help describe the interplay of the two constructs. However, these approaches were only useful in reaffirming our argument that such interplay of AUITC and SMM does exist; but, it did not help us in generalizing our findings to a higher level to categorize the nature of the interplay or in leading towards findings that could account for the variances among teams on this interplay.

While we built a summary table (Table A6) by combining both types of data for each construct of interest across teams, we found that the initial interaction of teams and virtual teams' awareness of IT capabilities are two important dimensions that can help categorize virtual teams' varied outcomes on shared mental models convergence and on the varied paths by which they adaptively used IT capabilities (AUITC). Further, we identified three salient patterns (Table A7). We iteratively derived a plausible set of logical patterns that seemed to coherently explain the evidence we had generated from both the qualitative and quantitative data.

As Jick (1979, p.608) accurately contends "[O]verall, the triangulation investigator is left to search for a logical pattern in mixed-method results. His or her claim to validity rests on a judgment, or as Weiss (1968, p.349) calls it, "a capacity to organize materials within a plausible framework". To identify the themes and patterns, we recommend mixed methods researchers be flexible in choosing pattern extraction strategies, i.e. identify the patterns/themes from qualitative study analysis and validate them with quantitative analysis, identify the patterns/themes from quantitative study analysis and validate them with qualitative analysis, or identify the patterns/themes from both types of analysis.

3.9 Risk 9: Ineffective Way of Presenting Findings

Researchers often struggle with writing up their findings from mixed methods (Bryman, 2007). One challenge with stems from the varied styles of communicating facts and meanings from the qualitative and quantitative paradigms. In other words, the qualitative and quantitative paradigms have different implicit conventions for reporting findings. Researchers following the qualitative paradigm prefer words to form a holistic picture of the evidence while researchers using the quantitative paradigm prefer numbers and statistical significance testing. To address this challenge of mixed research design we started with a clear research question in our mind. This made our task of writing our EMM research design findings more about "how best to accommodate the mixes in mixed methods studies (Tashakkori & Teddlie, 2003)." Furthermore, "[C]rafting convincing mixed methods studies texts requires using words – especially the epistemologically and emotionally loaded terms *qualitative* and *quantitative* – in ways that will be accessible and appealing to the mixed audiences for mixed methods studies and respectful of the highly diverse communities participating in the creation of and served by mixed methods studies (Tashakkori & Teddlie, 2003, p. 345)."

Another challenge to presenting findings originates from the difficulty of explicitly presenting high quality integrative inferences in mixed methods, i.e. meta-inferences (Venkatesh et al., 2013, p.38). Meta-inferences are suggested to be at the core of high quality mixed-methods validation assessment criteria. For high quality meta-inferences, researchers need to be explict about how they integrate data analysis from qualitative studies and quantitative studies.

Mixed method researchers can attain meta-inferences following different approaches (e.g. transformation or non-transformation approaches) depending on their mixed methods design (Venkatesh et al., 2013). Based on our own experience, we recommend researchers to be flexible in how they integrate qualitative and quantitative studies at the meta-inference stage. Our experience illustrates that finding the appropriate path to build meta-inference out of findings from mixed methods study is an iterative process involving trial and error. For example, in our research (Yu & Khazanchi, 2015), during the pilot study data analysis, we quickly realized that merging the findings for survey and case studies kept us from building an accessible, appealing, and logical description using a holistic understanding because of high information overload. By trial and error,, we decided to use the survey findings as the starting point to unveil the stories in the large volume of qualitative data collected and then start the deeper analysis of the qualitative study findings. If we had not chosen this effective path, we would have been distracted and potentially overwhelmed by the diversity and amount of qualitative data, and therefore would not be have been able to discover the three distinct interplay patterns (refer Table A7).

4 Concluding Remarks

Mixed methods research designs offer both opportunities and challenges for researchers interested in studying the complexities of IS related phenomenon. Given its strengths in providing a more holistic, contextually sensitive view about the phenomenon of interest and its potential for allowing researchers to explore relatively “new” and “emergent” topics, it is important to have a sense of the risks and challenges of using mixed methods research designs. Although the literature is replete with general guidance on mixed research designs and examples thereof, there is inadequate clarity and a lack of guidance for addressing operational challenges while implementing mixed method research design strategies. Drawing on prior research in other disciplines and our own specific experience with an EMM study, we identified nine risks of conducting mixed methods research. In discussing each of the risks, we have illustrated the risks using our research study and provided some practical remedies based upon our own experiences. We also call on likeminded researchers to share more practical remedies for conducting mixed research.

From a future research perspective, there are many interesting issues about the implementation of mixed method research design that are still open to further study. We provide three examples that still are open issues and need further research. One critical area for further research has to do with data visualization and data fusion. Given that we collected a variety of data, it would be very pertinent to study optimal approaches to visualizing and fusing qualitative and quantitative data during the sense making process. A second area of interest in IS research will continue to be the development of approaches to resolve conflicting data when using multiple research methods. Are there systematic ways of doing this more effectively? How does one make choices when looking at conflicting data? Another interesting research issue is how to build the inferences when corroboration becomes difficult because of the missing data regarding the constructs of interest among multiple methods utilized in one particular study design?

Acknowledgments

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Appendix A: Embedded Mixed Method Research Design Study

The goal of this research study was to address the research question: “what is the interplay of two emergent processes within virtual teams, namely, adaptive use of IT capabilities (AUITC) and shared mental models (SMM) development?” (Yu, 2013). Our objective in this particular study was to study “how these two emergent processes interplay with each other in the context of virtual teams.” We argue that answers to this question can help us better understand the complex dynamics of virtual team behaviors and therefore build more effective virtual team management practices (Yu & Khazanchi, 2016). We further assert that though previous studies have contributed significantly to our knowledge about the nature of individual’s IT/S use, less knowledge has accumulated on IT/S use at the group level; and even fewer studies have considered some distinct group-level associated constructs as compared to individual ones.

Consistent with Venkatesh et al. (2013), we agree that the first step to take when considering a mixed methods approach is to assess its appropriateness. In addition to the aspects of research question, objective, and context, Venkatesh et al. suggest that researchers, editors and reviewers consider the strengths and purpose of mixed methods approaches to assess if mixed research designs are indeed necessary (i.e. adding significant value) in one’s study. Table A1 shows the characterization of our mixed methods research study based on the strengths and purposes of mixed methods.

Table A1. Appropriateness of the Mixed Methods Approach (adapted from Venkatesh et al., 2013)

Strengths of Mixed Methods Research			
Address confirmatory and exploratory research questions simultaneously			N
Provide stronger inferences than a single method through meta-inferences			✓
Assortment of divergent and/or complementary views			N
Purposes of Mixed Methods Research			
Complementarity	N	Corroboration/confirmation	✓
Completeness	✓	Compensation	N
Developmental	N	Diversity	N
Expansion			

As shown in Table A1, there are two main reasons for using a mixed methods approach for our example study: completeness and corroboration. First, we wanted to develop a holistic understanding of the complexities inherent within a virtual team's use of IT artifacts and shared mental models development. Previous studies provide fragmented knowledge about the nature of AUITC in virtual teams, AUITC's impact on another emergent team process, and potential influence of SMM on AUITC in virtual teams. We think using mixed methods can help enhance our chance to fully capture the developmental stages involved in the interested emergent process. Second, there lacks a consistent means for assessing the AUITC and SMM constructs in the literature. Combining both qualitative and quantitative methods can provide us an opportunity to enhance the credibility of the constructs' assessments as well as the strengths of the inferences.

For the purpose of the current paper, we summarize the key research constructs and related concepts in Table A2. Additional details about the theoretical and conceptual foundations of this research question and the theoretical origins of these constructs can be obtained from the authors.

Table A2 Definitions of Key Constructs

Construct	**Definitions**
Adaptive Use of IT Capabilities (AUITC)	• **AUITC** refers to the process by which virtual team members collectively use or modify one or more IT capabilities to perform a task (Burton-Jones and Straub 2006). • **IT capabilities** used in virtual teams can be broadly classified into three categories: *communication, team process, and interaction*. ✓ Communication capabilities refer to any capabilities that support a virtual team's communication and collaboration. ✓ Interaction capabilities refer to any capabilities that support the process of people working with others and engaging with the virtual collaborative environment. ✓ Team process capabilities refer to any capabilities that support team processes, such as process structure, information processing, appropriation support, and socialization/community building (Davis et al. 2009; Zigurs et al. 1998). • **Usage experience, inclusiveness,** and **fit** are the three most salient factors in understanding AUITC at the team level (Yu and Khazanchi 2015). ✓ Usage experience refers to total amount of time and frequency of using IT capabilities. ✓ Inclusiveness refers to the extent to and purpose for which users explore diverse IT capabilities. ✓ Fit refers to the process when virtual team members actively find a match between the use of IT capabilities and the need of their tasks and/or the need of their team (Khazanchi, 2005; Zigurs & Buckland, 1998).

Shared Mental Models (SMM)	• **SMM** refers to "knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of [their unique domain]" (Cannon-Bowers et al. 1993, p.228). In virtual teams, the development of teams' shared understanding regarding taskwork, teamwork, and also regarding the IT capabilities are essential to positive virtual team outcomes. ✓ A team's taskwork mental models (SM-TS) are knowledge structure and beliefs held by the team about the task goals, steps to accomplish the tasks. ✓ The teamwork mental models (SM-TM) refer to the knowledge structure and beliefs held by the team about the team interaction and team members' roles, skills, and knowledge. ✓ A team's equipment mental models (SM-EQ) are knowledge structure and beliefs held by the team about the technologies' functions, strengths and likely failures (Mathieu et al. 2000).
Interplay	• **Interplay** refers to the dynamic, emergent and interdependent relationship between AUITC and SMM development (Yu and Khazanchi, 2015).

The mixed research study was conducted in an asynchronous, online undergraduate-level course taught at a Midwestern University in the USA. Participants of the study were students enrolled in an online class. A total of 17 participants were assigned into five teams of three to four. Gmav (i.e. email), Blackboard (BB), and Google Sites were the primary collaborative technologies used in this study. The task was a group project which lasted seven-weeks and the goal was to develop an e-commerce business plan. Participants were required to submit three deliverables that were related to the final business plan, namely, the business concept/model, the IT platform design, and a design of the ecommerce web site with a mockup. Figure 1 depicts the overall research design for the study, where the quantitative survey was mixed in the primary traditional qualitative multiple case study (Creswell & Clark, 2010). For qualitative data collection, first, self-reports with open ended questions regarding members' usage and feelings about various technology capabilities were used periodically (i.e. weekly); and second, all the IT-enabled team communication texts (after getting students read the consent forms and agreed being research subjects) were also used; and finally, the qualitative posts from Google Sites Logs (i.e. comments) were collected. Regarding the quantitative survey design, measures on constructs were mainly adapted from previous literature. This design allowed us to capture not only the numerical scores for each construct but also the rich context in which emergent team behaviors regarding the use of IT capabilities and shared understanding occurred.

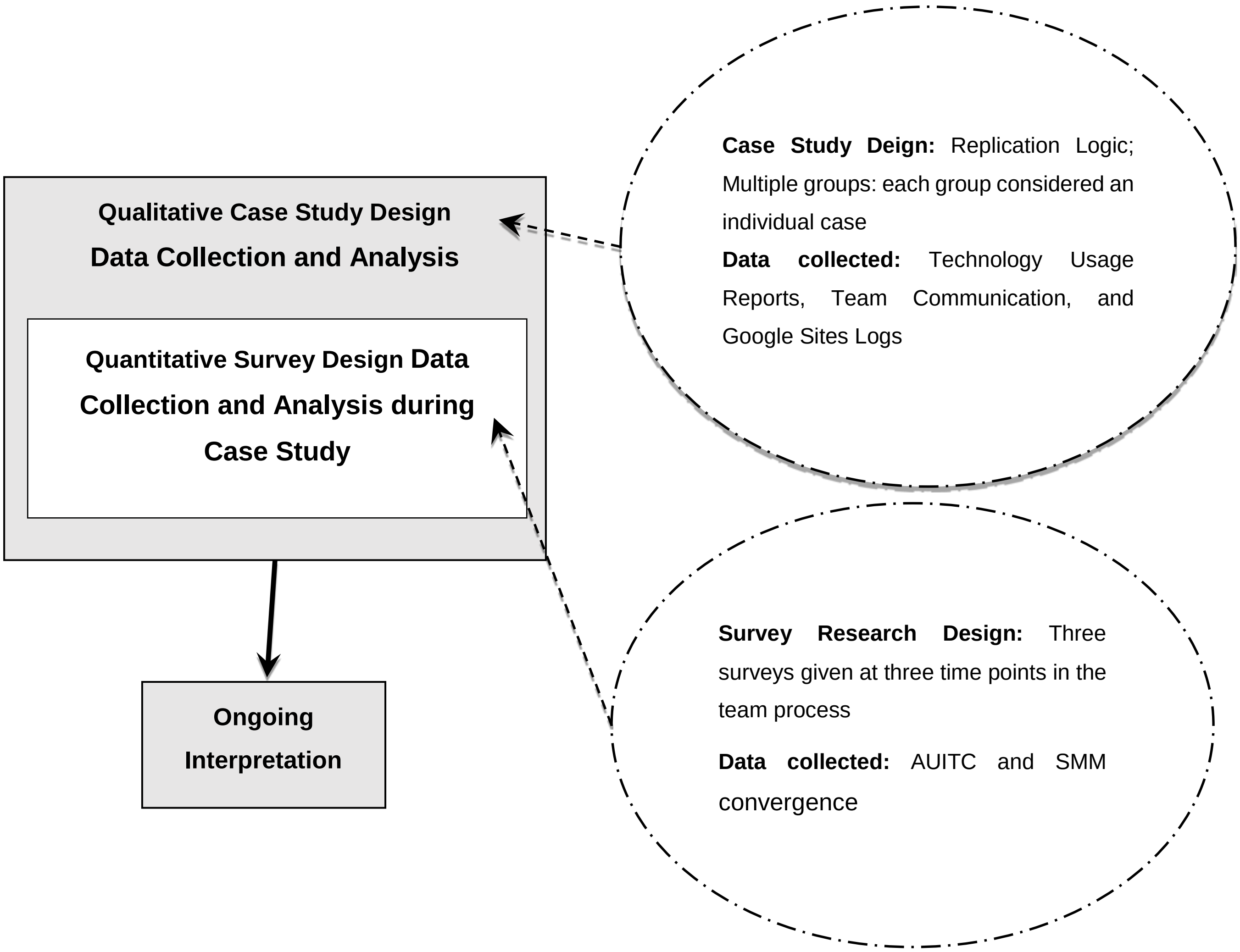

Figure A1: Embedded Mixed Methods Research Design Procedure

This illustrative study followed an emergent mixed method (EMM) research design as contrasted with fixed mixed methods deign. According to Creswell and Clark (2010, p.54), emergent mixed research designs are useful when issues develop during the process of the research that result in addition of a second approach after the study is underway because one method is found to be inadequate. In our first pilot, we planned a purely quantitative survey based research design, but, after doing our first pilot we realized that a better approach to addressing our research question to examine the interplay between AUITC and SMM was to mix the primarily qualitative approach with quantitative methods throughout the process of the research study. For example, when we want to assess virtual teams' AUITC, simply using the numerical ratings in the survey was not adequate to inform us of the contexts of members' technology usage, such as the timing, content, and perception of the usefulness of the IT capabilities in use. We realized during the pilot study that the interplay we were investigating was more complex and dynamic than we anticipated and that it was not adequate to look at mere correlations between constructs alone to explain this phenomenon. This also illustrates the importance of doing detailed pilot studies before conducting a full-fledged mixed research design (or for that matter any other research approach) to develop a strong understanding of the data, timing and mechanism for mixing a data collection approach at each stage of a mixed research study design.

Therefore, the specific MM research design used for our research study can be described as embedded mixed methods design with case study as the larger study design and survey study as the complementary design (Creswell & Clark, 2010; Johnson & Onwuegbuzie, 2004; Johnson et al., 2007).

A.1 Pre-Study Preparations

As a precursor to the full study, two detailed pilots were conducted to test the validity of both the qualitative and quantitative strands in the EMM design and the mechanism and timing for embedding the quantitative survey during the case study. We decided to embed the survey during the data collection phase and develop techniques to combine the data based on Miles and Huberman's (1994) suggestion. The pilot studies helped further refine the case study protocol (Yin, 1984) and also provided the researchers an opportunity to validate the technology capabilities, task, research procedure, qualitative data collection approach, and the data coding scheme. With respect to the embedded survey design, conducting the pilot studies helped researchers adapt and validate survey items from previous research to this particular study. In fact, once the pilot was completed and decision made to use an EMM research design approach, the second pilot was essentially used to ensure that the EMM design would work in the full study.

A.2 Data Collection

Lessons learned from the two pilot studies were used to guide the study's data collection. In particular, as explained in the previous section, one critical adjustment that was made was to overlap the case study and survey data collection over time. The entire study last seven weeks, from the formation of the teams to the dismissing of the teams. The collection of the case study data occurred in the entire study, and three surveys were administered at multiple timing points during the study (i.e. the 3rd, 5th, and 7th week).

Table A3 shows the details of each data collection method and the nature and timing of the data collected.

Table A3: Study Design, Data Collection Methods and Data Analysis Strategy

Study Design	Data Type	Data Collection Technique	What	When	Where the data were collected
Case Study Design	Qualitative	Open-ended questions	specific technology capabilities they have used and their reflections on their usage experience	at the end of each week	students complete the open-ended questions online
	Qualitative Quantitative	Technology usage data	• email messages; • Google site activity logs; • Blackboard discussion board; • Blackboard journal • Blackboard blog • Blackboard Wiki	when subjects use the IT capabilities	real-time data collected in Gmail, Blackboard, Google Site
Survey Method	Quantitative	Quantitative surveys	items for measuring AUITC and SMM	at the end of the week 3, 5, 7 which is the milestones time for the group	students completed the surveys

A.3 Data Visualization

One major task of data visualization is to organize collected data and present it in an appropriate way so that patterns can be identified. Table A3 shows the three major kinds of data collected in the study. For each data source, we first carefully examined the format and quantity of the data and put them into organized files. Then we utilized different data visualization techniques based on the nature of the data and the purpose of our study. In general, for qualitative data, we compiled the data into structured files for each group for the preparation for the next step of data exploration. While for the quantitative data, we used charts and tables to visualize the results. More specifics about the data visualization, data exploration, and data analysis techniques we used in the study for each of the data collection method are shown in Table A4.

Table A4: Data Visualization, Data Exploration and Data Analysis Strategy for Each Data Collection Technique

Data Collection Technique	Data Visualization	Data Exploration	Data Analysis
Open-ended questions	Compile the surveys for each group.	read through several times	• data coding (what IT capabilities are used by the group; what are their SMM regarding IT capabilities) • develop the time-ordered matrix using based on data coding.

			Develop the summary table based on the time-ordered matrix results.
Technology usage data	variety of data visualization techniques have been used. For example, emails were compiled for each group/case; google site activity logs were summarized in both tables and line charts; all of the texts in Blackboard were compiled into one document for each group/case.	read through several times and scan the charts and tables	• data coding (AUITC and SMM on taskwork and teamwork) • develop the time-ordered matrix based on the coding. • develop the summary table based on the time-ordered matrix results.
Quantitative surveys	line charts (showing the trend of each group's AUITC and SMM) and matrix-like charts (showing the relationship between AUITC and SMM) based on the descriptive statistics of the surveys	review statistics and charts	• identify patterns of the interplay between AUITC and SMM • develop a sense-making summary table based on integration of data from the statistics and the visualization of the results.

According to Table A4, to visualize the survey data, we merged surveys collected at all three temporal events together into a single spreadsheet by adding a new variable, i.e. time (range 1 to 3), to indicate the timing when a particular survey was administered and collected. Further, missing values were imputed by replacing them with the average score of before- and after- items. Then, we computed the descriptive statistics, such as the means and standard deviations. Next, we visualized the mean scores for each construct per team through the line chart shown in Figure A2.

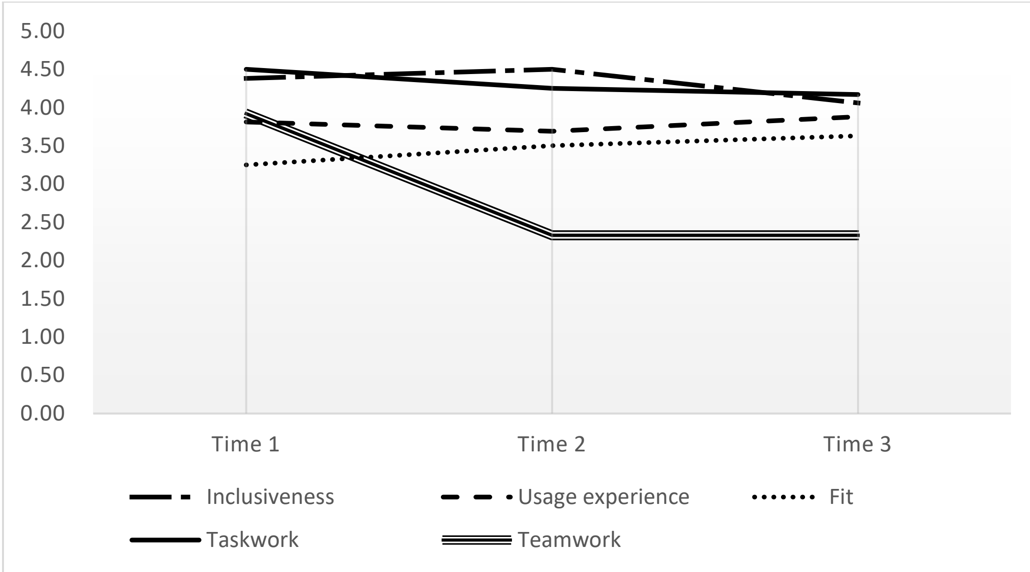

Figure A2: An Example of Line Chart of Means on Variables of Interest for One Team

We also visualized the survey data by compiling the data by each construct using matrix-view plots as shown in Figures A3 and A4. In the matrix-view plots, we plotted the mean AUITC score and each type of SMM convergence into appropriate cells in the picture. In Figure A4, we display the virtual teams' mean AUITC score and taskwork mental model convergence scores at a single time point. In contrast, Figure A3 on the left displays all five virtual teams' mean AUITC scores and taskwork mental model convergence score at all three time points. This helped us ultimately understand, identify and describe the patterns that are common between the teams with regards to the interplay between IT capabilities and mental model convergence.

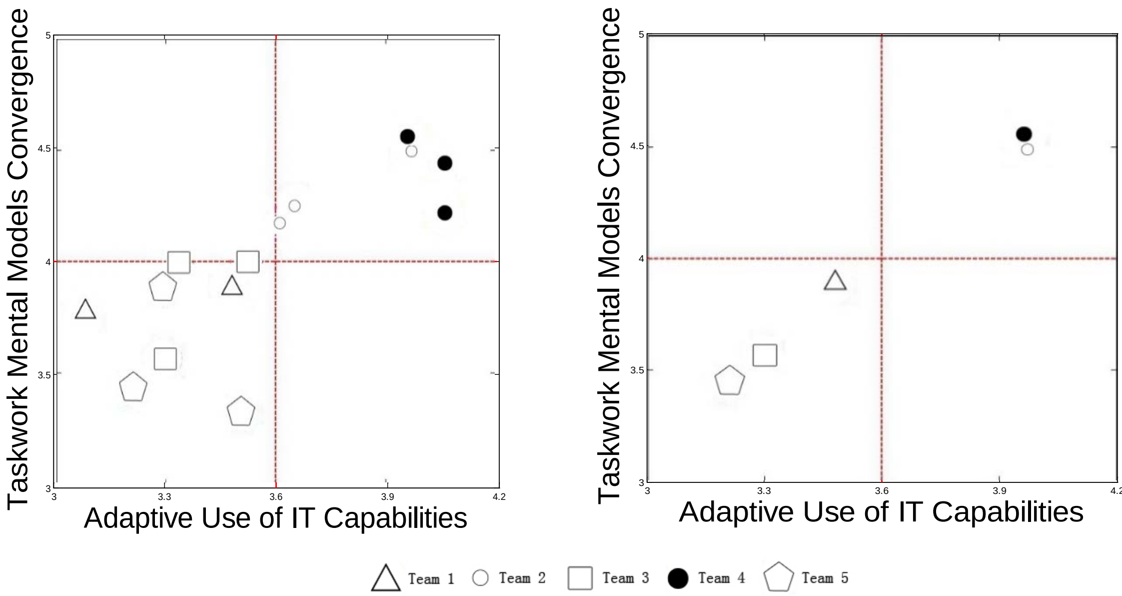

Figure A3: An Example of Matrix-view of Survey Data at All Three Times (Figure on the Left)

Figure A4: An Example of Matrix-view of Survey Data at a Single Time Point (Figure on the Right)

A.4 Data Exploration

During the data exploration phase, we read through the compiled documents and also scanned the visualized charts to identify important patterns with a focus on the relationship between AUITC and SMM. The results of such data exploration were our general understanding gained out of the whole package of data we collected. This general understanding gave us a clue to how we would proceed with the following data analysis and interpretation.

A.5 Data Analysis and Interpretation

In the data analysis phase, we kept our two purposes of doing mixed methods in mind, i.e. attaining completeness and corroboration. To this goal, we chose two particular techniques, the time-ordered matrix and the summary table. In particular, we synthesized the data collected by both case study and survey research methods by adapting the time-ordered matrix technique to build a valid chronology of salient sequential characteristics of the events for following events (Miles & Huberman, 1994).

As shown in Table A5, the columns are arranged by week, from the first week to the last week of the case study project. We learnt from the first pilot study where we determined that the time period of “week” was a good fit in this study because “week” can capture the separate events and their sequence rather than blending all events together. The key constructs, AUITC and SMM, were used as rows of the matrix. The

AUITC components capture the virtual teams' adaptive usage behaviors with respect to three types of IT capabilities. The SMM components include three types of SMM suggested in previous literature. Furthermore, one row for documenting the field notes was also added. Specific rules for entering data into the time-ordered matrix were developed according to the pilot data analysis experience. For each week, if a change in a component occurred, a short description of the change was entered. A blank cell meant no change occurred for a specific component at a specific time period.

By using this approach for displaying data, it is possible to identify the strengths of interaction between AUITC and SMM development. On one hand, this time-ordered table helps to identify if teams' choice made on using specific IT features (that is the adaptive use of IT capabilities) does affect and how such choice can affect the subsequent convergence on teams' mental models. For example, table A5 shows that team 1 used BB discussion board as the main method for team communication in the second week. Then we can identify team 1 is satisfied with such choice because "BB….is great to organize the discussion and present them orderly". As is shown in table A5, specific mental model contents converged by team 1 indicated that the influence of AUITC on teams' development of SMM. On the other hand, the time-ordered table can show how teams' mental models convergence influence the subsequent adaptive use of IT capabilities. For example, table A5 shows that in the third week of the team project, team 1 only use BB discussion board for team communication rather than using both email and BB discussion board as they did in the previous two weeks. By analyzing table A5, we can infer that this IT use changes was made because team 1 converged on the usefulness and fit of BB discussion board for communication. Therefore, teams 1's adaptive use of IT communication capabilities can be influenced by teams' mental models convergence.

Table A5. The Time-Ordered Matrix for Team 1

		Week 1--9/23	Week 2--9/30	Week 3--10/7
AUITC	Communication	email, bb discussion board	email as optional, main method is BB discussion board	BB discussion board
	Team process	email	N/A	Google site deliverable, Task management
	Interaction	Google site set up	Google site calendar	

SMM	IT/Equipment	email works for initial contact	bb discussion board is great to organize the discussion and present them orderly	N/A
	Taskwork	not yet converged	Brain storming and reached agreement on task goal and strategies	
	Teamwork	N/A	Agreed on communication channel would be BB discussion board	Agreed on roles and assignments

Next we developed an index-based summary table based on the time-ordered matrix and statistical analysis. Table A5 shows how we synthesized the primary qualitative and the embedded quantitative data to make meaningful sense of the results. To summarize the findings from the case study evidence, we employed a high-moderate-low index rating for constructs relating to group/case. Both objective and subjective methods were used to assign the index for each constructs relating to each group. Specifically, based on a construct's operational definition, we first identified each particular incident of each construct from the time-ordered matrix and then we counted incidents for each construct. Based on the occurrences of the incidents, we assign indices. When incidents were difficult to identify, such as when missing video/audio chat logs occurred, indices were subjectively assigned according to the strength of the evidence inferred from a cross-case analysis of the qualitative and quantitative data. Findings of this stage were also corroborated by looking at the technology usage logs. After comparing and contrasting across cases, we can finally assign the rating to each construct for all teams. In addition, survey statistics, particularly the means of the construct across a particular team for each of the constructs was provided in the summary tables as is shown in table A6.

Table A6: Illustrative Case Study and Survey Evidence Analysis for Inclusiveness

Construct	Team 1	Team 2
INC[a]	The team identified specific IT features that worked out for communication, team process, and interaction. The level of involvement from each team members was the	Team 2 did most of their team interaction through BB discussion board. The team organized their team communication well through the forums, threads, and replies. Not many explicit

	key factor affecting the IT choices that the team made	team process usage of IT was found
	Index = Low (survey = 3.72)	**Index = High** (survey = 4.3)

Based on this high level analysis and comparison across groups/cases, we ultimately derived three distinct patterns that describe the interplay between AUITC and SMM development in virtual teams. They are SMM-driven pattern, AUITC-driven pattern, and the Struggle Pattern. For SMM-driven pattern, teams tend to develop their shared mental models on task, technology, and team early in the team process. Compared to SMM-driven pattern, teams fell into the AUITC-driven pattern tend to develop their knowledge about how diverse IT capabilities can fit their teams best in the entire team process as needed. In the Struggle pattern, teams tend to be uncomfortable with both shared mental models development and adaptively using IT capabilities due to variety of team contingent factors.

Table A7 provides some of the key characteristics of these patterns.

Table A7: Salient Characteristics of Three Patterns of the Interplay between AUITC and SMM in Virtual Teams

Salient characteristics	SMM-driven Pattern	AUITC-driven Pattern	Struggle Pattern
Initial Interaction	• Members engaged in initial interactions early in the project, relatively low time pressure.	• Members engaged in initial interactions late in the project, relatively high time pressure.	• Members engaged in initial interactions early in the project, relatively low time pressure.
Awareness of IT Capabilities	• Members were aware of the diverse technology capabilities and the diverse requirements to accomplish tasks.	• Members adapted diverse technology capabilities given various task needs and team interaction needs over time.	• Members were aware of the diverse technology capabilities and the diverse requirements to accomplish tasks.
SMM Convergence	• Early convergence of SMM on technology capabilities' usage for supporting team interaction and task completion.	• Members tried to follow the direct sequence of completing project or tasks, from problem identification to execution, with paying little to no attention to the relationship building among team members and the potentials of using technology capabilities to enhance team interaction.	• Teams were unsuccessful in one or more these areas: 1) coping with team members' conflicting work schedule, 2) adapting technology capabilities to the task/team needs when needed, 3) identifying the particular fit between a particular bundle of activities and a particular period of time (McGrath 1991).
Level of AUITC	• Relatively high AUITC evidenced by quality IT usage, inclusive IT capabilities, and fit between tech and task.	• Members experienced increasing degree of AUITC evidenced by increasingly usage of IT capabilities in communication, team process, interaction, and the increasingly usage of diverse IT capabilities or in increasingly diverse ways.	• Relatively low to moderate degree of AUITC evidenced by low degree of fit between technology capabilities and the team/task's requirement.
Level of SMM convergence	• Relatively high SMM convergence.	• Members achieved higher degree of convergence on SMM when there is a fit between the technology capability and the requirements for building particular type of mental models.	• Relatively low to moderate degree of SMM

Appendix B: Survey

SECTION A: DEMOGRAPHIC INFORMATION

Group Number: _______________

Gender: Male Female

Status: Freshman Junior Sophomore Senior Graduate or post-baccalaureate.

Age: __under 20__20-24__25-29__30-34___35-39__40-44__over 44

SECTION C: TECHNOLOGY CAPABILITIES ADAPTATION

Circle the number that most closely described your opinion about your experience of interacting with the technologies on the line preceding the statement:

Strongly Disagree --1--2--3--4--5--Strongly Agree

Dimension: Inclusiveness

___1.I played around with features in Google Sites.

___2.I played around with features in Blackboard.

___3.I figured out how to use certain Google Sites features.

___4.I figured out how to use certain Blackboard features.

Dimension: Usage Experience

___5.Compared to other students, I believe I spent above than average time on Google Sites.

___6.Compared to other students, I believe I spent above than average time on Blackboard.

___7.Compared to other students, I believe I spent above than average time on Google Sites.

___8.Compared to other students, I believe I visited Google Sites more frequently.

___9.Compared to other students, I believe I visited Blackboard more frequently.

___10.Compared to other students, I believe I used Email more frequently.

Dimension: Fit

___12.I created work-a-rounds to overcome system restrictions.

___13.I combined features in Google Sites with features in blackboard to finish a task.

___14.I used some features in Google Sites in ways that are not intended by the developer.

___15.I used some features in blackboard in ways that are not intended by the developer.

SECTION D: SHARED MENTAL MODELS

Circle the number you feel that most closely represents how you feel with each the following statements on the line preceding the statement:

--1—2—3—4—5—

None a lot

Mental Model: Equipment Model

___16. How am I familiar with the capabilities provided by Email.

___17. How am I familiar with the capabilities provided by Blackboard.

___18. How am I familiar with the capabilities provided by Google Sites.

Mental Model: Task Model

___19.How frequently are there conflicts about understanding project goals in your team?

___20.How often do people in your team disagree about opinions regarding the work to be done?

___21.How much conflict is there about the work you do?

___22.How frequently do members disagree about the way to complete a team task?

Mental Model: Team Interaction Model

___23.To what extent did team members alert each other to impending decisions and actions.

___24.To what extent did team members seek out and pass along information to rest of team.

___25.To what extent was the team's behavior coordinated

Mental Model: Team Model

___26.How often do members disagree about who should do what?

___27.How much conflict about delegation of tasks exists in your team?

___28.Did the team members adjust individual task responsibilities to prevent overload?

Appendix C: Summary of Risks and Remedies

Table. A List of Risks and Remedies

Risks	Remedies
1. No clear intention	Given the complexities of implementing MM studies, MM researchers should plan to review and audit the study design during the study and remind themselves of the intention of choosing a mixed methods research design. Being explicit about why (purpose, reason, value-added) of MM in taking the maximum advantage of mixed method designs thus avoiding the challenges of cognitive overload.
2. Inadequate pre-study preparations	Check if the various data collection methods do complement each other's weakness. Getting a sense of the data that will be collected and thinking of the potential ways of combining data together.
3. Unclear plans for data collection	Developing plans for data collection (i.e. the form, the timing and the rationale of including the specific type of data). One should also be aware of, and identify the limitations of each kind of data collection technique
4. Inefficiency in data organization	Exploring multiple ways of organizing the data to determine the best one for understanding, presentation of the data, and therefore engendering the ability to draw focused insights.
5. Inappropriateness of data visualization	Paying attention to, and being innovative at the visualization of the qualitative data where standard data visualization method is lacking compared with in quantitative data.
6.Lack of data exploration	Try derive multiple data exploration purposes based on research questions and then employ data exploration techniques accordingly to maximize benefits of data exploration.
7.Focusing on agreement	Be open to the idea of divergent findings and be willing to revisit and/or modify their initial theoretical assumptions or hypothesis or conclusions and to potentially draw on further theoretical concepts that have not yet been applied to the domain in question
8.Barriers in pattern/theme recognition	Be flexible on choosing pattern distraction strategies, i.e. identify the patterns/themes from qualitative study analysis and valid them in quantitative study analysis, identify the patterns/themes from quantitative study analysis and valid them in qualitative study analysis, or identify the patterns/themes from both types of study analysis.
9.Ineffective way of presenting findings	Researchers to be flexible at the possible path of integrate qualitative studies and quantitative studies.

About the Authors

Xiaodan Yu is Associate Professor of Information Systems at the University of International Business and Economics (Beijing, China). Her research interests include adaptive IT capabilities use, business intelligence, and software development. Her articles have appeared in *Information and Software Technology* and *Communications of the Association for Information Systems.*

Deepak Khazanchi is Professor of Information Systems and Quantitative Analysis and Associate Dean in the College of Information Science & Technology at the University of Nebraska at Omaha. His research has been published in peer-reviewed journals such as *JAIS*, *CAIS*, *Electronic Markets, DSS*, *Information Systems Management* and *DATA BASE for Advances in Information Systems.*