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Improving Business Intelligence Design Process Using a Multi-perspective Inter-disciplinary Communication Approach

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IMPROVING BUSINESS INTELLIGENCE DESIGN PROCESS USING A MULTI PERSPECTIVE INTER-DISCIPLINARY COMMUNICATION APPROACH

A doctoral project submitted to Dakota State University in partial fulfillment of the requirements for the degree of

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By

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PROJECT APPROVAL FORM

We certify that we have read this project and that, in our opinion, it is satisfactory in scope and quality as a project for the degree of Doctor of Science in Information Systems.

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Doctoral Project Title: A MULTI PERSPECTIVE INTER-DISCIPLINARY COMMUNICATION SYSTEM FOR BUSINESS INTELLIGENCE SYSTEM DESIGN

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DAKOTA STATE UNIVERSITY

DISSERTATION APPROVAL FORM

This dissertation is approved as a credible and independent investigation by a candidate for the Doctor of Science in Information Systems degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this dissertation does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department or university.

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Dissertation Title: Improving Business Intelligence Design Process Using A Multi Perspective Inter-Disciplinary Communication Approach

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I declare that the project describes original work that has not previously been presented for the award of any other degree of any institution.

Signed,

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ABSTRACT

Organizations are continually accumulating large amounts of business data, as an increasing number of business processes are being conducted electronically. Analyzing these large data sets is often referred to as the “Big Data” problem because of the complexity and distributed nature of the data. While there is an abundance of business data available to business users for analysis, it is not being used due to lack of Business Intelligence (BI) Tools’ capability and a growing backlog of requests to Enterprise IT departments for new and modified data models to support continuously evolving reporting and analysis requirements. In addition, current processes for the design of data models predominantly relies on a sequential and phased approach from requirement collection to data model development; therefore; business analysts often do not get to see the impact of the changes until a prototype is created. This process is often time-consuming and can further exacerbate the large backlogs of requests for new and modified data models at IT departments. This dissertation addresses the above problem by proposing a collaboration-based tool for use by business users and database developers that can reduce communication gaps, help with the different views of data representation between the different disciplines, and lead to faster development of more comprehensive data models for addressing underlying business needs. Using a design science approach, an IT Artifact is developed with a basis in Inter-disciplinary Communication Medium (ICM) and Data/Frame Theory. The potential impact of this process is a more accurate data model that is delivered more quickly, because less rework would be required and less scope creep; thus, the business can better develop its requirements in the early conceptual design phase. This design science research resulted in the development of a model and instantiation of a Multi Perspective Inter-Disciplinary Communication System for Business Intelligence System Design. This dissertation research describes the theory-driven design of the system, the system implementation and results from the user study of a novel way to create more comprehensive and accurate data models for BI and decision support.

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Signed,

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Michael Albert Tomasura

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CHAPTER 1

INTRODUCTION

Business Data and Decision Making

Organizations continue to accumulate large amounts of data as an increasing number of business processes are conducted electronically. While there is an abundance of business data available to business users for analysis, it is not being used due to inaccurate model design caused by ill-communicated requirements and a lack of Business Intelligence (BI) design tools capability. There is growing backlog of requests being submitted to Enterprise IT departments for new and modified data models to support the continuously evolving reporting and analysis requirements (Forrester, 2010). There is a need for quick and accurate data-driven decision making at data-intensive corporations. Effective BI systems are needed to provide users with access to data at all enterprise-levels for analytical and reporting requirements. This data can be analyzed and used to make better business decisions. Organizations gain a competitive advantage when they can leverage their own data for decision-making. Companies are using data as way to outperform their competitors (McGuire, 2012). However, this is only possible if the decisions they are making are from information that is easily accessible, relevant and accurate.

Issues Impacting Business Intelligence Design

The lack of effective collaboration and communication between Business Analyst and Database Developers hinders the development of quick and accurate BI design. This is a major issue in this era of agile processes, big-data and widespread deployment of analytics technology. Organizations have large complex data sets that are difficult to process using traditional database methods, which is an issue called big data. This data is often distributed and sometime stored in data silos with stale data. In addition to growing data volumes and the distributed nature of organizational data, the problem of underutilization of available data for decision-making can be further exacerbated by large backlogs of requests, lack of effective collaboration and different logics of data representation. This is primarily due to the sequential nature and inflexibility of current processes of data modeling in which Business Analysts typically do not get to see the impact of the changes they are requesting until a prototype is made available(Watson, 2010). Design issues that are discovered during user acceptance testing performed against business scenarios, or test cases, creates additional rework. If the requirements are miscommunicated or missed during testing, fixing the issue after it is in production can be a costly and time-consuming process. This is because the system development lifecycles require release management to track the issues and project management to create a new phase in the project to correct any issues, which is an expensive undertaking and sometimes not feasible. This often leads to the business trying to find ways to analyze their data using other methods.

Spreadsheets are often used as a low cost alternative for analyzing data for decision making because of easier access to data manipulation capabilities and easier access to data through data exports. It has been known for a long time that spreadsheets are a concern for quality and 25% contain errors (Cragg, 1993). However, almost two decades later spreadsheets are still a costly concern when used as a modeling tool for decision-making. These poor model designs lead to poor decisions. Errors in spreadsheets have been found to be frequent and potentially costly (Powell, 2008). In addition, knowledge is lost when the creator of the spreadsheet leaves the organization. The European Spreadsheet Risks Interest Group (EuSpRIG) has been keeping track of news articles involving common problems that occur with the uncontrolled use of spreadsheets. The uncontrolled use of spreadsheets poses many risks for organizations, such as adverse press coverage, public embarrassment, loss of share value, investor confidence, personal career damage, financial loss and, in some cases, unintended fraud (O'Beirne, 2012). Any bad model that does not correctly represent the organization, whether in a spreadsheet or a BI model, can lead to a “decision-making disorder” within the organization. This is caused when decisions are sanctioned by individuals instead of the organization as a whole (Davenport, 2009). This dissertation looks at a new collaborative design process that is needed to support the growing demand for BI models. The following are three themes and issues affecting BI design that will be addressed in this dissertation.

First, many IT departments are experiencing long delays and backlogs because of ill communication of design requirements. According to a Forrester Survey (Forrester, 2010) 77% of respondents of a survey reported that it could take days or months to get BI requests fulfilled, 36% of respondents stated that time-consuming customization is required to answer BI requests, and 66% of respondents mentioned too many requests as the main reason for backlog. As this backlog grows, Business Analysts look for alternatives for decision making without IT, such as spreadsheets, as mentioned previously. This backlog needs to be addressed so organizations can keep pace with analysis needs.

Second, current database design processes lack effective collaboration and communication between the Business Analysts and Database Developers to support the quick and accurate BI model development needed for decision-making. If database developers cannot provide the business with the needed data models for analysis when they are needed, then the business will turn to other options for analyzing data and decision making, like spreadsheets or distributed systems and data silos. This can lead to many costly problems in the long term as discussed previously. However, the business still cannot be self-serving when the BI model that they are trying to use does not contain the information they need. These new requests for data models need to keep pace with the organization analysis demands. Given that it currently takes days or months to get requirements completed and that requirements change daily to monthly (Forrester, 2010), the enhanced multi-perspective collaboration-based BI design process was to help collaboration communication of requirements by improving the comprehensiveness and quality of requirements capture leading to better BI models.

Third, the mental models and BI capability perspectives of Business Analysts and Database Developers vary greatly. Database developers are primarily concerned with optimal data representation and retrieval performance, and these concerns drive their perspectives on data modeling. Business Analyst’s perspectives on data models are driven by the business context of their decision problems and their mental models of the organizational business processes. Collaborative systems are used today to assist with communication between IT and Business disciplines. None of these methods promote the translation of the different mental models the users have. In order to improve the effectiveness and efficiency of the BI development processes, the different logics of data representation and business decision-making, as well as, the differences in perspectives on BI capability held by Database Developers and Business Analyst need to be taken into consideration during the design process.

The following is a summary of the problems that this research addresses:

- Large backlogs of data analysis requests
- Lack of tools to support effective collaboration between Business and IT during design
- Lack of tools that support bridging the different logics of data representation between Business Analyst and Database Developers

The remainder of this dissertation is structured as follows. The next chapter includes a comprehensive literature review of relevant work and identifies the research gaps that will be addressed in this dissertation. Following the literature review, the design science research methodology is presented. Then the artifact requirements are tied to the theories that are discussed in the design of the Inter-Disciplinary Communication System chapter. The user study protocol is discussed, followed by the results and analysis of the user study. A discussion of contributions and impact concludes this dissertation.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a review of relevant work on issues affecting business intelligence design is presented, along with research gaps that are addressed in this dissertation. Research on data modeling issues and the latest developments for data modeling, as well as past efforts on bridging different logics of data representation, are discussed and followed by the research gaps with the current practices.

User Training for Database Design

Several studies have been conducted to look at ways to solve data modeling problems by enhancing modeling tools so users are less likely to make mistakes. One approach is to restrict known invalid modeling options in a system to help novice users make decisions and prevent human errors (D Batra, 1993). Another study compares a rule-based approach with a pattern-based approach at different levels of complexity of conceptual data modeling tasks (D. Batra, and Wishart, N.A., 2004) to see if rules or patterns could be used to assist with modeling. Rule based approach helps novice users by telling them the steps they need to take to model something; whereas, pattern based approach looks at prior patterns that were used to model similar models and guides the user through the process with the same pattern. However, a one-size-fits all approach is unlikely to continue (Stonebraker, 2005). Researchers then looked at how mental aids are needed to overcome cognitive issue of modeling (Antony, 2005). A study was conducted to look at how knowledge-based systems could be used for conceptual data modeling by reusing modeling knowledge (Malhotra, 2008). The recommended solution to overcome this modeling issue for users is to create mental aids to provide rules for modeling that a modeler can follow(D. Batra, and Wishart, N.A., 2004). One factor of design complexity is that there are no mental aids to help the data modeler at the time of design (D. Batra, 2007). All of these methods have been used in the past to try to overcome modeling issues and have had some success with novice Database Developers. However, even advanced tools and mental aids are not enough to help Database Developers with interpreting the data models requirements. Current tools do not ensure that the business requirements match the model.

Latest Developments of Data Modeling Technology

(Corral, 2006) observed that if users use data modeling applications, they can leverage their understanding of the structure of the star schema and can reduce their reliance on Information Systems (IS) professionals for the retrieval of information from data warehouses. However, this is only helpful for understanding the current implemented model and not changing to new conceptual models that are being designed. Tools have also been created to help automate modeling, as well as commercial tools that can generate data definitions, ETL scripts, SQL queries, and metadata or semantic layers. Some of these tools use wizards and tips to help guide analysts with their data model design. Vendors, like IBM, are preparing for more big-data solutions with software like InfoSphere with Netezza or EMC with Greenplum (Mustaquim 2011). Other vendors are doing the same, trying to address this issue (Henschen 2011). Data virtualization can now integrate data from disparate sources without any physical data movement, allowings IT to create views for Business Analysts more quickly. All of this may help lead to better BI models; however, without translation of the business requirements, they may be for the wrong problem. Software companies still must address the big-data pitfalls and potentials while also addressing users' ability to use these tools (McKinsey May 2011). The BI models used for reporting and analysis have to be developed to meet the decision makers' goal. The goal has to be communicated and developed in collaboration with the database developer.

Current Design Process

Current practices for model designing follow a sequential mode of design creation with a predefined workflow of sub-tasks, sequentially executed and requiring numerous iterations, which make design expensive and time-consuming (Shen, 2008). Prior research that examined collaborative design and development processes promised semi-automated tools, networked together that covered the full product lifecycle (Shen, 2008). Prior trends of centralized knowledge management repository are now being replaced with an interactive conversational approach (M. R. Lee, Lan, Y., 2007). Knowledge from the discipline domain experts is being shared with peers who also possess the same resources. Research calls for collaborative intelligent user interfaces for human involvement in the design processes (Shen, 2008). New trends like Web 2.0 and Business Intelligence 2.0 have characteristics of this collaborative intelligence.

While collaborative systems are used today to assist with communication between IT and Business disciplines, none of them try to encourage the translation of the mental models the users have. For example, one system created by Wang (2003) integrated web-based and agent-based tools for developing a distributed multidisciplinary design optimization environment for collaborative concept design. This system allowed for interaction between designers, users and servers; however, it was not BI specific. It did not address the conceptual database design issues that are experienced. Other current collaborative systems are not generally accepted in practice, and advanced systems are needed (Li, 2006).

An inter-disciplinary collaborative data-modeling tool for Business Analysts and Database Developers could help IT fulfill BI development requests faster and more accurately if there was a way that the BI models could be translated for the Business Analysts as the models are created. Tools for enhancing interdisciplinary communication have been developed to assist with design decisions (Fruchter, 1996a; Fruchter 1996b; Winowiecki, 2011). They have integrated a shared modeling environment to accommodate many perspectives for architecture, engineering and construction teams (Fruchter, 1996a). This has also been used for intensive cross-disciplinary communication of design concepts and decisions (Fruchter 1996b). Dissimilar disciplines, like physical and social sciences, and many different academic disciplines have used this concept with success (Winowiecki, 2011). However, such tools as those proposed by Fruchter do not exist for BI development.

Different Logics of Data Representation

The Business Analyst and the Database Developer have two different logics of data representation. The Business Analyst might see data as a chart or a graph, The Database Developer might see the data as a SQL statement or the relationships and cardinality in a star schema. The issue with different logics of data representation may result in poor designs of business models in which business decisions are made. Some industries have multiple analysis needs, like healthcare which has two unique reporting needs: administrative and clinical (T. Mettler, 2008). Getting the right resources can be difficult and expensive for organizations. Currently the Database Developers need to have both advanced administrative and clinical knowledge to be proficient at creating models for the healthcare industry. Hersh(2002) observed that there is a growing concern that information is not being used as effectively as possible in healthcare, and clinicians have to accept change to become more accountable for accurate data. McKinsey (May 2011) added to this by declaring that data is now an important factor of operations in every industry and business function. Getting the right talent and technology in place is required. Kohavi (2002) stated that even expert Business Analysts, in their particular areas, are still unlikely to be experts in technical fields. These knowledge domains need to be bridged between the Business Analyst and the Database Developer. If the gap is not closed, the BI models used for analysis are in jeopardy of being the source of bad business decisions.

Currently BI tools are often not used for decision making because of missing data, incomplete models or because the initial model is no longer relevant. If the data models do not fulfill the needs of the users or they are not comfortable with the data for analytical requests, they will not be used (Jukic & Nicholas, 2010). User adoption for BI tools has been about 25% since 2005. User adoption of BI tools in 2007 was 25% and in 2009 was 24% according to Howson (2009) and Swoyer (2010). If the information that these systems yield is not accurate, end users will not trust them for decision-making.

BI tools need to have up-to-date data with the current business views. A one-size-fits all approach for all business units and business areas, as is current practice, is unlikely to continue (Stonebraker, 2005). Different business areas need to view the data differently and data models need to evolve as quickly as the business does. The issue is that the current tools and change processes lack the collaboration with the Business Analyst that is needed to develop the models quickly and accurately. According to a Forrester report, it can take days and months to get BI requests fulfilled. Customization is required to answer requests, and the decision maker does not always have access to a Data Analyst to create custom reports. In addition, BI requirements can change daily and monthly. Practitioners have emphasized the importance of involving users in application development and have found that the users often have a better understanding of what they want after seeing a prototype (Watson, 2010). Viewing the prototype may lead to scope creep because the Business Analyst can then visualize a better solution. For many years, practitioners and requirements analysis scholars have emphasized the importance of design before development (Gause, 1989). The industry still demonstrates this behavior of missing requirements, which, unfortunately, is a common problem (Lim, 2013).

Research Gaps

The research gaps that this dissertation addresses are the collaboration problems between disciplines and how the different mental models can be communicated more effectively between disciplines. Both of these gaps contribute to the backlog that IS departments are facing. Data modeling can be complex for Business Analysts who do not have a background or training with data modeling. It would be best to allow the experts with this knowledge in data modeling to design and build the models to best practice. In addition, Business Analysts frequently have issues communicating requirements and their context. Database Developers have issues interpreting the business requirements. New user-analyst collaboration tools are needed to help translate Business Analyst requests to technical requests, which result in the technical answers providing business solutions.

CHAPTER 3

RESEARCH METHODOLOGY

In this research, the design science research methodology for information systems was followed for the design, development and evaluation of the proposed Information Technology artifact (Hevner, 2004). A key contribution of this research was an information technology artifact, the multi perspective inter-disciplinary communication system for BI design. This research is relevant to both researchers and practitioners, as it addresses an important problem facing organizations in their efforts to leverage organizational data for better decision making. It also evaluated the effectiveness of inter-disciplinary collaboration systems in supporting design tasks.

The design of the collaboration system was based on an analysis of relevant theoretical foundations in interdisciplinary and collaborative conceptual design frameworks. In addition, the use of the data/frame theory helped to understand the cognitive processes underlying the BI development process and identified the critical features of a collaboration system for interdisciplinary collaboration. The utility of the proposed multi perspective inter-disciplinary communication system was rigorously evaluated with a user observational study. The research contributions of this observational study advanced understanding of how mental models, or views, of data can be communicated more effectively between Business Analysts and database developers. It examined how ambiguity can be removed from the communication of data models request made by Business Analyst.

This research addressed both technical and managerial audiences that are experiencing issues with data modeling requests as described in the prior chapter in the Issues Impacting Business Intelligence Design section. From a technical perspective, the contributions of this research produced an IT artifact of a tool that used Interdisciplinary Communication Medium (ICM) theory and Data/Frame Theory of Sensemaking in order to improve communication and collaboration between the fields of Information Systems and Business. The next chapter will discuss in detail how these two theories were applied to the artifact. From a managerial perspective, the contribution of this research produced a method that can lead to the quicker delivery of data models and reduce the backlog of change requests. Table 1, summarizes the methodology using the seven steps proposed by Hevner(2004) in relationship to this research.

Table 1 - Methodology Summary

Guideline	Description
Design as an artifact	This research resulted in the development of a model and instantiation of an inter-disciplinary communication system for Business Intelligence System development.
Problem relevance	Previous studies states that BI tools are not being used because they do not meet users' needs. Industry surveys report a backlog of request due to long turn over time for IT to deliver new/changing data models. This research addresses the need for collaboration between the Business Analyst and Database Developer. It helps to reduces ambiguity in requirements by translating the models between the users.
Design evaluation	The utility of the proposed multi-perspective inter-disciplinary communication system was evaluated using an observational study and interviews.
Research contribution	The contributions advanced understanding of how models help during design to remove ambiguity in the communication of requirements.
Research rigor	The model is based on past research and has a theoretical basis in both Interdisciplinary Communication Medium (ICM) and Data/Frame Theory.
Design as a search process	The artifact went through several iterations in a search for an effective artifact. After the model was implemented and evaluated, problems were addressed and the cycle was repeated with a modified solution.
Communication of research	The results of the observational study and the post study interviews were coded and evaluated. The technology audiences can benefit from the results because the framework

	was found to help communicate the different mental models that exist between Business and IT. The business management audiences can benefit from the results because the framework was found to reduce rework, improve delivery and help to create better database models.

CHAPTER 4

DESIGN OF THE INTER-DISCIPLINARY COMMUNICATION SYSTEM

This chapter starts with a description of the objective for the project. In this chapter, the two theories used in the creation of the IT artifact, Interdisciplinary Communication Medium (ICM) and Data/Frame Theory of Sensemaking are described along with how they were used in the artifact design and system components of the collaboration tool. The chapter includes the system architecture and description of system components. Finally, how the system was implemented and the formative design evaluation of artifact is discussed.

Objective of the Project

The primary objective of this dissertation is to develop a communication and collaboration based tool for BI design process that can help bridge the difference in logics and perspectives among Database Developers and Business Analysts. This dissertation utilized the design-science research methodology as a guideline to create a model and a theory-based IT artifact in order to address this issue and improve the current BI development process by supporting collaboration between Business Analyst and Database Developers for the design of data models. The goal of the enhanced multi-perspective collaboration-based BI development process is to reduce the development time and improve the comprehensiveness and quality of requirements capture.

The contribution of this research adds to the Information Systems field in two ways. First, the design of the collaboration tool for the BI development process with theoretical foundation in both Interdisciplinary Communication Medium theory and Data/Frame Theory were used as a template for the development of a more user friendly and effective BI development platform. The design adds to the knowledge base of next generation data engineering processes that involve closer interaction with end users. Second, a user observational study of the collaboration-based tool helps to advance our understanding of how mental models, and views, of data can be communicated more effectively between Database Developers and Business Analysts. This dissertation looks at how ambiguity can be removed from the communication of data models requests made by Business Analysts.

The two theories used in this dissertation have been used in similar technical fields to improve collaboration between disciplines. This dissertation presents a BI design process using a multi perspective inter-disciplinary communication approach, a protocol to validate the process, and the results of a study using the process.

The Inter-Disciplinary Communication System Requirements

The communication tool requirements were created because of the research gaps identified in the Research Gaps section. The research gaps have to do with the fact that both Business Analysts and Database Developers have different mental models. These mental models are based on what their perception of the organization is and what the BI models should look like. For example, someone's role in an organization and the tasks they have to perform can influence their mental model. In addition, training, education and background can influence their mental models. The collaboration system in this dissertation research helps to facilitate communication of the user's perceptions so they can interpret the requirements being communicated. The first two communication tool requirements have to do with bridging the gap of the knowledge domains and interpreting their discipline models. To help the Business Analyst understand what the database developer is doing, the BI model had to be translated into a model that the Business Analyst would understand, such a Business Requirement Document (BRD). The process of communicating the BI model and creating visual displays allows the Business Analyst to clarify requirements and correct any misinterpretations of the requirements through collaboration. The third requirement of the tool has to do with helping develop these requirements. The tool was designed to improve delivery times for business requests with less rework of the models after the initial requests. The fourth requirement is to allow users to monitor the process of the model design to allow them to suggest changes and ask clarification questions as the model is being built. The fifth requirement is to help remove ambiguity using the collaborative approach. The new model in the current research included the items listed in Table 2 Collaboration Tool Requirements. The requirements were used to create the five metrics that were coded and analyzed in the user study. These will be discussed in detail in the user study chapter. The two theories that were utilized to address the requirements are discussed next.

Table 2 - Collaboration Tool Requirements

1. Bridge gap of knowledge domains so both Business Analysts and Database Developers can collaborate.
2. Interpret business discipline model for the Database Developer and the IT discipline model for the Business Analyst.
3. Help Business Analyst develop requirements.
4. Allow Business Analysts to monitor progress of model design and allow them to suggest changes to the model as it is being developed.
5. Help to remove ambiguity between business change request and data modeler.

Interdisciplinary Communication Medium

ICM framework is a framework for communication between different disciplines to support collaborative conceptual design and to present a prototype (Fruchter, 1996b). This concept suggests that a designer’s cycle starts with proposing a shared model. This shared model is then interpreted into discipline models with their meaning translated into the discipline’s context. The discipline models are than communicated. The process compares the discipline models to the functional requirements and explains the results to other members of the team (Fruchter, 1996b).

The disciplinary approach users take can hinder effective collaboration because of different cultures, educational backgrounds, or design habits of designers (Li, 2006). When used, interdisciplinary communication techniques reveal differences in the way people think and the way people process data when they are tasked with interdisciplinary work (Winowiecki, 2011). One interdisciplinary communication technique, scenario-building, can be used to help develop interdisciplinary communication (Winowiecki, 2011). This process can be used to help expose conflicts in communication. It also creates a platform where the conflicts can be communicated and addressed with both parties, in this case the Database Developer and the Business Analyst, working together to develop a Business Intelligence model.

When the business and IT disciplines have difficulty communicating their mental models, they experience delays and miscommunication that may lead to a poor final design and may require rework to correct the issues. The framework of ICM has been found to help other disciplines, such as architectural design and learning environments, to try to communicate designs between different disciplines (Fruchter, 1996a; Winowiecki, 2011). In this study, applying the ICM framework to BI modeling for Business Analysts and Database Developers is utilized to help with BI design, which requires a rigorous cross-disciplinary communication of modeling concepts, and the decision process used to create the BI models. This path was chosen because Database Developers needed a way to communicate their BI models to a business view and for Business Analysts to communicate their views to Database Developers' views in order to help communicate model requirements that lead to reduced time spent reworking in the design process because of miscommunication and ambiguity.

In the early conceptual design stage, there is an opportunity to have a positive impact on the decisions made to form the models (Wang, 2001). Getting different disciplines to commit to a common view of the models during the design phases has been a difficult collaborative design task (Wang, 2001). Using the ICM framework with the proposed collaborative system helps to bridge the BI model views between the two disciplines required to support the complex design during the design process. The proposed collaborative system allows each discipline to see the BI models in their own common conceptual view of the actual BI model and an intermediate view that helps with the mental mapping of each discipline to a common view. Frameworks that are used for collaboration and communication that promote participation of the Business Analyst can contribute to the conceptual design and can lead to an increase in diverse perspectives, higher levels of discourse, and new environments to enhance collaboration (Fischer, 2010).

Data/Frame Theory of Sensemaking

Sensemaking is a central cognitive function performed by practitioners in natural settings (Klein, 2007; Weick, 1995). The Data/Frame Theory of Sensemaking suggests that when someone tries to make sense of an event, they begin with a perception or a frame (Klein, 2006b). The frame concept originally came from Minsky(1974) who stated that frames defined data. Klein (2006b) expanded it and stated that frames themselves actually shape the data, and frames change as data is acquired. The Data/Frame Theory assumes sequence between mental model formation and mental simulation (Klein, 2006b). The data/frame relationship has been best described as something that is difficult to identify until it is pointed out. After it is pointed out, it cannot be missed (Klein, 2007). Experiences and training help to create people's frames, formingtheir biases. People sometimes make decisions without consciously recalling these experiences. Frames shape data that is measured for Sensemaking, and the data itself changes the frame.

The two cycles of Sensemaking are elaborating a frame and re-framing. Analyzing the frame as data is acquired leads to replacing the frame with a frame that has a better fit for the data. As the frames are refined, the data becomes clear. This process of framing and reframing inputs to a problem in a continuous process helps filter and interpret the data (Hutchins, 2011).

Sensemaking can be a difficult task for BI development when communicating the requirements between the Database Developers and the Business Analyst. The database developers need to understand the business, and the business users have to understand consequences of their requests. Business Analysts and Database Developers can both have different perceptions of the same BI model at the time of design. Data/Frame Theory can be utilized to assist with the reconciliation of the mental models of the database developer frame to the models of the other collaborators' data. For example, a star schema or dimension hierarchy would be a frame for the Database Developer. This frame would be reconciled with the Business Analyst perspective through data in a chart or a table.

Artifact Design

The solution that was created to address the collaboration tool requirements using the two theories was discussed in the Design of the Inter-Disciplinary Communication System section. This system helps to translate the different mental models that the two fields have about business requirements and database models. This collaboration can be synchronous or asynchronous between the Database Developers and the Business Analyst.

Figure 1 shows the system architecture of the Multi Perspective Inter-Disciplinary Communication System, which includes three areas: a business view for the Business Analyst, a data view for the Database Developers creating the BI model view, and an intermediate view for collaboration between the disciplines. The business view contained items that are familiar to the Business Analyst, such as Business Requirement Document (BRD). The translation of the data model relationships could be explained in a nature language. The data view contained items that database developers are familiar with, such as a star schema with the relationships and cardinality. The intermediate view contained tables with sample data and annotated diagrams so that both Business Analyst and Database Developers could have a shared representation of the models. Having these views in the same location is helpful, because they normally exist in different environments. For example, Business Analysts often create documents and store them in a repository, while the Database Developer might use software like ERwin to create the models. There might also be collaboration software used. However, this just creates a third environment that might not be linked to the Business Analyst's environment or the Database Developers' environment.

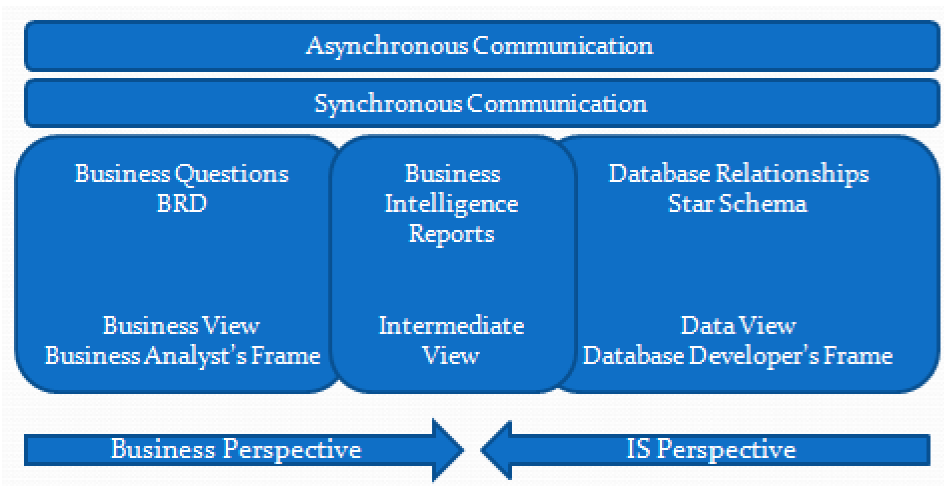

Figure 1 - System Architecture

System Components

The system components include communication methods, three display views, templates and stencils. The tool has both asynchronous and synchronous communication features. Asynchronous communications are available with a chat window that stores the history of resolved comments that are saved. The system includes an option to open prior chat sessions to review what dialogue took place when deciding what decisions to make while modeling. Synchronous communication is available through comment chat windows. The on-line status helps to allow both parties to know if the other party is available to talk. In addition, the development of the models is updated in real-time to allow all participants to see changes to the models as they are being made. The communication is used to ask questions and help to remove ambiguity. During thee study, communications and versioning were recorded for analysis and validation.

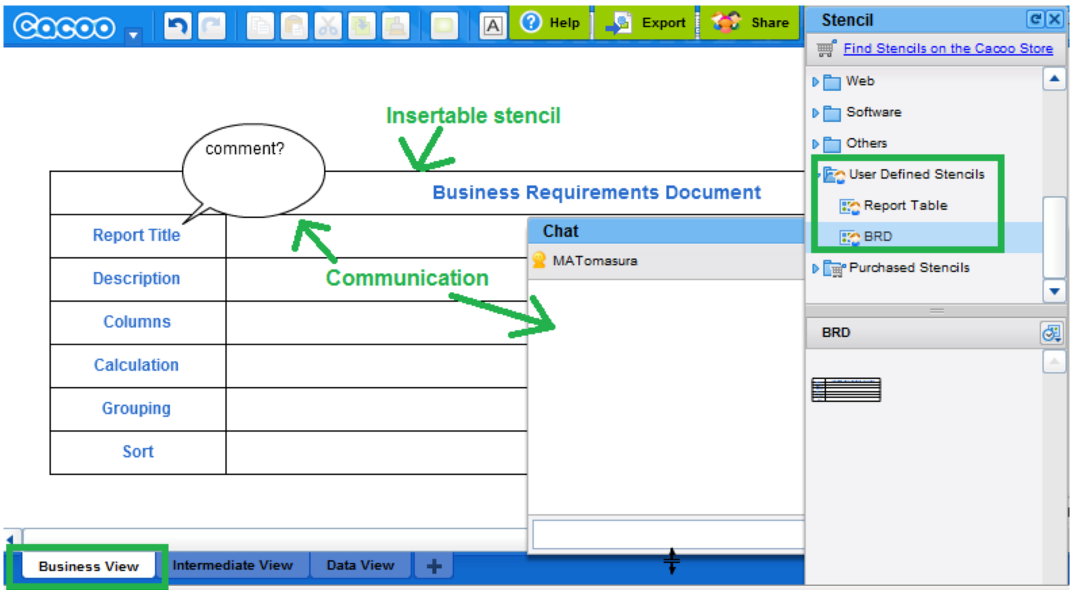

Figure 2 - The Business View

The three display views are the Business View, Data View, and the Intermediate View. A template was created with the three tabs. The template also includes a sample BRD, Star Schema, and list report. This was to simulate the ICM Framework and to expedite the user study.

The business view, Figure 2, is a visual example of those entities, which are contained in the collaboration view for the Business Analyst. The tool contains translation of the model in a business language. Both disciplines can work on the project at the same time and the views are updated as the users make changes. There is a BRD stencil to help expedite the design process and the user study.

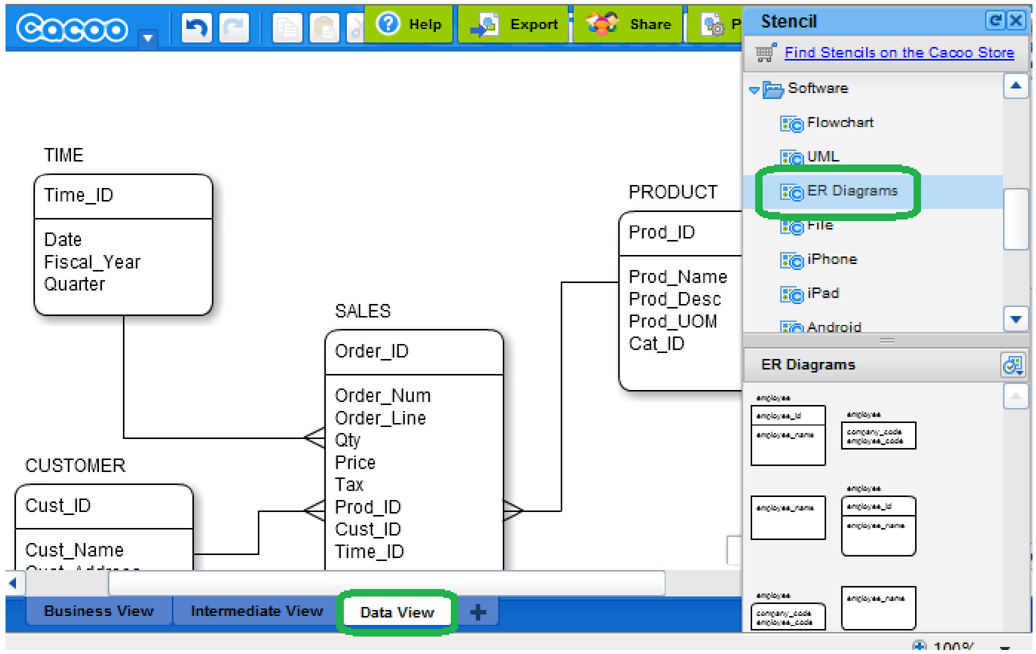

Figure 3 - The Technical View

The technical view, or Data View, displayed in Figure 3 contains basic modeling features similar to the commercial modeling tools. The communication features are also available in the technical view so feedback could be addressed. The ER Diagram stencils are available with the tool.

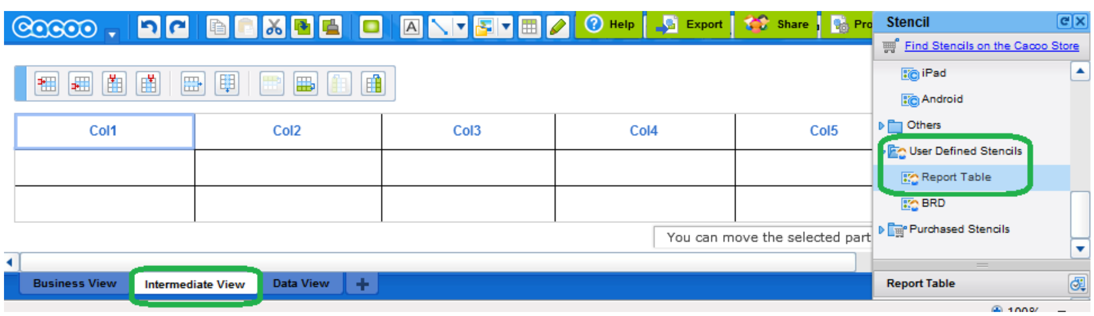

Figure 4 - The Intermediate View

The Intermediate View, displayed in Figure 4, is used to reconcile the two discipline models and to allow for collaboration of the final BI report design. A report table stencil is used to help expedite the design process.

System Implementation

The Multi Perspective Inter-Disciplinary Communication System is web based and no client software is required. The system is web based so it can be accessed from anywhere with real-time modeling information. Communication for feedback is enabled as the models are being designed to help with collaboration. The collaboration tool can be used at this point to work in real-time or be used to mark an object with feedback, so when the data modeler is back on-line, the feedback can be addressed.

Collaborative design software Lucidchart and Cacoo were selected as the platform for the prototype because they best met the requirements of the artifact that was needed to test the ICM and Data/Frame theory. They are both real-time collaboration tools for making diagrams online while working together with a team. Some configurations had to be made and some stencils and templates had to be created to meet the requirements of the artifact. The tools have the ability to track revisions of the development of the collaborative diagramming. Lucidchart was used for the first iteration. Cacoo was used after the first iteration, because it had a more user-friendly table feature that was required for the business view.

The three views are easily pre-configured using the tool. Stencils for the tables and star schemas were created to help procure a usable system for the participants of the user study. A shared model, for the intermediate view, is used to annotate diagrams, which helps collaboration. Sample table templates were created for the Intermediate view to illustrate the idea. The data view has relationship shapes available that can be used to create diagrams/star schemas. The business view templates are available to help expedite representation of business questions. Templates for BI reports are available so they could be created quickly. Other business view templates are available that can be inserted to display BRD. A template for a star schema is available for the data view to expedite development.

Formative Design Evaluation of Artifact

The artifact was built using formative validity proposed by S. A. Lee, Hubona, G.S., (2009). Using a theory-driven approach the design of the artifact follows the ICM Framework and Data Frame theories' accepted procedure. The constructs were emerged from these theories and were used to create the design features of the artifact. The artifact evolved during the iterations of the study. Data was obtained during observational studies and post study interviews through representative sampling, where the participants included novice and exports in the Information Systems field and Business field. The studies were used to measure if the design features were perceived to have addressed the research requirements. Table 3 is a summary of the research flow from the gap to the design features.

Table 3 - Evaluating the Formative Validity of the Proposed Artifact

Gap	Research Requirements	Theory	Design Features
- Collaboration and communication problems between disciplines. - How different mental models can be communicated more effectively between disciplines.	- Bridge gap of knowledge domains so both Business and IT can collaborate and develop data models more quickly and more accurately. - Help Business Analysts develop requirements to limit scope creep and reduce rework. - Help to remove ambiguity in change request requirements. - Interpret content into a discipline model. - Allow Business Analysts to monitor progress of model design and allow them to suggest changes to the model as it is being developed.	- ICM theory is a framework for communication between different disciplines to support collaborative conceptual design. -Data/frame theory can explain why certain data representations can cause different decisions, between Business Analysts and data modelers.	- Discipline views to interpret content into knowledge domains. - Intermediate view helps to reconcile frames to the discipline models. - Scenario helps to promote collaboration process and develop requirements. - Communication via asynchronous or synchronous communication. - Help to remove ambiguity in change request requirements and data modelers' interpretation using stencils or items that are familiar to Business Analyst such as a BRD, report, graph or chart. A Star-schema for the Database Developer.

			- To monitor design progress real-time and versioning.

This chapter summarized how theory was used to design the inter-disciplinary communication system and validate the design features. The next chapter will discuss how the user study was setup to measure and validate the results.

CHAPTER 5

USER STUDY

In this chapter, the protocol for the user study is discussed in detail. The purpose of the study is discussed first. The participants and tasks that were performed are discussed next, followed by the system used in the study and the process used to conduct the user study. Finally, the chapter will conclude with a discussion on how data was collected, coded and analyzed.

Purpose of User Study

In order to validate the proposed system and evaluate whether the research objectives had been satisfied, an observational user study was conducted to test the impact of the proposed tool on the efficiency and effectiveness of the BI development process. The prototype of the multi perspective inter-disciplinary communication system for the BI system design was configured for the observational study. The utility of the proposed inter-disciplinary communication system was evaluated using the user observational study. The goal was to reduce rework compared to current sequential BI development processes and to improve the quality of the BI models with the use of the collaborative tool compared to the current sequential BI development process. The observational study was designed to evaluate the research requirements listed in table 3. This was used to bridge the gap of knowledge domains so both Business and IT could collaborate, to develop data models more quickly and more accurately, and to help the Business Analysts develop requirements in order to limit scope creep and reduce rework.

Similar to the manner in which social media research is performed, the observer was not in the physical location during the study. (Brown, 2011). Observation data was taken from interaction logs and used to analyze the user's actions. Interviews were performed after the tasks were completed to collect additional data and measure the usefulness of the collaboration tools. In a post study interview, participants compared the existing sequential model for BI development with the collaboration tool.

Participants

Subjects were recruited from the student population of Dakota State University's graduate programs and were provided with the collaboration tool. Prior approval from the Dakota State University Institutional Review Board was requested for this research, because the study included human subjects. Groups consisted of one participant from the Business discipline and one from the Information System discipline. Multiple groups of participants were needed to perform the observation because multiple design iterations were necessary to validate the requirements of the design science artifact. The groups used the collaboration tool that had been pre-configured to use the Interdisciplinary Communication Medium (ICM) for collaborative conceptual design and data frame theory. Working as a team, the Business Analyst worked with the business view and the Database Developer worked with the technical view. Both disciplines collaborated to work with the intermediate view. The participants' prior experience with data modeling varied from novice, with only some academic experience, to expert, with many years of experience in the field. The participants' prior experience with business requirements also varied. A few participants had many years of experience and academic training in both business requirements and database development. Some participants' prior experience with data modeling was limited to face-to-face meeting room communication, while others had much more experience working in remote teams.

User Study Tasks

The participants were tasked with a change request that called for business requirement development and data modeling. A business scenario was used to help promote the interdisciplinary communication between the Business Analyst and the Database Developer. Each group was given directions and a demo on how the tool worked prior to performing the tasks. The directions for the user study can be found in appendix B. The directions were created following the ICM framework, where both disciplines developed their model and then critiqued the models. The tasks in the directions were modeled in a similar fashion to business requests in order to simulate a real BI report request; for example, adding a complex calculation or adding a new entity to an existing model. The Business Analyst was tasked with preparing the Business Requirement Documents (BRD) in the business view for the given business scenario. The Database Developer was tasked with modifying a star schema in the data view tab using the business requirements given in the business view. Both participants were tasked with collaborating with each other to make sure the report layouts in the Intermediate View meet the requirements of the Business View and the Star Schema in the Data View. In traditional data modeling process, this task does not happen. Business Analysts would have to wait until a test environment is setup to see the results of their requirements. With this task, they get to see the possible impacts before development has to start. This can help to remove scope creep after the final design. They also get a change to change their requirements if something is wrong or missing. They get to ask questions which can help to remove ambiguity.

System Used in Study

A collaboration tool for making diagrams online while working together in real time with a team was used for the study. The tool was selected because it was configurable with views for the ICM Framework. There was a revisions option or a history option that made revision history available. The tool also highlighted the changes that happen from version to version as seen in figure 5. Communications were enabled with asynchronous and synchronous communications, asynchronous with a comment window, in which a history of resolved comments is saved with the option to re-open a comment, and synchronous with a chat window.

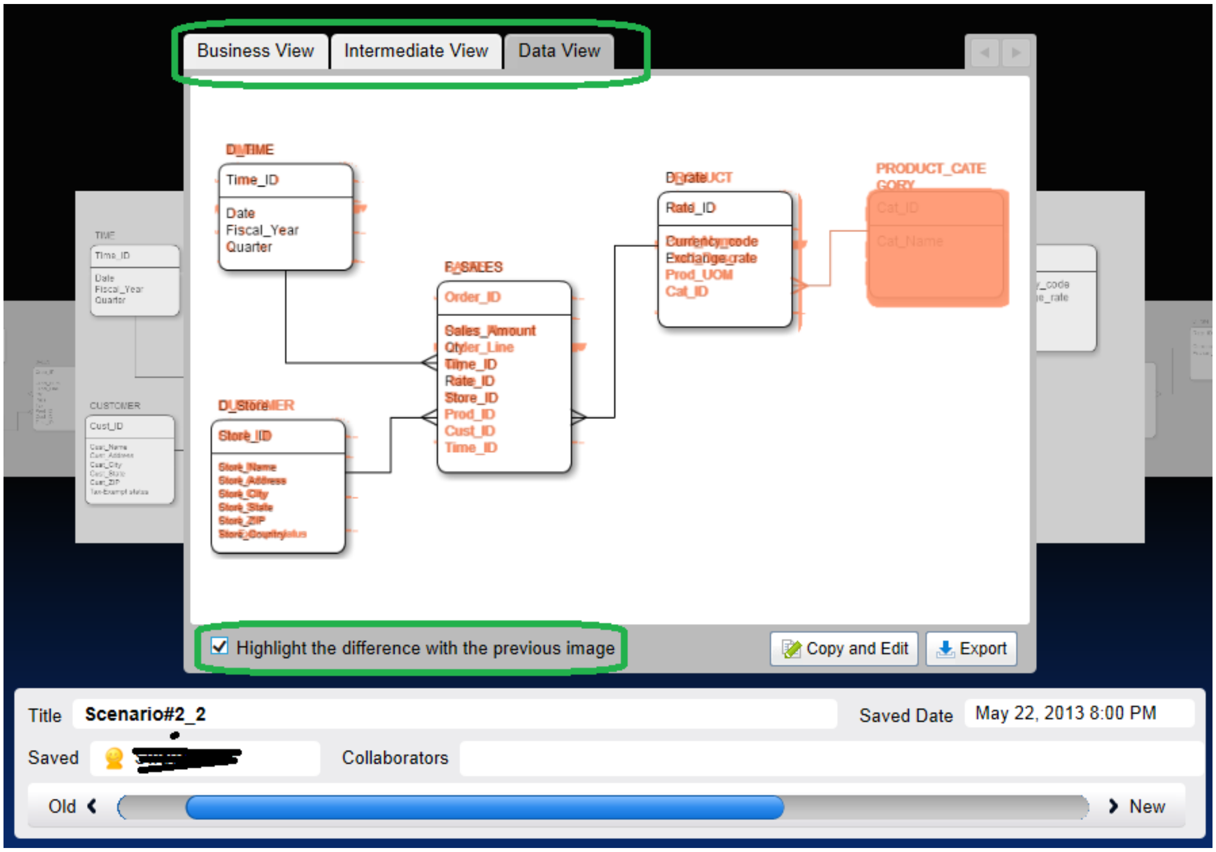

Figure 5 – BI Tool Revision History

User Study Protocol

While the participants performed these tasks on the system, observational data was gathered from the user study and coded right after the study. A follow-up interview was given after the user study was completed to gather additional information. Open ended questions about the experience using the tool and the ICM process were asked. Participants were asked if the audio responses could be recorded. The audio recordings were destroyed after the responses had been transcribed. An IRB committee approved the study.

During the interview, notes were taken and coded right after the interview. The recordings were played back and each sentence was analyzed using an interview protocol that was created prior to interview. The interview protocol used keywords that were used as flags. Relevant statements were coded as positive or negative for the metric that the question was trying to measure. The coding and analysis section discusses this analysis in more detail.

User Interviews

After the tasks were completed, interviews were performed to collect additional data and to measure the usefulness of the collaboration tools. Open ended and non-leading questions were used to encourage a full, meaningful answer using the participants' own knowledge and feelings. The interview started with three questions to help set the setting for the rest of the interview. The participants were asked about their experience in BI and the methods that they used in the past to communicate business requirements. After the setting was set, questions were asked about the five metrics.

The participants were asked to compare their prior experiences with similar tasks to the new process. The actual questions can be found in the Appendix A. Follow-up questions were asked to gather additional data for analysis. The next section will discuss how the user study was coded for the five metrics that were measured and the analysis that was performed.

Observational Data Collected

It was expected that the participants would utilize the collaborative system features during this process, such as the views and communication features. It was also expected that the process and features would reduce the perceived amount of rework and scope creep. Rework was measured as 1) the number of wrong requirements or misinterpretation of requirements requiring additional requests and 2) scope creep or the number of new additional requests created after the original request. Clarification questions were not counted as rework.

The text interaction between participants was recorded and used for analysis. The tools versioning and text messages between the participants were also used for analysis. The observational data was collected and coded as follows. The number of clarification questions, model revisions, and submissions were measured for analysis. Clarification questions were measured by the number of times the subjects asked their team member a question about the model they were creating. A high number of clarification questions indicated that the collaboration tool was helping to generate ideas, which should be helping the modeler fully develop the requirements and remove ambiguity. It was also an indication that the team member was monitoring the progress of the design and trying to interpret the other team members discipline model. A low number of clarification questions with a low level of revisions indicated that interdisciplinary communication was not occurring.

Revisions to the model were measured by the number of times the subject in the Database Developer role sent the DB model and reports back to the subject in the Business User role. Text exchanges were coded as clarification or revision. Clarification questions were not counted as revisions.

Submissions were measured by the number of times the team submit the documents to the moderator. The quality of the submission was measured by how many of the requirements were met with each revision. A scenario solution for expected requirements of the solution can be found in the appendix.

Coding and Analysis

The five metrics that were measured are Bridge Gap, Develop Requirements, Remove Ambiguity, Interpret Model and Monitor Progress. These five metrics were based on the requirements defined in the prior chapters as part of the system design and research methodology and summarized in Table 3 of the research flow overview. Questions were grouped into metric themes. The interview questions and responses were recorded. The recordings were played back and each sentence was analyzed using an interview protocol that was created prior to interview. The interview protocol used keywords that were used as flags. Relevant statements were coded as positive or negative for the metric the question was trying to measure.

One of the requirements of the tool was to bridge the gap of knowledge domains so both Business Analysts and Database Developers could collaborate and develop a better model more quickly. A question was asked about comparing their prior experiences with similar tasks compared to this process with respect to collaborating with their teammate. Words like cooperate, worked together, teamed up, shared and teamwork were used as flags to indicate that the metrics was being discussed. A complete list can be found in Appendix A. An example of a negative comment was “we did not team up.” An example of a positive comment was something like “we teamed up to…”

Another requirement of the tool was to help interpret the model and content into discipline model. A question was asked about comparing their prior experiences with similar tasks compared to this process with respect to understanding their teammate's perspective. Words like understand, translate, decipher and figure out were used as flags to indicate that the metrics was being discussed.

Another requirement of the tool was clarifying different interpretations of the requirements. A question was asked about comparing their prior experiences with similar tasks compared to this process with respect to clarifying different interpretations of the requirements. Words like make clear, clarify, clear, interpret and understand were used as flags to indicate that the metrics was being discussed.

Another requirement of the tool was developing the requirement. A question was asked about comparing their prior experiences with similar tasks compared to this process with respect to developing the requirement. Words like expand, build, communicate, share and progress were used as flags to indicate that the metrics was being discussed.

Another requirement of the tool was monitoring the progress of model design. A question was asked about comparing their prior experiences with similar tasks compared to this process with respect to monitoring progress of model design. Words like watch, check, observe and keep eye on were used as flags to indicate that the metrics was being discussed.

The communication approach was to help the Business Analyst develop requirements to prevent scope creep and accurately communicate the requirements to the Database Developer domain. It was to allow Business Analysts to monitor progress of model design and allow them to suggest changes to the model as it was being developed. Finally, it was to help to remove ambiguity between business change request and IT.

Revisions were measured by the number of times the Database Developer asked the Business Analyst to look at the reports. Chat logs and notes were coded as clarification, revisions or submissions. A low number of revisions indicated that the mental models were being communicated more effectively between the fields of IT and Business and the gap was being bridged. A high number of revisions indicated that the requirements were not being communicated between disciplines.

Submissions were measured by the number of times the team submitted the documents to the moderator. A high number of submissions indicated that requirements were not being fully developed and rework was needed. A low number of submissions indicated that the requirements were fully developed and communicated.

The questions that can be found in the interview protocol located in Appendix A were designed to ask the participants to compare their prior experience to the ICM framework. Additional ad-hoc questions were also asked to determine why a particular process occurred as it did during the study. The results of the interview are discussed in the next chapter.

CHAPTER 6

RESULTS AND ANALYSIS

In this chapter, the results are discussed and analyzed. The results of five metrics are discussed by study iteration, followed by a summary of the findings concerning the metric and over all iterations. The design changes between iterations are also discussed. The chapter concludes with the summary of all findings and the overall conclusions.

Bridge Gap

In the first iteration, the study was stopped before the results could be fully collected. There were usability issues that had to be addressed before the second iteration. This is reviewed with the iteration discussion that follows the metric results. In the second iteration, the Bridge Gap metric had positive feedback. When the participants were asked how the process compared to prior experiences with similar tasks in respect to collaborating with team members, they said it forced them to “dig into it more” when talking about the requirement sharing. They also stated that they “never did this at this level before because the teammate normally does not know what attributes to look for.” The comments demonstrated that a bridge was built between disciplines. Comments also referred to the process as better because it enabled real-time diagramming. The Business Analyst also found it to be “integrating for at a distance” users. The feedback indicated that the tool did help to bridge the gap of knowledge domains so both Business and IT users could better collaborate and develop data models more quickly and more accurately. One bias was that the Business Analyst also had extensive IT experience and training. In the next iteration, a Business Analyst that had intermediate experience participated in the study.

In the third iteration, the Bridge Gap metric had mixed feedback. When the participants were asked how the process compared to prior experiences with similar tasks in respect to collaborating with team members, the Business Analyst, who only had prior experience with BI requirements in a face-to-face environments, stated that it was not as good as his prior experience and not as quick. The Business Analyst did say he preferred this process to email exchanges because of diagramming in each view. The Database Developer, on the other hand, who had experience with many different communication methods, said it was better compared to prior experiences and thought the live real-time editing and chat made it more interactive and engaging compared to prior tools. This feedback indicates that face-to-face may still be the best way to communicate requirements between IT and Business disciplines; however, when face-to-face meetings are not possible, this method enhances the process and helps to bridge the gap between disciplines.

In the fourth iteration, the Bridge Gap metric had positive feedback. When the participants were asked how the process compared to prior experiences with similar tasks in respect to collaborating with team members, the Business Analyst, who only had prior experience with BI requirements in face-to-face environments, stated that face-to-face and meeting rooms are better. During a follow-up question, he said if face-to-face were not available it would be very useful. The Business Analyst said that collaborating with partners was successful. This feedback indicates that face-to-face may still be the preferred way to communicate requirements between IT and Business disciplines; however, when face-to-face meetings are not possible, this method enhances the process and helps to bridge the gap between disciplines.

In the fifth iteration, the Bridge Gap metric had positive feedback. When the participants were asked how the process compared to prior experiences with similar tasks in respect to collaborating with team members, they said it was “good to communicate” and “spin back-and-forth” when working together. They thought the live real-time editing made it better for communicating compared to prior tools. This feedback indicated that the method can enhance the process and that it helped to bridge the gap between disciplines.

In terms of bridging the problem knowledge and communication gap between the Business Analyst and Database Developer, positive feedback was observed in the Bridge Gap metric. This feedback indicated that the method can enhance the process and that it helped to bridge the gap between disciplines.

Developing the Requirements

In the second iteration, when asked about how the process compared to prior experiences with similar tasks in respect to developing the requirements, the subjects responded that it “forces the business users to think things through more” when referring to the requirements. This question measured the Develop Requirements metric. Comments suggested that the tool, especially the intermediate view, made it easier to communicate the requirements with the tables in the business view. Those interviewed said that the “intermediate view was very important” for the process. They said it was “better because of the availability” of the three views in the tool. The consolidation of the requirements, DB model, and report specs in one location allowed them easy access to the information they needed when they needed it. This feedback indicated that the tool did help Business Analysts develop requirements to limit scope creep and reduce rework though the use of the intermediate view and the consolidation of discipline views.

In the third iteration, when asked about how the process compared to prior experiences with similar tasks in respect to developing the requirements, the Business Analyst responded that it was not as rich as face-to-face where there could be more “question and answer.” The Business Analyst also said the BRD was restrictive and had no graphical enhancements. There was a concern that the BRD was not scalable enough and would not work with larger projects. In the prior iteration, concerns about the BRD were also stated. For the next iteration, the BRD was revised to be more scalable. A scenario with more requirements was also given to the next set of participants to increase the use of the BRD. On the other hand, in regards to developing the requirements, the Database Developer said that the process was better than prior experiences because of the tab views. They said, “The BRD is right there and this is good.” As with the prior iteration, the availability of the BRD was helpful for the Database Developer for developing their requirements.

In the fourth iteration, when asked about how the process compared to prior experiences with similar tasks in respect to developing the requirements, the Business Analyst would like to have more training in this area before using the tool. The Database Developers said they could collaborate and keep in touch with all people in the project and see where the project is going as the requirements were being developed. This feedback indicated that the tool could help the Database Developers gather their requirements and help to limit rework.

In the fifth iteration, when asked about how the process compared to prior experiences with similar tasks in respect to developing the requirements, the Business Analyst responded that it was "more interactive" and the Database Developers liked the quick back and forth and not having to work with static documents. In addition, they said there was "so much more documentation before, it would be better to have more collaboration like this". This process helps to develop the design before writing and rewriting the documentation in the traditional method of database development. In a follow-up question about the quality of the requirements, they said this process could help create a better model, especially if working in real time.

With the exception of the third iteration, this metric had mostly positive feedback. In the third iteration, the participants preferred face-to-face communication and had an issue with the BRD that was addressed in the following iteration design. This feedback indicated that the tool could help the Database Developer gather, develop their requirements, and help to limit scope creep in the process.

Remove Ambiguity

In the second iteration, when asked about how the process compared to prior experience with similar tasks in respect to clarifying difference interpretations with their team, the participants said that the collaboration helped to clarify the new attributes. This question measured the Remove Ambiguity metric. When a follow up question asked if they could share an example, the Database Developer said, "I asked the Business Analyst to clarify more of the requirements. If I missed something I could ask the Business Analyst" when in the intermediate view. "The Business Analyst gave me more information that told me to add a missing attribute." This interaction helped them to "interpret and clarify the requirements with the Business Analyst" which led them to add a missing attribute. The Business Analysts said they "had to clarify the tax exempt requirements" when they got to the intermediate view. They did not understand the requirements at first when referring to the process before using the intermediate view. After working in the intermediate view, the attributes were clarified. The comments indicated that the tool did help to promote an environment that helped to remove ambiguity and misinterpretation through the use of an intermediate view. The DB developer seemed to benefit more from the process than the Business Analyst did with respects to removing ambiguity when comparing keywords in their responses.

In the third iteration, when asked about how the process compared to prior experiences with similar tasks in respect to clarifying difference interpretations or removing ambiguity, with their team the participants gave positive feedback. They said that the "chat feature was useful in clarifying information and being able to refer back to the diagrams in real-time was also helpful and enhanced our communication and our ability to clarify ambiguous topics." The Database Developer said that this tool was better at "clarifying differences" and "other tools do not have this" when talking about the different views feature. The Database Developers stated that they did not use any features to communicate in the intermediate view. This may be because the ambiguity was removed when they were working in the discipline views. They said that collaboration was helpful and the ability to go back and forth between tabs helped. They said that the ability to see versioning would have been helpful. In the next iteration, the history option was pointed out because versioning was an available feature of the tool.

In the fourth iteration, when asked about how the process compared to prior experiences with similar tasks in respect to clarifying difference interpretations or removing ambiguity, with their team they gave positive feedback. They said that the some requirements needed more clarification than others did. It was very helpful for discussing requirements with teammates, not having to go back and forth and modifying requirements later but rather do the back and forth while developing the requirements. This feedback indicated that the user thought it would reduce rework though the use of the views and the consolidation of discipline views.

In the fifth iteration, when asked about how the process compared to prior experiences with similar tasks in respect to clarifying difference interpretations, or removing ambiguity, with their team, the participants gave positive feedback. They said that the process was "better than the old way" and the "history" and "three views helped" to create a "clear picture." It should be noted the only negative comment was that the tool lacked audio. An elluminate session was used for audio during the study. They found having the audio was helpful. This was not coded as a negative since audio was available for the process outside of the tool. In a follow-up question, asking if synchronous communication was not possible because of time zones or work schedules, they said the tool would be a "little more convenient." It was obvious that they preferred the real-time and synchronous communication in both audio and text formats during this study.

This metric had almost all positive feedback. The feedback indicated that the users thought it would help to remove ambiguity and that it would lead to reduced rework by using the consolidated discipline views.

Interpret Model

In the second iteration, when asked about the process compared to prior experiences with similar tasks in respect to understanding different interpretations of the requirements when working in a team, the participants used keywords like "clarify" and "collaborate" in regards to helping them understand others perspectives while working in the intermediate view. This question measured the Interpret Model metric. In a follow-up question, the Database Developer also said that the intermediate view was "very important" in the process to "clarify the requirements and to make sure the business requirements are there in the star schema." The Database Developer said the business analyst "was trying to clarify tax exempt requirement" during the intermediate view. These comments indicated that the tool did help to promote an environment where they were encouraged to interpret each other's model and would lead to suggested improvements earlier in the design phase. Like the prior metric, the Database Developer seemed to benefit more from the process than the Business Analyst did with this metric. This may be because the Business Analyst had more experience than the Database Developer did. In the subsequent iteration, someone with more experience on the database side exposed more details about this metric. In addition, someone from the business discipline, with less experience, exposed more details about the metric.

In the third iteration, when asked about the process compared to prior experiences with similar tasks in respect to understanding different interpretations of the requirements, or interpreting the model when working in a team, the Business Analysts said they would have liked to express themselves differently in the chat windows, such as in face-to-face discussion where they can change the tone of voice. On the other hand, the Database Developers said they "could see their teammate's perspective" and could "understand their perspective." This mixed feedback for interpreting the model is different from the prior iteration where both teammates gave positive feedback. This may be because the Business Analyst was more business oriented and had a different communication style. In the next iteration, the use of the available elluminate sessions was encouraged so the Business Analysts could express themselves through both text and voice for synchronous communication.

In the fourth iteration, when asked about the process compared to prior experiences with similar tasks in respect to understanding different interpretations of the requirements, or interpreting the model when working in a team, the Business Analysts said that the dynamics of the team created similar differences in viewpoint. The Database Developers said they felt like the other person understood the part they were working on. They also cautioned that a lack of experience may make the process difficult and training would be needed. These comments indicated that the tool did help to promote an environment where they were encouraged to interpret each other's model and would lead to suggested improvements earlier in the design phase.

In the fifth iteration, when asked about the process compared to prior experiences with similar tasks in respect to understanding different interpretations of the requirements, or interpreting the model, when working in a team the participants said it was beneficial because of the ability to go back and forth with the visuals and three views. They said that with the communication features, it was great. In the study, a tax status entity was added to the scenario. The Business Analyst and the DB Developer were collaborating about this entity, and they gave a good example how this process can be very useful. The example was that in Canada there is a tax on donuts when purchased in certain quantities. Then there was a discussion on the different tax status for different countries. This not only helped the Database Developer to interpret the model; it also helped the Business Analyst to develop the requirements. This type of communication helps to build better models and can reduce rework later in the system development lifecycle.

This metric had almost all positive feedback. These comments indicated that the tool did help to promote an environment where the participants were encouraged to interpret each other's model, which led to suggested improvements earlier in the design phase.

Monitor Progress

In the second iteration, the Monitor Progress metric had mixed feedback. When asked about the process compared to prior experiences with similar tasks in respect to monitoring progress of the model design, the Database Developers said they did watch the BRD being created and modified but did not know that they could collaborate in the business view. They used the intermediate view for all collaboration. They did say that adding notes to the business view could be useful. The next iteration of the study included more references stating that the BRD can also be annotated by the Database Developer for clarification questions, as it is being developed or modified. In a follow-up question about the intermediate view, the participants said it was very helpful for “making changes” and it made the process “more interactive and collaborative.” The asynchronous and synchronous communication features were also found to help. The Business Analyst “liked it for monitoring the process with the on-line tool especially with remote users.” In a follow-up question about using the tool with team members in different time zones or with different work schedules, the participants said it would also be helpful. From the comments, it appeared that they were able to suggest changes to the model but were only able to monitor the progress when communication efforts were made. The next iteration of the study also included a follow-up question asking the Database developers if they were able to start their part sooner or start to visualize their model earlier, since they were able to see the requirements being developed.

In the third iteration, the Monitor Progress metric had better feedback after the changes from the last iteration. When the participants were asked how the process compared to prior experiences with similar tasks in respect to collaborating with team members, the participants said they liked the real-time ability and it helped them to visualize the model. The Database Developer said they never worked with a tool like this to model designs and found it to be more agile then their prior experiences.

In the fourth iteration, the Monitor Progress metric had positive feedback. When the participants were asked how the process compared to prior experiences with similar tasks in respect to collaborating with team members, they said that time zone differences could be seen as an important factor in such communication, and monitoring was very helpful. They said doing something “interactively with both parties involved during the modeling process makes a much clearer model and you will end up with a design everyone will agree on, not like during the traditional method of any design." This statement helped to sum up what the tool was designed to do. The only mixed feedback was that there was a software issue with the views not refreshing at one point, but they liked the real-time ability.

In the fifth iteration, the Monitor Progress metric provided positive feedback. When the participants were asked how the process compared to prior experiences with similar tasks in respect to collaborating with team members, the Business Analysts said it was "much better" because it allowed for "immediate feedback in both directions" and you can "get it fixed right then" in real-time. The Database Developer said it was "good for following through" and you "can check to see if you got everything" from the requirements. The Database Developer color-coded the fields in the star schema to indicate that he added the fields that were new in the BRD. The Database Developer also said, "It made sense" to do it this way.

This metric had mostly positive feedback and some mixed feedback. The participants said doing something interactively with both parties involved during the modeling process made a much clearer model and led to a design everyone agreed on, not like during the traditional method of any design. This statement helped to sum up what the tool was designed to do.

User Study Design Iterations

Five iterations were performed for the study. Prior to the first iteration, pilots were performed to test the study protocol and the process using the tool. In the first iteration of the study, the Business Analyst reported usability issues while editing the Business Requirement Document (BRD). The usability issue was addressed by changing the platform to different online diagram software. The new tool had all of the same features as the prior tool but was found to be more intuitive and user friendly by the Business Analyst, who tested the tool prior to the second iteration. Due to time constraints on participants' availability, the first iteration of the study ended early. In addition, due to the time constants of the participants, the scenarios were reduced to allow the participants to finish the exercise in an estimated 2 hours, instead of 4 hours.

To address the negative feedback in the second iteration of the study, the following changes were made for the next iteration of the study. In regards to the tool itself and the user experience, more references saying that even though the business view can be used by the Business Analyst to create the BRD, it can also be anointed not sure what you want here by the DB Developer asking for clarification as it is being developed or modified. The business view was changed to include a filter row in the BRD. This report feature was missing in the BRD and the Business Analyst pointed this out. There was also an issue reported with logging back in after several work sessions. To resolve this issue, the project was made public so that anyone with the URL can modify the project without logging in.

To address the negative feedback in the third iteration, the BRD was revised to be more scalable. The participants were under the impression that only one report could be maintained using the tool. In addition, the history option was to be pointed out. The participants said it would be a nice feature. The versioning was available, athough it was not in the demo prior to the study. In regards to the survey used to gather data, the next iteration of the study also included a follow-up question asking the Database Developers if they were able to start their part sooner or start to visualize their model earlier, since they were able to see the requirements being developed. This was to help to better assess the monitor progress metric.

To address the negative feedback in the third iteration the with Business Analyst not benefiting as much as the Database Developer, the fourth iteration included the following four changes. First, the use of the available elluminate session was encouraged so the Business Analysts can express themselves through both text and voice for synchronize communication. Second, the BRD was revised to be more scalable. Third, a scenario with more requirements was given to the next set of participants to increase the use of the BRD. Fourth, the history option was pointed out in the pre-study demo.

User Study Coding Iterations

The interview protocol used predetermined keywords that were used as flags for coding. Relevant statements were analyzed phrase-by-phrase and coded as positive or negative for the metric the question was trying to measure. If participants used a relevant keyword that was not listed in the predetermined list, it was added for the next iteration of the study. There were several keywords added to enhance the interview coding. For the Monitor Progress metric, the following keywords were added: “following through” and “monitoring.”

For the Bridge Gap theme, the following keywords were added: “collaborating”, “communication” and “back and forth.” No keywords were removed from the list. The keywords for mapping artifact components did not have any changes. The complete final list of keywords that were used can be found in Appendix A.

User Study Observation Results

In the second iteration, two revisions and two clarification questions were asked with only one submission. The duration needed to complete the model was about two hours in total. A low number of clarification questions with a low level of revisions indicated that interdisciplinary communication was not occurring. A low number of revisions indicated that the mental models were being communicated more effectively between the users and the gap was being bridged.

In the third iteration, three revisions and two clarification questions were asked with only one submission. The duration needed to complete the model was about two hours in total. A low number of clarification questions with a low level of revisions indicated that interdisciplinary communication was not occurring. A low number of revisions indicated that the mental models were being communicated more effectively between the users and the gap was being bridged. In the second and third iterations, the visual views in the discipline and intermediate views helped to communicate the requirements. However, more clarification questions should have been asked for the interdisciplinary communication to be working.

In the fourth iteration, two revisions and eight clarification questions were asked with only one submission. The duration needed to complete the model was about two and half hours in total. This high level of clarification questions was a good indication that the collaboration tool was helping to generate ideas. This helped the participants to fully develop the requirements and remove ambiguity. It was also an indication that the team members were monitoring the progress of the design and trying to interpret the other team members’ discipline model. A low number of revisions indicated that the mental models were being communicated more effectively between the users and the gap was being bridged.

In the final iteration, there were three revisions and five clarification questions were asked with only one submission. The duration needed to complete the model was about two hours in total. This high level of clarification questions was a good indication that the collaboration tool was helping to generate ideas. This helped the participants to fully develop the requirements and remove ambiguity. It was also an indication that the team member was monitoring the progress of the design and trying to interpret the other team members discipline model. A low number of revisions indicated that the mental models were being communicated more effectively between the fields of IT and Business and the gap was being bridged.

Results Summary

The expected research contribution of this research was the implications for more accurate BI models that are delivered more quickly because less rework would be required in the design. The contributions of this research included an advancing of our understanding of how IT and Business knowledge domains can be bridged. It also helped to validate that the process can help to remove ambiguity from the communication of data models requests made by business users and hopefully also into other areas within the Information Systems field.

The expected result of the study was that increased levels of communication with the collaborative views of the BI model results in less rework and a shorter design phase for BI development projects. The contributions of the results can be used to help organizations by providing knowledge about what level of collaboration is needed to help reduce the database development backlog. Allowing business users to assist with the design phase and making it interactive did have a positive impact. The new collaboration system addresses the collaboration problem between business and IT in regards to the current BI design process that is causing the backlogs and delays. It also has potential to prepare organizations for the "Big Data" problem, and the potential the data has for the organization, by allowing them to be more agile with the ever growing demand and changing business requirements.

Overall, the user study found that the tool did help in almost all aspects of the requirements. The Bridge the Gap and Remove Ambiguity metrics had the best results when compared to the participants' prior experiences using similar tools and using a similar process. The Monitor Progress and Interpret Model had mostly positive feedback but also had some mixed feedback. Develop Requirements had mostly positive feedback but had the most negative feedback of the five metrics. Figure 6 is a high-level view of the results. The visual shows a solid line for the Remove Ambiguity metrics indicating a positive perception of the process and tool to remove unclear requirements throughout the iterations. The graph has a valley in the Develop Requirements metric indicating that some negative perceptions were observed in some of the iterations. Most of the negative perceptions were in the third iteration. The final two iterations had almost all positive feedback.

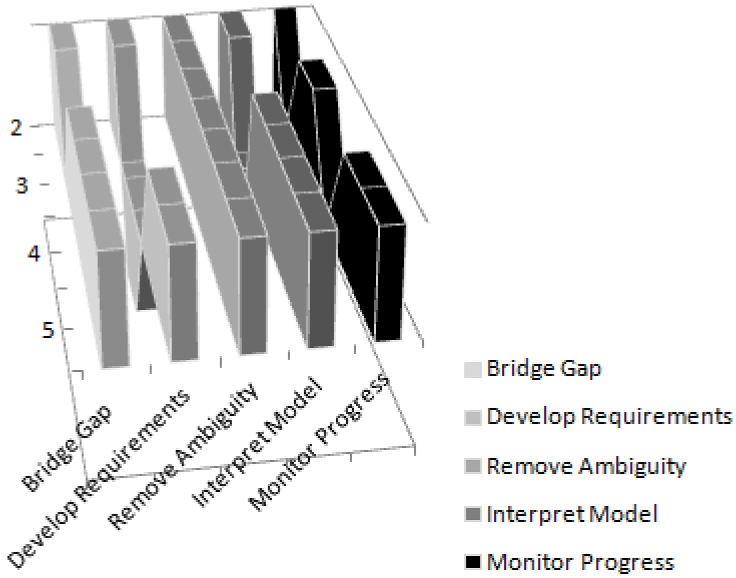

Figure 6 - Metrics by Iteration High Level Results

In table 4, the results for the five metrics are summarized by iteration for both the Business Analyst (BA) and the Database Developer (DB). Checkmarks are positive feedback and crosses are negative feedback. The checkmark with the cross indicates mixed feedback. The metrics are ranked by positive perceptions. The Database Developer benefited more from the tool than the Business Analyst. However, the Business Analyst and the Database developer both found the process and tool to benefit the most with Removing Ambiguity. The first iteration is not in the results because the study did not make it to the post interview. The following section will discuss the results for the metrics.

Metrics	2nd Iteration		3rd Iteration		4th Iteration		5th Iteration		Rank (positive perception)		
	BA	DB	BA	DB	BA	DB	BA	DB	BA	DB	Both
Bridge Gap	✓	✓	✓X	✓	✓	✓	✓	✓	2	1	2
Develop Requirements	✓	✓	X	X	✓	✓	✓	✓	3	2	4
Remove Ambiguity	✓	✓	✓	✓	✓	✓	✓	✓	1	1	1
Interpret Model	✓	✓	X	✓	✓	✓	✓	✓	2	1	2
Monitor Progress	✓	✓X	✓	✓	✓X	✓	✓	✓	2	2	3

Table 4 - Summary of Iterations

CHAPTER 7

DISCUSSION AND CONCLUSIONS

In this chapter, a summary of findings and research contributions are discussed along with the potential practical impact of this research. The limitations of the study and recommendations for future research conclude the chapter.

Summary of Findings and Research Contributions

This dissertation started because of a need to bridge the gap between IT and Business’s mental models that are used for developing Business Intelligence models. There is a need to expedite the modeling process and create better quality models early in the design phase, in order to prevent scope creep later in the development phase, and rework after the models have been deployed. Interdisciplinary Communication Medium and Data/Frame theory were utilized, because they have been utilized in other design disciplines where prototypes helped to communicate requirements to other non-technical disciplines. It helped to visualize the models that were being designed to all parties that had a stake in the project. Computer-aided design (CAD) and drafting software are readily available and can help to speed-up design communication and make the requests of the model clearer. Other collaboration software tools can be configured to utilize the process described in this dissertation also. By applying these theories to the IT and Business discipline in this research, it was found it did help to speed-up the design process by limiting scope creep, developing the requirements up front, and reducing rework by clearly communicating the requirements in a language with which the discipline is familiar. The five metrics that were measured helped to validate this. The results of the five metrics show that the tool can help to accomplish the goals defined in this dissertation.

The contributions of this research added to the Information Systems field in two ways. First, the design of the collaboration tool for the BI development process with theoretical foundation in both Interdisciplinary Communication Medium theory and Data/Frame Theory were used as a template for the development of a more user friendly and effective Business Intelligence development platform. The design also added to the knowledge base of next generation data engineering processes that involve closer interaction with end users. Second, a user observational study of the collaboration-based tool helped to advance our understanding of how mental models, and views, of data can be communicated more effectively between Database Developers and Business Analysts. It looked at how ambiguity can be removed from the communication of data models requests made by Business Analysts.

Potential Practical Impact of This Research

In conclusion, researchers need to work more closely with vendors so their research is aligned with what is relevant to the industry and the discipline. This will be needed to overcome the disconnect between research and industry as Arnott(2008) pointed out. In addition, aligning Decision Support Systems (DSS) with the industry would also help to solve most of the pressing issues. This problem is not limited to just DSS, but to all of the IS discipline. Researchers need funding, and industries can use researchers to validate theories and discover new opportunities.

This dissertation research presented a discussion of a process to help to create more accurate data models that are delivered more quickly because less rework would be required. Other disciplines that can use prototypes to collaborate during the design phase could benefit from this model. Prototypes can be an integral part of a proposal (Vaishnavi, 2004).

This research has relevance for practitioners. Some believe there is a disconnect between DSS researchers and IT Professionals (Arnott, 2008). This dissertation helps to bridge the gap between research and industry and improves relevance and rigor within the IS discipline. Research and the industry need to work more closely together. Researchers and industry need to seek out each other for synergy. This theory can be applied to any design discipline from landscaping to aerospace design.

Limitations

A limitation of the study was the business scenarios used in the study were small, compared to some large organizations that may take weeks to develop requirements and a design. The small business scenarios were used to expose the participants to the new process, so they could compare it to the traditional process they have used in the past. Another limitation was that the change requests were small. They only had a few requirements that had to be fulfilled. The final limitation was that there were only five iterations. More iterations may have produced a more reliable and effective system.

Recommendations for Future Research

Future research in this area can include other areas of IS, such as network engineering, information assurance, application development. In addition, including multiple disciplines could yield some fruitful results. The ICM framework can be used to improve communication between other technical and nontechnical disciplines, and the hope is that it can be used in practice to promote both the Information System discipline and other design disciplines.

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APPENDICES

APPENDIX A: INTERVIEW PROTOCOL

Interview Protocol

Thank you for your willingness to participate in this research project. Before we begin the Interview, I would like to reassure you that this interview will be confidential and the tape in addition, transcripts available only to me. Do you mind if I record the interview? ______*<if yes> If there is anything you don't want recorded; just let me know and I will end the session.*

Excerpts of this interview may be made part of the final research report, but under no circumstances will your name or identifying characteristics be included in this report. Is it all right for me to turn on the recorder now?

How many years of experience do you have working with Business Intelligence ___

What process have you used in the past to communicate BI requirements?

Face-to-face, meeting room, work area, email, phone, online meeting, collaboration sharing site (for example SharePoint), or other _______

Theme	*Keywords*
Same location	*face-to-face* *meeting room* *work area*
Remote location	*Email* *Phone* *online meeting room* *collaboration sharing site*

<If they only answer, same location themes> ask if they ever worked with someone remotely while developing BI reports/models. <If they answer yes> ask them to use that frame of reference to answer the following questions.

Question 1

Compared to your prior experiences with similar tasks, like the tasks in the user study, how would you compare this process and tool with respect to collaborating with your teammate?

How did you collaborate with your teammate?
Were theses features helpful?

Theme:	*Keywords to look for:*
Bridge Gap	*cooperate* *work together* *team up* *share* *pool resources* *teamwork* *collaborating* *communication* *back and forth*

On a scale from 1 to 5 with Poor = 1 Fair = 2 Average = 3 Good = 4 Excellent = 5 how would you rate your understanding of the DB developer's perspective using this process?

Question 2

Compared to your prior experiences with similar tasks, like the tasks in the user study, how would you compare this process/tool with respect to developing the requirements?

How did you go about developing your part of the project?

Theme:	*Keywords to look for:*
Develop Requirements	*expand* *build* *communicate* *share* *progress* *advance* *improve* *interactive*

On a scale from 1 to 5 with Poor = 1 Fair = 2 Average = 3 Good = 4 Excellent = 5 how would you rate this process/tool with respect to developing and communicating requirements?

Question 3

Compared to your prior experiences with similar tasks, how would you compare this process/tool with respect to clarifying different interpretations of the requirements with your teammate?

Did you experience any misinterpreted requirements when working with your teammate? <if yes> can you share that example?

Theme:	*Keywords to look for:*
Remove Ambiguity	*make clear* *clarify* *clear* *interpret* *understand* *infer* *translate* *explain*

Question 4

Compared to your prior experiences with similar tasks, how would you compare this process/tool with respect to understanding your teammate's perspective during the user study?

Can you describe the steps you took to validate that the Application Template Layout (Intermediate View) met the requirements of the End User Application Template Definition and the Star Schema?

Theme:	*Keywords to look for:*
Interpret Model	*understand* *translate* *decipher* *figure out* *explain* *back and forth*

On a scale from 1 to 5 with Poor = 1 Fair = 2 Average = 3 Good = 4 Excellent = 5 how would you rate your understanding your teammate's perspective during the user study?

Question 5

Compared to your prior experiences with similar tasks, how would you compare this process/tool with respect to monitoring progress of model design?

Were you able to start their part sooner, or start to visualize their model earlier, since your were able to see the requirements being developed?

Theme:	*Keywords to look for:*
Monitor Progress	*watch* *check* *observe*

	keep eye on *following through* *see* *monitoring*

On a scale from 1 to 5 with Poor = 1 Fair = 2 Average = 3 Good = 4 Excellent = 5 how would you rate the process/tool with helping you to monitor design progress?

Are there any comments you would like to make about the process?

Comments:	

Mapping artifact components

Features	*Tags*
Asynchronous Communication *Note/Comment*	*Post it* *Textbox* *Square* *Boxes*
Synchronous Communication *Chat/ Elluminate*	*conversed* *conservation* *chat* *talked*
Intermediate View	*Intermediate View* *Shared view*
Business View	*Business View* *Business Users View*
DB View	*Database View* *DB View* *DB Developers View* *Data View*

APPENDIX B: USER STUDY DIRECTIONS PROTOCOL

Business Analyst Directions

Thank you for taking the time out of your busy schedule to participate in this study. You participation in this study very much appreciated.

You will be using an online collaboration tool (www.cacoo.com) to work as a team. Please log on to the site, create an account prior to participation in the study and test the connection and functionality of the tool. Each team will have two participants, one with a business background and one with a database background. The tool has been configured to have three work areas: Intermediate View, Business View, and Data View. The Intermediate view will be shared with the business user and the database developer for creating report layouts. The Business view will be used by the business user to define the business questions and requirements. The data view will be used by the database developer to modify the database model.

For Business User:

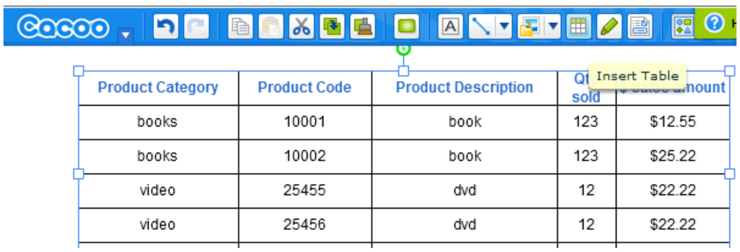
1. End User Application Template Definition (Requirements)

As the business user, you will need to prepare Business Requirement Documents (BRD) in the Business View for the given scenario. Start by reviewing the scenario and make a list of the reporting requirements that you think will be needed. These requirements will be used by the DB Developer to modify a star schema and reports. Notify the DB Developer when the BRD is ready for review.

	Business Requirements Document
Report Title	2013 Sales Summary by Product
Description	Annual product sales report summary
Columns	Product Category, Product Code, Product Description, Qty sold and $ sales amount
Calculation	Qty Sold * Price = $ sales amount
Grouping	Product Category and Product Code
Sort	Product Category, Product Code ascending

2. Report Layouts

Collaborate with the DB Developer to create Report Layouts in the Intermediate View and make sure they meet the requirements of the Business View. The DB Developer will make sure that the data model matches the requirements.



Product Category	Product Code	Product Description	Qt[illegible] sold	[illegible]mount
books	10001	book	123	$12.55
books	10002	book	123	$25.22
video	25455	dvd	12	$22.22
video	25456	dvd	12	$22.22

Use the Chat window to communicate or post Notes on items to ask questions or to clarify requirements for the reports. When you believe the Application Template Layouts are complete, notify the moderator MATomasura@dsu.edu. You will be notified if any of the requirements are missed.

DB Developer Directions

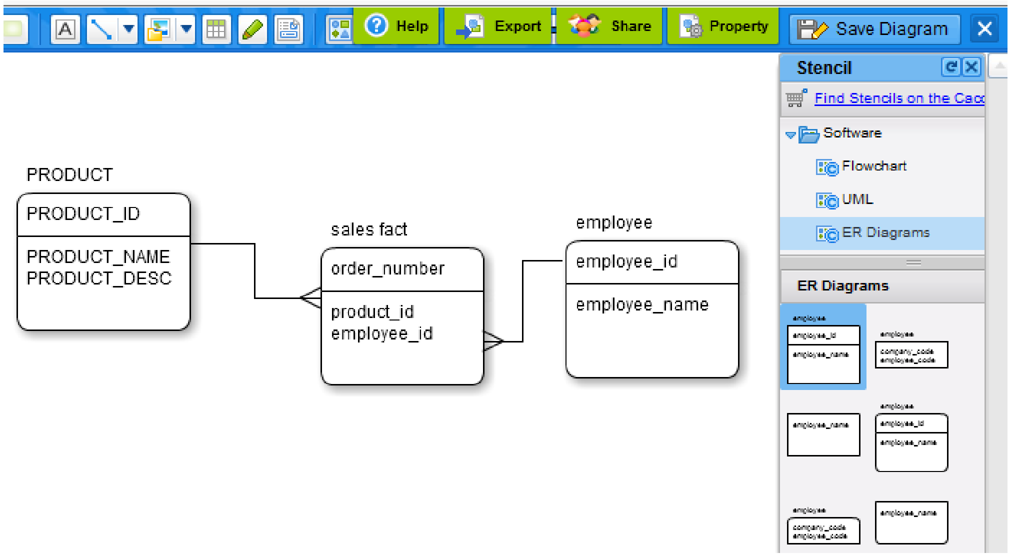
Thank you for taking the time out of your busy schedule to participate in this study. You participation in this study very much appreciated.

You will be using an online collaboration tool (www.cacoo.com) to work as a team. Please log on to the site, create an account prior to participation in the study and test the connection and functionality of the tool. Each team will have two participants, one with a business background and one with a database background. The tool has been configured to have three work areas: Business View, Intermediate View, and Data View. The Intermediate view will be shared with the business user and the database developer in order to create report layouts. The Business view will be used by the business user to define the business questions and requirements. The data view will be used by the database developer to create the database model.

For DB Developer:

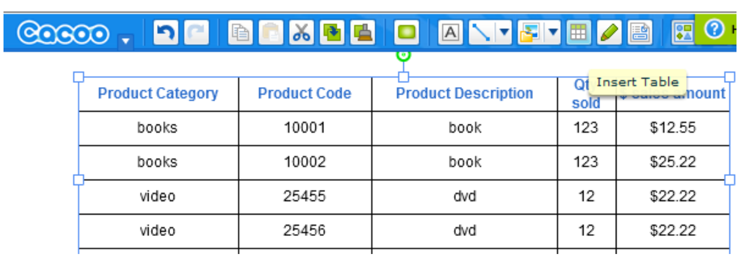
1. Modify Star Schema

Based on the business requirements given in the Business View modify a star schema design in the Data View tab of the tool. The Business User will notify you when the requirements are ready for review. You can monitor the progress of the BRD being developed on the Business tab. Also, the business view can be anointed by the DB Developer asking for clarification. You can start work on the Star Schema when you think you have enough information to get started or when the business user notifies you that the BRD is complete. Use the Entity Relationship shapes to edit the Star Schema in the Data View.



2. Report Layouts

Based on the business requirements given in the Business View and the Star Schema create Report Layouts, in the Intermediate View of the reports that are requested by the business user.



Collaborate with the Business User to make sure the Report Layouts in the Intermediate View meet the requirements of the Business View and the Star Scheme in the Data View. Use the Chat window to communicate or post Notes on items to ask questions.

When you believe the Report Layouts are complete, have the Business User notify the moderator MATomasura@dsu.edu. You will be notified if any of the requirements were missed.

APPENDIX C: USER STUDY SCENARIOS

Sporting goods scenario #1 (estimated time 2 hour)

A regional sporting store chain recently won a contract to be a supplier for a local little league baseball association. The little league association has a tax-exempt status that needs to be added to the reporting system. The owner of the sporting store would like to bid on other contracts for local sporting teams. The accounting firm, which works with the store, can handle the new requirement for preparing the tax forms but will require the customer's tax-exempt information and the sales information summarized at year-end. Please work with the DB developer to create this report for the accounting firm.

Sporting goods scenario #2 (estimated time 2 hour)

A regional sporting store chain is looking to expand its market into Canada. The accounting firm, which works with the store, can handle the new requirement but will require monthly sales reports to have the currency information at the time of the sale, and the consolidated sales amount. Please work with the DB developer to create this report for the accounting firm.

Sporting goods scenario #3 (estimated time 2.5 hour)

A regional sporting store chain is looking to perform analysis on seasonal sales. The marketing team has seen new trends for tennis, soccer and baseball sales outside of their normal season. They believe that new indoor sport complexes are driving the sales. The marketing team is looking for a way to trend these new sales patterns and discover if any other sports are seeing an increase of sales outside of their normal season. Please create a report for the marketing team so they can track seasonal sales.