Transactive Memory Systems in Undergraduate Information Systems Student Project Groups

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ABSTRACT

Today, group collaboration is becoming more and more vital in the workplace. Hence, undergraduate curriculums must be updated to include group project courses that help to prepare students for their post-graduation work. This research focuses on how the theoretical foundation of transactive memory systems (TMS), or the collective awareness of the group's specialization, coordination, and credibility, influences a group's overall performance. These influences were analyzed through the use of focus groups, a TMS survey, and follow-up interviews with student groups in an undergraduate Information Systems project course (67-373) at Carnegie Mellon University. It was found that although determining the strength of a student group's TMS provides a small window into how that group is working together, TMS does not provide the whole picture of group collaboration. In order to be successful as a group, students must recognize the importance of the group formation process and understand that a group is a living organism that needs constant management over time. Therefore, if student groups focus on developing a structure that fits their initial needs and continually update this structure based on changes that occur over time, they will be more prepared to effectively collaborate on their project.

INTRODUCTION

Not long ago, information systems (IS)[1] work was restricted to a small group of people within the technology department of large companies. Now, with the rapidly changing technological environment that we live in, technology and computing are not only large parts of our everyday lives but also greatly affect how organizations do business. Information systems has moved from a strictly supporting role (e.g., IBM servers administered by two people, or Technical Support at a company) to a function that is interwoven within every aspect of an organization's business – from its business models and strategies to its communication and project management. Not only has technological advancement impacted business across many levels, it has also allowed organizations to take on larger and more complex projects. This general shift toward large-scale projects has changed how organizations approach and implement such initiatives. Consequently researchers argue that small teams of IS professionals can no longer complete projects alone; projects now require the collaboration of diverse teams that include IS professionals as well as professionals with backgrounds in other disciplines (e.g. Castells 1996; Lee, Trauth & Farwell 1995; Noll & Wilkins 2002).

Information Systems is an interdisciplinary field that crosses a broad range of academic areas and professional industries. It encompasses information technology, business, communications, economics, and global systems, and can be applied to industries such as consulting, finance, manufacturing, and software development (just to name a few). Because the field of information systems crosses so many academic and professional boundaries, developing a comprehensive curriculum for undergraduate courses can be a daunting task. In order to be successful beyond graduation, IS students need to develop a broad range of skills during their undergraduate studies that span the technology, business, and organization disciplines (Noll & Wilkins 2002). More specifically, students must not only have the ability to apply technical concepts to novel problems, but they also must be able to communicate effectively and work collaboratively in groups (Lunt et al 2008).

[1]While in some quarters a distinction is made between IT and IS, for purposes of this paper the term 'IT' is used to include the information systems profession and its workforce.

Hence, in order to meet the needs of companies and prepare students for graduation, university classrooms are beginning to include group collaboration in IS curriculums (e.g., Johnson, Johnson & Smith 1998; Joseph & Payne 2003; Mercier, Goldman & Booker 2006).

Group collaboration allows students to take on more complex, real-world tasks during a course while learning to collaborate with others (Bransford, Brown & Cocking 1999; Mercier, Goldman & Booker 2006). These group interactions help students learn interpersonal communication, task responsibility, and teamwork skills that are vital to their post-graduation work (Tan & Jones 2008). Given that no two people are alike, groups are typically comprised of people with diverse knowledge and viewpoints. Each individual brings a different demographic and functional background, as well as different past experiences and knowledge, to the group. In order to be successful, a group must find a way to pull out and build on the unique experiences and knowledge of each group member during the course of their project.

Most research on group collaboration and group performance focuses on general characteristics of successful groups, such as open communication, group cohesiveness, trust, goals, etc. (e.g., Crown & Rosse 1995; Huang & Huang 2007; Mercier, Goldman, Booker 2006). Although each of these characteristics is important for ensuring group collaboration, they are all impacted by and tie into the idea that a group must first understand its distributed knowledge in order to tackle a complex project. Since groups are typically comprised of people with varying backgrounds and past experiences, it is important for group members to be able to recognize each other's expertise so that the entire group can benefit from its wide range of knowledge. Communication, trust and cohesiveness are just some characteristics that contribute to a group's ability to identify and use its distributed knowledge.

Therefore, the purpose of this study is to examine the effects of the collective awareness of a group's specialization, coordination, and credibility, or transactive memory system (TMS) development, on a group performance. Specifically, this study examines how TMS are developed and maintained in undergraduate Information Systems student project groups at Carnegie Mellon University. This investigation contributes to a stronger understanding of the role of TMS in student project groups and helps to identify key processes that groups can follow when working together to ensure high-quality performance. This paper is organized into four main sections: first, a review of transactive memory systems literature that provides an overview of the theory and its influence on group performance; second, a description of the methodology used to examine the undergraduate IS student project groups; third, an analysis of the results collected during this study; and finally, a discussion of the conclusions drawn and their impact on how undergraduate student groups should or should not work together.

TRANSACTIVE MEMORY SYSTEMS

The group knowledge that emerges from the combination of each group member's individual knowledge is referred to as a transactive memory system (TMS). More specifically, a transactive memory system is "a collective memory system for encoding, storing, retrieving and communicating group knowledge" (Lewis, Lange, & Gillis 2005, 581). It is a "combination of the knowledge possessed by each individual group member and a collective awareness of who knows what" within the group (Huang & Huang 2007, 2125; Wegner 1986). A group's TMS goes beyond simply storing explicit information (i.e., documentation or electronic repositories) and facilitates the use and dissemination of tacit information. The dissemination of this tacit information brought on by a group's TMS is what links TMS with knowledge management or the "process of capturing, storing, sharing and using knowledge" (Huang & Huang 2007, 2124; Davenport & Prusak 1998). The ability for a group to identify and recognize a member's knowledge of a particular skill or topic (i.e., an element of TMS) will subsequently allow the group to effectively share distributed knowledge – a process that is thought to be most essential for knowledge management in groups (Bock & Kim 2002; Huang & Huang 2007).

Additionally, research has shown that certain group behaviors (i.e., memory differentiation, task coordination, task credibility) are associated with the operation of group transactive memory systems (Jackson & Moreland 2009, 510). Jackson and Moreland (2009) elaborate that memory differentiation within a group refers to the inclination of different group members to concentrate on remembering different aspects of a task. Task coordination refers to how well group members work together. Task credibility refers to the levels of trust among group members regarding each person's knowledge. Therefore, the combination of memory differentiation, task coordination and task credibility lead to a strong, well-developed TMS within a group.

Initial TMS Structure

The initial TMS structure within groups is made up of location information and lower-order information. In the early stages of a group project, members begin to learn about each other's specialty knowledge and areas of expertise. Thus, groups build location information that allows members to associate individuals with specific knowledge. For example, in a group tasked with managing a software product, members might come to associate Joanne with information about software and design. In this case, Joanne would be known within the group as the location for software engineering information (Lewis et al 2005, 583). In addition to this location information, groups store lower-order information, or specific facts and details that each member possesses about a particular topic, within their initial TMS structure (Lewis et al 2005; Wegner et al 1985). Using the previous example, lower-order information within this group's TMS structure might be details about recently implemented functionality and bug fixes – possessed by Joanne (Lewis et al 2005, 583). The combination of location information and lower-order information provides groups with a base understanding of each member's knowledge to work from during the course of a project. From this, group members can come to rely on others to be responsible for particular areas of knowledge and therefore focus their attention and learning on his or her specialty area (Hollingshead 1998; Lewis et al 2005; Wegner et al 1991).

The second component of a group's initial TMS structure is the transactive processes, or the processes by which the group encodes, stores and retrieves knowledge relevant to the group's task (Lewis et al 2005, 583). These transactive processes are established through group communication and what Wegner et al (1985) refers to as integration of members' knowledge. Continuous communication allows members to form an understanding of who knows what within the group – building on the accuracy of the group's location information. Through repeated interactions, group knowledge integration begins to link member's knowledge together and creates new knowledge that members did not previously possess (Lewis et al 2005, 584). The newly linked and created information within the group is known as higher-order information. Moreover, an initial TMS structure allows group members to learn who possesses what expertise, develop new member-level knowledge in the form of specialized expertise and develop new collective knowledge in the form of higher-order information.

Learning by Doing

Although much of TMS research has focused on the structure and theory of transactive memory systems, one area that has not been explicitly defined are the steps a group must take to create an initial TMS structure. That being said, after an initial TMS structure is in place, groups can continue to build their knowledge by simply progressing through their project. Learning by doing affects both parts of the initial TMS structure – the location/lower-order information and the transactive processes. Simply performing a group task can affect group information in three ways – identifying new knowledge, linking individual's knowledge in new ways and building on previously established individual knowledge.

By working through a task, groups recognize how each member works both individually and within the group. Through this, groups may find that one member has knowledge that was not evident before and will therefore need to revise their location information. For example, a software development group may develop an initial understanding that Bill is the location of programming information and Sam is the location of interface design information. After working together and participating in group discussions, the group might come to find that Sam also has some programming knowledge from a previous project that applies to their current project. Because of this newly identified knowledge, the group will have to update Sam's location information.

As a group works together they may discover that members' lower-order information link in new ways and create new shared information within the group. For example, as Sam and Bill work through the initial stages of their development project, they can begin to link various aspects of their past software development experiences to create new shared information that specifically pertains to their current project. Also, while working together, groups engage in discussions and exchange knowledge that helps members elaborate on their own individual knowledge. This is in essence the combination of the previous two forms that learning by doing occurs within a group. By understanding who knows what and working through tasks as a group, group members begin to add new links to their current knowledge and identify areas in the project where they can specialize or focus their learning.

Group work can help with transactive processes in that performing a task helps set patterns for future interactions in the group (Gersick & Hackman 1990; Hackman & Morris 1975; Lewis et al 2005). Groups get a better understanding of how tasks are performed and any uncertainty that the group may have at the start of the project is reduced (Gersick & Hackman 1990; Lewis et al, 2005). For example, as a group works together during the early weeks of a project, the members begin to learn the processes used for group meetings, member roles, task divisions, communication, etc. As these patterns and understandings form, the group can more easily focus on their individual tasks rather than the group's processes and therefore avoid unnecessary effort. Thus, learning by doing can help the group perform more effectively and efficiently because it refines location information, further develops individual knowledge and establishes patterns for communication and information retrieval (Lewis et al 2005).

Influences on Group Performance

Past research has shown that a well-developed TMS can also improve group functioning and performance. Group performance demonstrates the ability of a group with a well-functioning TMS to store and recall more knowledge than any individual group member, and to use the knowledge of others better (Jackson & Klobas, 2008; Hollingshead & Brandon, 2003; Moreland et al, 1998; Stasser et al, 1995). Groups benefit from TMS through enhanced communication and coordination as a result of the group's awareness of the collective knowledge that is available and where it resides within the group (Mathieu et al 2008; Wegner 1986). A strong TMS improves group performance by giving members quick and coordinated access to one another's specialized expertise. Thus, this ensures that a greater amount of task relevant knowledge is brought to bear on group tasks (Lewis 2004). Additionally, a group with a strong TMS will be able to match problems with the group member that is most likely to resolve the issue because he or she is more familiar with each member's area of expertise (Jackson & Klobas 2008; Moreland & Levine 1992). By knowing more about each other, a group is also more likely to be able to assign appropriate roles and tasks to members throughout the project and overall, coordinate more efficiently (Cruz et al 2007; Jackson & Klobas 2008; Wittenbaum et al 1998). Thus, transactive memory systems help groups spread their relevant knowledge among group members and use that collective knowledge to coordinate on tasks within their project.

Since research has shown that transactive memory systems provide group members with the knowledge of who knows what within the group, it is evident that without a strong TMS, groups will experience difficulty understanding each member's knowledge and building new shared knowledge. Groups without a TMS lack a shared understanding of who is responsible for what and thus, may allow multiple members to encode new information at the same time. This process may cause unneeded redundancy within the group (Lewis et al 2005, 587). In addition to this encoding redundancy, groups without a TMS may have to take more time to determine which members have a particular skill during task assignment.

Given that TMS structures have been linked with group knowledge management, a group with an insufficient TMS may have a difficult time sharing their distributed knowledge effectively (Huang & Huang 2007). Sharing individual knowledge helps groups create a common understanding of the various problems in a project or task and coordinate individual activities. Additionally, a substantial amount of TMS research has shown that a well-developed TMS allows each individual group member to hold less knowledge while the group as a whole holds more knowledge (e.g., Brandon & Hollingshead 2004; Jackson & Moreland 2009;

Wegner 1986; Wegner 1987). This occurs because group members know who knows what and therefore, can focus on the specific area of knowledge for which they are most responsible. When groups lack this shared understanding, individual group members may be forced to acquire more knowledge then is actually necessary. Ignoring the importance of a TMS structure inhibits the group's overall coordination during a project. In general, having an insufficient TMS structure within a group can make a group less efficient at retrieving information and communicating about task elements (Lewis et al 2005).

Contextual Considerations of TMS Studies

Over the past twenty years, TMS research has been mainly conducted in laboratory settings (e.g., Jackson & Moreland 2009; Lewis et al 2005; Lewis et al 2007; Liang, Moreland, & Argote 1995). For instance, Liang, Moreland and Argote (1995) compared the task performance of groups whose members were trained individually with that of groups whose members were trained together. Their study found that groups that were trained together made fewer task-related errors and recalled more about the task. Overall, there was stronger evidence of TMS in groups whose members were trained together than those who were trained individually. The group training created a stronger TMS in the groups and, therefore, led to better task performance because the groups that were trained together had greater memory differentiation, task coordination and task credibility.

Additionally, Lewis et al (2005) proposed a learning framework for groups and tested it using an empirical study where three-person groups performed electronic assembly tasks over the course of three sessions. The learning framework included three learning cycles – initial TMS structure, learning by doing, and generalizing to the task domain. Lewis et al (2005) found that having a well-developed TMS not only affects the group's performance on the task for which the TMS was first developed but also affects the development of abstract knowledge about the task domain. This abstract knowledge helps groups perform better on tasks in similar task domains. For example, if a group develops a TMS for the first phase of their project, this TMS will continue to help them during future phases. The TMS allows members to maintain their specializations across different task contexts because it provides the group with information about who knows what within the group.

Although there has been much focus on the study of TMS in laboratory settings, there have also been a handful of studies done using real groups outside of the lab (e.g., Akgun et al 2006, Austin 2003, Faraj & Sproull 2000, Garner 2006, Huang & Huang 2007, Lewis 2004, Yoo & Kanawattanachai 2001). For instance, Austin (2003) investigated the relationship between transactive memory and performance in groups whose members worked together for several years in a sporting goods and apparel company. After testing the group's knowledge stock, knowledge specialization, transactive memory consensus and transactive memory accuracy, Austin found that there was a positive relationship between the strength of the group's TMS and their performance (Austin 2003).

Akgun et al (2006) also studied the effects of a TMS on new product development teams among Masters of Business Administration students. The authors found a positive association with the team's TMS and team learning, speed-to-market, and collective mind (or the members' attention to interrelating actions). The TMS allowed team members to make effective and quick decisions throughout the product development process because they had substantial knowledge of each other's expertise and skills. It enhanced the team's ability to find and correct the product-related problems, facilitated the incorporation of lessons learned during the project to the product development process, and helped to launch the product faster than originally planned and the industry standard (Akgun et al 2006, 104).

Huang and Huang (2007) studied the effects of transactive memory systems, network ties, team-based outcome expectations and trust in their examination of technical Research and Development (R&D) teams. Huang and Huang (2007) explained that network ties refer to the strength of the relationships, the amount of time spent and the communication frequency among team members; team-based outcome expectations refer to community-related outcome expectations (an individual's expectations about the impact of his or her knowledge sharing on community) and team-based outcome expectations (a knowledge contributor's judgment of likely consequences that his or her knowledge will produce for the team); and trust refers to the willingness of team members to engage in cooperative exchange and interaction (2125). Huang & Huang's findings show that an R&D team's TMS can facilitate knowledge sharing between team members. They also found that the TMS mediates the relationship between trust, network ties and knowledge sharing. Since TMS provided a link between the trust and relationships of team members and the knowledge that they shared, Huang & Huang concluded that the development of a TMS is important for technical R&D teams because it provides the cooperative division of labor for learning, remembering and communicating relevant team knowledge (2127).

Overall, past TMS research – whether it was in a laboratory, classroom or professional setting – has found that a well-developed TMS fosters a knowledge network within the group for knowing who knows what (Akgun et al 2006, 98). This knowledge network provides the group with the ability to share and combine their individual knowledge to better work through their project or problem. By knowing who knows what, the group members can coordinate activities and assign tasks more efficiently. Additionally, groups with a TMS can create new knowledge by combining the individual member's knowledge and past experiences to complete tasks. *Therefore, the development of a TMS is a crucial step in a group's project because it enables them to work together effectively.*

Much of the TMS research outside of the laboratory has focused on groups in organizations (e.g., R&D teams, New Product Development teams, IT-Sector project teams) and, to a lesser extent, student groups (e.g., MBA student groups). An interesting aspect of these studies is that the groups involved have typically worked on complex, non-routine projects and included diverse, multifunctional group members. As discussed previously, Information Systems is a diverse, interdisciplinary field that spans across a number of different academic areas and professional industries. Information Systems projects tend to focus on solving complex problems and, in general, bringing together people from multiple disciplines to successfully complete the projects. This natural complexity and diversity makes the group members' awareness of each other's knowledge even more important in Information Systems groups.

Since previous research has mainly studied groups in laboratory settings as well as technical groups in business settings, there is a need for additional investigation into the effects of TMS on other types of groups, specifically student groups. Hence, this study draws on the findings of TMS research among professional groups and explores those themes among undergraduate Information Systems project groups. In doing so, the following research questions are investigated:

1. How does the use of transactive memory systems in undergraduate Information Systems student groups influence group performance?

2. What factors influence the strength of a transactive memory system in student groups?

3. What steps can a student group take to ensure an initial TMS structure is in place?

METHODOLOGY

Expanding on past TMS research, this study examines how transactive memory systems are developed and maintained in undergraduate Information Systems student project groups.[2] It looks to extend on TMS research by identifying steps that student groups can take to ensure that a TMS structure is in place and used throughout the project. Additionally, this study focuses on the effects of transactive memory system development on overall group performance.[3] The course description, participants, research procedures, materials, and measures are described in the following sections.

Course Description

The Software Development Project course (67-373) is a junior-level project course in the Information Systems program at Carnegie Mellon University. In

[2] Much of the research on TMS, collaboration and group productivity has used the terms 'group' and 'team' interchangeably. Therefore, for the purpose of this paper, 'group' and 'team' will continue to be used interchangeably.

[3] For the purposes of this study, group performance is determined based on the final evaluation given by the group's Information Systems faculty advisor.

this course, students are broken into small project groups and tasked to analyze, design and build an information system of their choice. The Information Systems faculty members determine the project groups prior to the start of the course. Each project group is then assigned an IS faculty member to act as an advisor during the semester. Generally, project groups meet with their faculty advisor on a weekly basis for group meetings, evaluations, status updates, troubleshooting, and to turn in deliverables.

At the start of the course, each project group must determine formal roles for each of its members. These roles are determined by each project group and often vary from group to group. Generally, each project group has, at the very least, a Project Manager and a Quality Assurance Manager. Then, each project group comes up with two ideas for an information system to pitch to their faculty advisor, and once approved, begin developing the system. To help keep students on track during the semester, project groups are required to turn in five written phase reports to document their progress. Phase reports differ based on the group, its project, and the faculty advisor. Typically, all groups follow the five-phase report schedule discussed in the syllabus but occasionally groups use different development methodologies for their projects. The phase reports are reviewed by the group's faculty advisor and help advisors identify project-related problems as quickly as possible. The students' final grades are determined based on the quality of their phase reports, the final group presentation, group peer evaluations, and the faculty advisor's notes from throughout the semester.

The course is designed such that students learn how to apply the five phases of the system development life cycle, while also refining their technical skills and building teamwork skills.

Research Procedures

In order to determine the role of TMS in the student project groups, three sequential data collection phases were employed that consisted of the following methods: focus groups, a TMS-specific survey, and follow-up interviews. This triangulation of data collection stems from a combination of the initial TMS research and the general structure of the junior-level IS project course (67-373). The initial TMS research analyzed for this thesis identified the previously researched influences of TMS on group performance in different types of groups. It identified a number of positive influences that strong TMS can have on group performance. The main focus of this research is to further explore these influences in the context of IS student project groups. Additionally, because this course provides students with great experiences to apply outside of Information Systems, this research is also focused on identifying steps that student groups can take to perform better as a group. All of the data collection phases were conducted using procedures consistent with the standards of qualitative research (Golden-Biddle & Locke 1997; Mason 2002). The relationship between the initial TMS research and the methods of data collection is shown below in Figure 1.

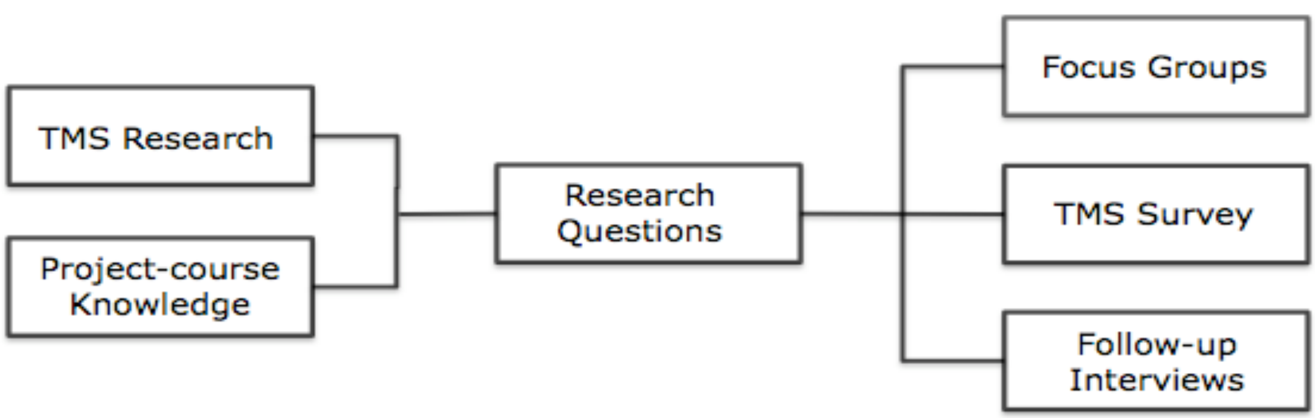

Figure 1. Structure of Data Collection Methods

Phase 1 – Focus Groups

A small subset of student groups were chosen to participate in focus groups that examined the group's knowledge of others, and their general structure. The focus groups consisted of two self-composed groups and three IS faculty-composed groups. The focus group sessions took place during the second and third week of the semester during the group's weekly meeting (without their faculty advisor). The sessions consisted of a short set of questions for the entire group and about an hour's worth of meeting observations. The questions focused on three main areas: knowledge of others, team structure and meeting structure. These areas were selected with the intent to both examine the important aspects of TMS theory and determine the general structure of how the group works together. Since a large part of TMS theory deals with a group's knowledge of others, many questions were created to discover the group's current and prior knowledge of each other's skills. These questions explored the group's previous experience working with each other, and whether or not the group took specific steps to learn about each other at the start of their project. The observation portion of the sessions helped to discover how the students worked together during their meetings. Key points of interest included the specific procedures used during meetings, the type of communication used between group members, and the task assignment process used. See Appendix A for a full list of the focus group questions.

Phase 2 – TMS Survey

In the fifth week of the semester, a web-based questionnaire was sent out to all of the students in the 67-373 to identify the level of TMS sophistication within each group. The goal of the questionnaires was to quantitatively determine what level of understanding each student had about how knows what within their group. These questionnaires used Lewis' (2003) scale items for transactive memory systems (see Appendix B for the full instrument). The results were used to identify groups that either had a TMS in place or lacked a significant TMS structure. This information coupled with the qualitative observations from the early-semester focus groups helped to identify individual groups that qualified for follow-up interviews and observations.

Phase 3 – Follow-up Interviews

The final method of data collection consisted of follow-up interviews and observations with five student groups. These five groups included the same student groups that participated in the Phase 1 focus groups. The follow-up interviews allowed for further investigation into the presence and impact of TMS on the group's performance, and the evaluation of TMS changes throughout the semester. The main focus of the follow-up interviews was to determine any significant changes that had occurred within the group since Phase 1. Any changes that were identified were then analyzed in conjunction with the data collected from Phase 1 and Phase 2 to further understand how the group worked together during their project.

Participants

As previously mentioned, participants were junior undergraduate Carnegie Mellon University Information Systems students enrolled in 67-373, Software Development Project, in the spring of 2010. The course consisted of 61 students broken into groups of four or five by the Information Systems faculty members prior to the start of the semester. In total, there were 13 student groups and 4 faculty advisors. Of the 61 students that participated, 18 were female (30%) and 43 were male (70%). All students were between the ages of 19 and 23. Experience and expertise (both technical and group-related) varied among the students from minimal experience beyond the skills learned in core Information Systems courses to large amounts of external and/or professional experience.

Table 1 depicts the breakdown of students and groups for each data collection phase. Given the objective of Phase 1, five groups consisting of a total of 23 students were chosen to participate in focus groups that looked at each group's initial knowledge of others. Similarly, all 13 groups (totaling 61 students) in the class were chosen to voluntarily complete Lewis' TMS survey. Finally, the groups that participated in Phase 1 (5 groups with 23 students) were identified to also participate in the last data collection phase for follow-up interviews. For a more detailed breakdown of the students and their groups, see Appendix C.

Table 1. Participant Breakdown for Data Collection

	Phase 1	Phase 2	Phase 3	Total
Students	23	61	23	61
Groups	5	13	5	13

FINDINGS

Overview

The following section is organized based on the three phases of data collection that were conducted for this research. Each of these data collection phases investigated different aspects of TMS and the student group process used for these projects. Phase 1 consisted of group observations and interviews (for Groups 1-5) that took place during the early stages of the project. At this time, groups were in the formation process and were developing an initial structure for their meetings and group roles. Phase 2 consisted of the results of Lewis' (2003) TMS survey that was sent to all groups in the class. This survey was sent during the fifth week of the semester to give the students time to develop a TMS and to provide results that could be compared to the qualitative data collected in Phase 1. Finally, Phase 3 consisted of follow-up interviews and observations (of Groups 1-5) that provided information about how the groups changed since the early weeks of the course. Any changes made to the project structure, meeting structure and group roles can often be linked to what a group has learned about each other while working together. Each of these data collection phases is discussed in more detail in the sections below.

Phase 1: Group Formation

The degree to which group members know each other at the start of a project can be influenced by multiple factors, which mainly occur prior to the group's creation. Depending on the amount of time group members have spent together and the environment in which they have interacted with each other, a group's initial knowledge of each other, or initial TMS, can vary a great deal. For undergraduate student project groups, there is a good chance that students have never worked together before in a large-scale project setting. Additionally, students may or may not know each other simply because they have not taken classes together that involve group work.

In the Information Systems Program at Carnegie Mellon University, students typically have general knowledge of the other students in the program because each class is limited to approximately 60 to 70 students. The close-knit culture of the IS program helps groups establish the foundation of their TMS at the start of their 67-373 projects because students have typically heard of their group members and may know them by sight. Although the culture generally helps all of the groups early on, there are still certain groups that are more familiar with each other than others. For the first data collection phase of this study, two types of groups were interviewed and observed – groups with prior knowledge of each other and groups with limited prior knowledge of each other. The observation of these groups allowed for a better understanding of the interconnectedness of group knowledge of others, group structure and meeting structure.

Prior Knowledge of Others

The creation of strong familiarity within a group prior to the start of a project can occur in a number of ways. Specifically, for undergraduate students, working together in groups in previous classes, regardless of the size of the group or the scale of the project, can be a great way to build location and lower-order information with other group members. Similarly, any projects or work completed outside of the classroom can help students learn more about how other group members work in project settings. Additionally, students who have similar majors or minors not only have the advantage of taking more classes together and thus, learning more about how other students work, they also have a strong understanding of other students' specialties and skills prior to starting a project. By simply being in classes together, students have more opportunity to work together on small projects and homework assignments or study for tests. This work setting interaction allows for a better understanding of each other's background, and an increased awareness of what other students have worked on, what skills they have learned, and what they are interested in. In other words, any interactions of this kind prior to the start of a project will help a group begin to build their initial TMS structure.

The two self-composed groups observed in this study consisted of members with the most knowledge of each other at the start of their project. Since these groups were formed by the students rather than the IS faculty advisors, they had the advantage of knowing each other well enough before the project to pick each other for their group. In the case of Group 1, all students were not only Information Systems majors but also Computer Science (CS) double-majors or minors. Because of this, they have had the chance to not only take IS core and elective classes together but also many CS classes together. In addition to having similar general backgrounds, each of these students has also worked together in previous classes on other group projects and assignments. While observing Group 1, it became apparent that they were all very familiar with each other's areas of expertise when it was explained that they each were capable of filling out the rest of the group members' individual skills assessments.[4]

Group 2, the second self-composed group, presented a similar situation to that of Group 1 with a few interesting variations. Although this group was self-composed like Group 1, it did not consist of members with as similar of backgrounds as Group 1. Three of the four group members had worked together on multiple class projects prior to the start of the project. But, although the whole group took a similar set of classes during their first five semesters (because of the IS curriculum's structure), none of them had worked with Sally[5] until this project. It is important to note that despite the lack of experience working with Sally, the other three group members identified and chose Sally to be in their group one semester before the project started. Obviously, these group members knew about Sally's background in design and therefore had already created location information for Sally before the project started. But, unlike Group 1, this group did not have the opportunity to take more classes together outside of IS to build their knowledge of each other. They simply worked with each other before and identified the type of knowledge they needed to successfully complete their project. Therefore, at the start of the project, the group had location information set for project management, design, and programming because of their previous experience working together and their general knowledge of each other's skills (i.e., Sally's design expertise).

Influence on Group Structure

A group's structure encompasses the formal roles that are assigned to group members, how those roles impact group work, and how the group assigns tasks throughout their project. The amount of prior knowledge that a group has can greatly impact how this structure is created and used. For groups without prior knowledge of each other, a great deal of time and energy must be spent building a strong TMS by learning about everyone in the group. This requires various group activities and processes that help to pull out each individual's abilities and make working together a smoother process. Groups with a large amount of prior knowledge, like Group 1 and Group 2, generally skip a lot of the front-end work of creating a group structure that fosters learning because they've already built this within their group.

Again, looking at Group 1 and Group 2, we see some variations in how they structure their group. Most groups in this class create formal roles for each member of their group. These roles typically consist of a Project Manager (PM), Assistant Project Manager (who switches to the PM role halfway through the semester), Quality Assurance Manager (QA), Technical Lead, and Design Lead. Contrary to this, Group 1 did not set up many strict roles at the start of their project. They created the PM and Assistant PM role but nothing else. Instead, all members were categorized into either the front-end or back-end subgroup for programming. Based on this division, group members worked within their respective areas alongside other members in their subgroup. This less formal group structure was possible from the beginning because Group 1 knew each other very well. They did not rely on formal roles to identify each group member's area of expertise because, going into the project, they all already had a strong knowledge of each member's background. Groups without prior knowledge may run into more problems than groups similar to Group 1 if they fail to create a formal role structure within their group.

[4] One requirement of this class is for every group member to fill out an individual skills assessment sheet during the first phase of the project. The assessment includes quantitative rankings that students self identify of their technical and nontechnical skills and experiences. These sheets are compiled by the Project Manager and available for review by the entire group.

[5] Student names have been changed to ensure privacy.

Group 2, conversely, did create formal roles in their group structure. They chose their formal roles (PM, QA Manager, Technical Lead and Design Lead) by a combination of prior knowledge of each other and individual volunteering. Although this group did know a great deal about each other when starting their project, they showed continual learning during the project's first phase. When specific individuals volunteered for positions within the group structure, they were teaching their fellow group members more about what they know, what they have done in the past, and what they are interested in. More interestingly, during the group's first meeting Joe, James and Mike realized that they tend to disagree a great deal while working together in meetings. Once this became apparent, Sally was appointed to the role of Team Moderator to keep the group on track during meetings. Disagreements that focus on the task rather than the person can help groups creatively work through problems. Although Joe, James and Mike's disagreements may eventually help the group, they still needed someone to keep them focused during meetings to ensure that the group stayed on schedule. It's been discussed that Group 2 had a substantial amount of prior knowledge about each other at the start of their project but clearly by working together during group meetings early on, they continued to learn about each other. This shows that even groups with a strong TMS can continue to learn about each other as they begin to work closely together.

Influence on Meeting Structure

A group's knowledge of each other can also greatly influence their meeting structure. In this class, each individual group has the power to create their own meeting schedule and structure their meetings as they wish. Based on the individual group's decision, a group can meet three times per week, five times per week, or just once per week. Generally, most groups meet about three times per week including once with their faculty advisor. The amount of time that groups spend working together can either enhance their learning of each other or be unnecessary to their development as a group.

In terms of meeting structure, Group 1 was basically the complete opposite of all the other groups in this course. Rather than coming together three or four times per week for group meetings, they met once a week as an entire group for fifteen minutes and then had a short meeting with their faculty advisors immediately afterwards. This meeting structure was put into place to compliment the overall project structure that Group 1 chose. For their project, they chose to follow the SCRUM development framework rather than the general software development methodology that most groups follow for this class. The SCRUM development framework includes a series of "sprints" where the group develops a working (i.e., without errors) portion of their final project during a two to four week period. Within this framework, groups typically have short fifteen minute meetings that start exactly on time where each member tells the group what they have done, what they plan to do, and any problems that they've run into. Outside of this SCRUM meeting, Group 1 had no other scheduled meetings during each week. As needed, they met with their programming subgroups (front-end or back-end) during the week to complete their tasks.

The fact that Group 1 used a different development framework than most groups and only met once per week can be explained by a combination of their strong prior knowledge of each other and their strong technical backgrounds. The task divisions for SCRUM development focus on quick stages of development and thus require group members who are technically skilled to take on such development. Additionally, not meeting frequently as an entire group requires that all group members fully understand their responsibilities, and trust each other's skills. After observing this group, the findings were consistent with Jackson and Moreland's (2009) findings that the more face-to-face communication a group had, the stronger its TMS at earlier, rather than later, stages in their project. It may be the case that face-to-face communication is key to TMS building early on in a project but once a group has a substantial TMS in place, it no longer needs to rely on face-to-face communication. Group 1's meeting structure seems to be a strong example of how prior group knowledge may reduce the necessity of multiple group meetings per week.

Limited Prior Knowledge of Others

Starting off a project with limited prior knowledge among group members is not uncommon at the undergraduate level in the IS program. At this time in a student's career he or she is just beginning to build academic relationships with others and often does not have the opportunity to work closely with other students on large projects. Additionally, professors often randomly place students into groups for small assignments or group projects. Although this allows students to work in diverse groups, it does not always allow for relationship building over time, across groups and projects. In terms of 67-373, faculty advisors put most groups together without the input of students. It is actually very rare that the students compose the project groups themselves. Before the start of the semester, faculty advisors work together to intentionally place students in groups without close friends or students they have worked with before. This helps to ensure that groups are evenly created with students who have distributed knowledge across a wide range of areas. The faculty advisors use this strategy because this class is generally seen as a way for students to learn how to work in groups and to prepare for the more challenging senior project course that takes place the following semester. Because of this strategy, students often start 67-373 with limited prior knowledge of the other students in their group.

Of the three faculty-composed groups that were observed for this study, there was large variation in terms of each group's proactive TMS-building activities. Some of these groups recognized that they had little knowledge of each other's backgrounds going into the project whereas others did not seem to actively recognize the importance of this knowledge at the time of the Phase 1 observations. For groups with limited prior knowledge of each other, there are a number of activities that can be done to foster early TMS building. Most importantly, groups need to recognize the importance of knowing who knows what within their group. Any group activity that focuses on learning about other group members' past experiences, knowledge, or interests can help a group build their TMS during the early stages of their project.

An illustrative example of a group with limited prior knowledge of each other that recognized the importance of learning about each other early on was Group 3. This group only had a general knowledge of each other from other IS classes prior to the start of their project. Additionally, one group member recently transferred into the IS program so he and all of the other group members had little knowledge of each other in the beginning. To combat these obstacles, the group actively took a number of measures to learn about each other. First, the group took time during their first meeting to talk about what each member did over their winter break and what each member was interested in. Second, each group member reviewed the individual skills assessments of all group members to learn about who knew what. Finally, each Wednesday they scheduled a weekly group lunch where they generally did not talk about their project. These meetings allowed them to learn about their fellow group members' outside activities. Although these meetings did not specifically focus on who knows what within their group (in the context of their project), they still allowed the group to learn about other activities and interests that group members had which can influence their behavior on the project.

Not all of the focus groups were as proactive with learning about each other as Group 3. For example, Group 5 was also a faculty-composed group that had limited prior knowledge of each other but did not recognize the importance of learning about its members' skills and backgrounds during the first few weeks of the project. The members of Group 5 generally knew each other from previous IS classes but, outside of that, none had worked closely together prior to this project. At their first meeting, Group 5 discussed their interests in order to assign formal roles to each group member. During this process, group members volunteered for certain positions and thus expressed what they were interested in as well as what they had worked on in the past. Although this process helped the group to learn about its members to a certain extent, it was more focused on selecting formal roles rather than on learning about each other.

When asked what Group 5 did to learn about each other's skills and knowledge, Ben responded that they had completed and compiled their individual skills assessments. Contrary to this, Amy (PM of Group 3) explained how they team initially formed an understanding of one another.

> *"Once we realized how little we knew about each other, we decided it would be best to look over each other's skills assessments to learn more about everyone's backgrounds"* [Amy].

Again, this shows the fundamental difference between Group 3 and Group 5. Group 3 quickly acknowledged that they had little prior knowledge of each other and took a number of steps to improve upon that early in their project. Group 5, on the other hand, failed to take similar steps to learn about each other in the early stages of their project.

Influence on Group Structure

As stated previously, a group's structure encompasses the formal roles that are assigned to group members, how those roles impact group work, and how the group assigns tasks throughout their project. When a group is very familiar with each other, it tends to be easier to select who would correctly fulfill a specific role. For those groups who have limited prior knowledge of each other, it can be difficult to identify the correct person for a specific role. Such was the case for all three groups (Group 3, Group 4, and Group 5) with limited prior knowledge that were observed during Phase 1. Although each of these groups acknowledged and worked through the problem of not knowing each other well in different ways, they all ran into similar problems when determining formal roles within their group.

At the undergraduate level, it is not typical for students to have great expertise in a specific area because they are still in the early stages of their academic careers. Undergraduate students, especially in their junior year, are still building their skills and generally have little experience outside of the coursework that they have already completed. For a group in the early stages of their project, the combination of having no standout "experts" and a limited knowledge of each other can make assigning formal roles a particularly difficult task. In cases like this, groups need to rely on volunteering by group members and suggestions made by their faculty advisors. The interesting aspect of this kind of scenario is that students can shape their class experience by volunteering for a position that they are interested in. When group members start on generally the same level of expertise, the role selection process can prove to be important because it allows students to select roles that they are interested in and really develop specialized skills over the course of the project.

All of the faculty-composed groups had to deal with this exact problem when selecting their formal roles. Whereas Groups 1 and 2 had an idea of at least some of their group member's areas of expertise, Groups 3, 4 and 5 went into this process relatively blind. In order to select roles, they generally had to rely on their group members to voice their opinions about the available positions and volunteer for positions that interested them. In fact, during the focus group sessions, each group described their role-selecting process as a *"combination of volunteering and coming to a consensus as a group"*. In order to select the specific roles that they were assigning, they took suggestions from their faculty advisors and, in the case of Group 3, brainstormed about any extra positions that they felt they would need. These groups stuck to the typical formal roles that their advisors prefer to use for their groups. Through brainstorming, Group 3 veered off this course and added the Secretary position to keep track of what was discussed during their meetings.

Influence on Meeting Structure

A group's meeting structure consists of how it conducts its meetings and the number of meetings it has per week. For groups with limited prior knowledge of each other, the meeting structure that they choose in the beginning can greatly evolve over the course of their project. Since groups like this don't know each other well and thus don't know each other's work habits, it is not easy for them to identify the perfect meeting structure from the start. During the observations it became apparent that the groups created their meeting structures by either modeling it after the structure of their advisor meetings or by following the lead of a group member that stepped forward. Some faculty advisors require that the Project Manager lead the weekly meetings between the advisor and the group. Therefore, groups with advisors that had this policy typically continued with the structure during their student-only meetings. Additionally, meeting structures can be created based on the student that steps up and takes the lead within the group. This student's typical work habits will greatly influence the group's meeting structure.

Both Group 3 and Group 4 have the same faculty advisor who requires that the PM lead all group-advisor meetings. Because of this, both groups adopted a student meeting structure where the PM leads the meeting with an agenda and keeps the group on track. Although both groups have a similar overall meeting structure, their meetings progressed in very different ways. This seems to be because the PM's for each group had different personalities and work habits. For example, Group 3's meetings were very structured and organized because the current PM, Amy, was a focused, detailed-oriented person. Group 3's meetings started precisely on time and closely followed Amy's preset agenda. During the meeting, each group member spoke individually about what he or she had done since the last meeting and any problems that were encountered. In general, the discussions within the group did not deviate from the project at hand.

Group 4, on the other hand, had a more laid-back approach to their meetings. They were not very strict about starting on time and usually approved of side-discussion about things other than their project. The group's PM, Jim, created an agenda for each meeting but did not seem to follow it quite as strictly as Amy. Similar to Group 3's structure, each group member in Group 4 explained what they were working on and any problems that they'd run into but this process was not very strict and these discussions typically flowed together during the meeting. These groups had roughly the complete opposite meeting structures because of the different personalities within the groups. Thus, they are a great example of how meeting structure can be determined by the student who is leading the group at the start of the project.

Phase 2: Group Execution

During weeks five and six of the course, a *Transactive Memory Systems* (Lewis 2003) group survey was distributed electronically to every student. Up until this point, the groups had approximately four weeks to develop their project idea and begin learning about each other's work style. From about week four through to the end of the semester, groups generally start to implement their ideas and the bulk of the project's work begins. Therefore, these survey results quantify the group's TMS at a time when their work became more difficult and time consuming; and thus, a time when a strong TMS can play a key role in group performance. Additionally, by distributing the TMS surveys after the initial focus group sessions, it was easier to identify specific group activities that may have impacted the group's TMS score.

The TMS survey included questions that not only measured overall group TMS but also measured group specialization, credibility, and coordination. The specialization, credibility, and coordination sub-categories of TMS help create a better picture of how the group is working together and how well they know each other. For example, a group with a high specialization score shows that the members feel that their group's knowledge covers a wide range of areas. A high credibility score shows that the group members trust each other's knowledge. And finally, a high coordination score shows that the group feels that they can effectively work together. These sub-categories also help when comparing the different strengths of each group.

In order to quantify the strength of each group's TMS, the individual group member responses were totaled for each sub-category of the survey, which produced a Total Specialization score, a Total Credibility score, a Total Coordination score, and an Overall TMS score for each group. These totals were then averaged for each group to determine the group's score for each sub-category (listed below in Table 2). Finally, the Class TMS Average was determined by calculating the average of every group's Overall TMS score. The Class TMS Average was used to determine whether each group's Overall TMS score was strong or weak compared to other groups in the class. See Appendix D for a detailed view of the TMS survey results that includes group average scores for each survey question.

In general, the TMS survey results were as expected. Of the five groups that participated in Phase 1 of the data collection for this study, none produced results that contradicted the findings discussed previously in the literature review. Specifically, the groups with strong prior knowledge of each other (Group 1 and Group 2) showed a higher Overall TMS score than the other groups in the class. This can be attributed to the fact that they had worked together before and thus, had a better understanding of who knows what. Group 5, on the other hand, had the lowest Overall TMS score of the five groups from Phase 1, placing it below the Class TMS Average score. This finding shows that Group 5, a group with limited prior knowledge, had not learned enough about each other at the time of this survey to produce a strong group TMS score.

Some of the more interesting results include the fact that Group 3, a group with limited prior knowledge of each other at the start of the project, had the third highest Overall TMS score out of the entire class. Their Overall TMS score was just .1 less than the two groups that started the class with very strong prior knowledge. This finding may be the result of the group-learning activities that Group 3 took part in during the early stages of their project (e.g., discussed interests during first meeting, reviewed individual skills assessments, and scheduled a group lunch once per week). Group 4 also scored a high Overall TMS even though they did not do as many group-learning activities as Group 3. This group scored very high in the coordination sub-category, which shows that they have developed a project structure that allows them to effectively work together. Their project structure may be what influenced their group learning during the project and led to their high Overall TMS score during Phase 2.

Group	Specialization	Credibility	Coordination	Overall
1	22.2	18	16	18.7
2	23.3	18.3	14.8	18.8
3	21	19	15.8	18.6
4	18.5	17.8	16.3	17.5
5	18	17	14.8	16.6
6	20.4	16.8	14.8	17.3
7	19.8	17.4	16	17.7
8	18	17.6	14.8	16.8
9	21.2	17.6	15.4	18.1
10	20	17.5	15	17.5
11	15.8	16.8	14.3	15.6
12	19.6	17.8	13.4	16.9
13	21.8	17	16	18.3
			Class TMS Avg.	17.6

Table 2. Group TMS Survey Results

Phase 3: Group Revisions

As the 67-373 course progresses through the semester, groups begin to move from the initial planning stages of their projects to the more time and work-intensive implementation stages. Implementation typically begins during the third phase of a group's project and can run through to the final weeks of the course. Because these group projects tend to be more complex than previous projects completed by students, the implementation phase can become a crucial time for effective group collaboration. To further investigate the status of each group's collaboration, follow-up interviews were scheduled with Groups 1-5 during the second half of the course, just after their implementation began. The information uncovered in these follow-up interviews was helpful in comparing how each group initially structured their project, meetings and group roles versus their current structures. Most structure changes occurred because of group problems, group learning, or the group's schedule. See Appendix E for a full list of the questions used during these follow-up interviews.

Prior Knowledge of Others

As discussed previously, Group 1 and Group 2 were both self-composed groups and thus, were considered to be groups with strong prior knowledge of each other who would work well together throughout the course of this project. The results of the TMS survey showed that each of these groups scored at the top of the class for overall TMS score. Although these scores were expected, looking more closely at each group's specialization, credibility, and coordination scores revealed some interesting information. This information, coupled with what was discussed in the follow-up interviews, provided strong evidence for a number of similarities between student groups with strong prior knowledge and student groups with limited prior knowledge.

At this point in the project, Group 1 was still using the SCRUM development framework for their project and meeting structure. This means that they continued to meet only once per week as a group and generally still worked on tasks independently. Although this framework was still in place within the group, during the follow-up interview a number of group members expressed that they thought it would be *"helpful to meet one more time each week to go over how people plan to complete their tasks."* Communicating their work processes and plans seemed to be the biggest problem that faced Group 1 at this point in their project.

Another problem, which may be influenced by the fact that they were a self-composed group, was that Group 1's overall knowledge did not cover a broad range of areas. Each group member had a strong, specialized background in technology but as a group, they did not possess a large range of interdisciplinary knowledge. This is somewhat contradictory to Group 1's specialization score (22.2) but may be due to some confusion in the interpretation of the specialization questions on the TMS survey. Even though Group 1's Overall TMS score was very strong, some of the problems that they faced as a self-composed group indicate the importance of team building activities and a strong focus on the creation of an appropriate project structure. Possibly because Group 1 was so familiar with one another at the start of their project, they failed to see the value in continuing to learn about each other in order to create an appropriate structure within their project.

In the case of Group 2, the follow-up interviews provided rich information about the problems the group was facing. Several interpersonal issues arose between the group members and made it almost impossible to hold full group meetings. This collaboration inefficiency led to a general decline in the number of scheduled full group meetings each week. Similar to Group 1, Group 2 also had a very high Overall TMS score on the TMS survey but their follow-up interview told a different story. This may be due to the fact that the survey was sent out right around the time the personal issue began, and therefore probably before the issue had time to greatly affect the group's collaboration. Additionally, looking closer at the group's TMS survey results showed that their coordination score was relatively low, which may be an indication of a problem that had snowballed by the time the follow-up interviews occurred. Regardless of when the group's issue began to affect its work, this occurrence gave some insight into the limitations of using TMS to analyze a group's collaboration. Since personal issues can greatly impact how effectively group members work together, it follows that understanding TMS may only be part of what it takes to understand group collaboration and performance.

Limited Prior Knowledge of Others

Varying results came out of the follow-up interviews with Group 3, Group 4, and Group 5. These groups were the groups that started the course with limited prior knowledge of each other so the reasons for the changes made to their group roles, project or meeting structures were especially important to investigate. Some of these groups continued to grow and learn about each other throughout the course of the project, while others showed evidence of slowly moving in that direction but were clearly not at the peak of their collaboration. Overall, Group 3 and Group 4 scored well on the TMS survey but Group 5 scored relatively lower than the other groups that were included in the data collection for Phase 1 and Phase 3 of this research.

At the start of the follow-up interviews, Group 3 was expected to have grown stronger as a group since Phase 1 because they were the only group to participate in group-building activities (i.e., discussion of interests, review of skills assessment, and group lunches) early on in their project. Their Overall TMS score on the survey was third highest among all of the groups, which indicates that they developed a strong understanding of each other's knowledge and how to effectively work together. The follow-up interviews showed that have kept their project and meeting structures the same during the course of their project and have continued their weekly group lunch/dinner. One change that was noticed when observing their meeting was that they were more relaxed and conversational with each other while progressing through their structure meeting agenda. Overall, this shows that they've become more familiar with each other, which may be due to a combination of their group-building activities and simply working closely together during their project.

Group 5, on the other hand, did not score as high as Group 3 or Group 4 on the TMS survey and their Overall TMS score was below the Class TMS Average. During the follow-up interview, Jim explained that while working together on their implementation, the group became aware of local expertise.

> *"[The group realized] who the most experienced coder was in [the] group (Lindsey) and now we can go directly to her with any of our technical-related questions"*[Jim].

Once this was realized, Lindsey's formal group role was changed to Technical Lead and the previous Technical Lead, Brad, was given the role of Quality Assurance Manager. Although it took the group until the middle of the semester to discover Lindsey's main strength, it is clear that they learned more about each other as the project progressed. The main difference between Group 5 and the other faculty-composed groups is that Group 5 learned about each other at a slower pace. This may be due to the fact that Group 5 started the project with limited prior knowledge of each other and did not participate in any group-building activities (like Group 3) to develop a strong TMS.

One of the more unexpected results that came out of the follow-up interviews was the progression that Group 4 made from the early stages of their project to the implementation stage. The follow-up interview along with Group 4's scores on the TMS survey showed that they were working very well together. As a group, they had the highest coordination score of the entire class, which suggests that they became very comfortable working with each other during this project. The implications of this score became apparent in the follow-up interview when discussing how their meetings have changed since the beginning of the semester. Overall, at this point in their project, they began meeting fewer days each week and worked independently or in small sub-groups between their full group meetings. During their full meetings, group members updated the others about their progress and any problems that may have come up. Generally, full group meetings only included these updates and the completion of important tasks that could be done together as a group. The fact that they reduced their weekly meetings over the course of the semester suggests that they really began to trust each other to complete the assigned work on time, and with high quality.

Another important finding from Group 4's follow-up interview was their relatively low specialization score on the TMS survey. This result suggests that they generally felt that, as a group, their collective knowledge did not cover a broad range of areas. Since this research focuses on undergraduate students, it makes sense that in general, the student groups did not have high specialization scores. At the undergraduate level, students typically have not had the opportunity to specialize within their major. Thus, the undergraduate student groups may not have had high specialization scores when they took this particular TMS survey. This finding suggests that in terms of undergraduates, coordination and credibility are more important when looking at the effectiveness of group collaboration. In the case of Group 4, it seems that they benefited from their lack of a high specialization score. Multiple times during the follow-up interview, Jen (as well as the other members of the group) expressed that she had *"learned so much"* this semester, in both technical and group-related areas. Had the group been highly specialized, it may have been difficult for each group member to learn and develop within a selected area during their project.

CONCLUSIONS

The main goals of this study were to identify how transactive memory systems influence group performance in undergraduate Information Systems student project groups and to determine what student groups can do to help ensure successful group performance. These goals differed from previous studies in that the main focus of this study was undergraduate student groups in an Information Systems program, rather than participants in a laboratory or professional position. In general, and specifically within this study, student groups can possess a varying amount of distributed knowledge and prior knowledge of each other. The core analysis of this study was the comparison of groups with strong and groups with limited prior knowledge of each other, and how that difference manifested itself within each group's project and meeting structure, and formal roles. Through the use of three data collection phases, information was collected about how the students structured their project, meetings and formal roles, and about how the students collaborated as a group to complete their project. The analysis of these three data collection phases provided strong evidence that supports the three main findings of this study. Each of these three findings is discussed in more detail in the sections below.

Finding 1: Importance of Group Formation Process

After observing the student groups at two points in the semester and reviewing their scores on the TMS survey, it became evident that the group formation process is one of the most important aspects of student group collaboration. During Phase 1, the strong prior knowledge groups (Group 1 and Group 2) presented different project and meeting structures than the limited prior knowledge groups (Group 3, Group 4, and Group 5). These structures were put in place and greatly influenced by how well the students knew each other at the start of their project. During Phase 3, it was found that some groups decided to change their meeting or project structure from what was initially shown in Phase 1. For example, Group 4 began to meet less as a full group than they initially planned, and Group 1 expressed a need to meet more each week than they initially planned. Some of the group changes seen in this study indicated that the group properly created initial project and meeting structures and were simply updating it to fit their current state of familiarity with each other, whereas other group changes indicated that the group did not place much thought into their initial project and meeting structures and thus needed to make changes to continue on with their project. Since all of the focus groups showed some change during Phase 3, *it is evident that the strength of a group's prior knowledge should not impact the importance placed on taking the time to create a sufficient initial project and meeting structure within a group.*

Finding 2: Recognition of Group Changes

Another important aspect of student group collaboration is the importance of recognizing that groups and group dynamics change over time and require continuous management. Significant changes were seen in how the student groups structured their projects or meetings and how they interacted with each other during the course of the project. As a group continues to work closely together, they learn about how each group member likes to work, what each group member is interested in or knowledgeable of, and overall, they become more familiar with each other. Over time, this learning can greatly change the dynamics of how the group works together and thus, require that the project or meeting structure be changed to better fit them as a group. If student groups don't recognize that these changes are possible and manage these changes as they occur, they may continue to work in an ineffective project or meeting structure for the remainder of their project. Therefore, students should be aware that *groups are like living organisms and really require continuous management as the group changes over the course of a project.*

Finding 3: TMS – just one part of the whole picture

Finally, the strength of a group's transactive memory system does not necessarily provide the whole picture of how effectively the group collaborates. Using assessment tools, such as Lewis' (2003) TMS instrument, helps to develop a high-level view of how well a group is working together and its group members' expertise. Yet, these types of tools do not focus specifically on illuminating the potential problems that a student group may have, such as conflict or lack of motivation, which can greatly affect how they work together. TMS theory takes a very high-level look at how a group collaborates as a whole. Given this holistic view, it can be difficult to use only TMS theory to understand group collaboration since groups are very multi-dimensional and can be affected by many things that are not included in TMS. Thus, to truly understand how a student group is working together, one must not only look at TMS but also look at how a group communicates, what personalities are present within the group, what skills the group members have or are missing, and the complexity of the project. *Groups develop a diversity of complex elements, including TMS, which are interconnected with one another and impact how the group collaborates and performs together.*

RECOMMENDATIONS

The three main conclusions of this research have strong implications for undergraduate students working in groups. Based on the findings of this research, it is recommended that students focus on the group formation phase of their project by learning about their fellow group members' interests and goals, assigning appropriate formal roles, and agreeing upon group procedures and meeting structures. After this initial structure is in place, it is also recommended that students acknowledge that certain aspects of their group structures may change over the course of the project and thus, may need to be updated. By keeping these recommendations in mind, students can create an appropriate group structure that allows them to collaborate effectively during their project. It would also be helpful for professors to be aware of these recommendations in order to properly advise and oversee their student groups. (For a more detailed list of recommendations, see Appendix F for the 'Top 10 Recommendations for Student Groups').

Future researchers should build on the final conclusion of this study, which found that TMS provides a high-level view of group collaboration and really only explains one aspect of how student groups work together. Because of this conclusion, more research should be done that not only analyzes student group TMS but also looks at the other factors that impact group performance and collaboration. Additionally, research conducted within this space using undergraduate student groups may really help prepare students for working in group projects in school and working on professional teams after graduation.

REFERENCES

Akgun, A. E., Byrne, J. C., Keskin, H., & Lynn, G. S. (2006). Transactive Memory System in New Product Development Teams. *IEEE Transactions on Engineering Management, 53,* 95-111.

Austin, J. R. (2003). Transactive Memory in Organizational Groups: The Effects of Content, Consensus, Specialization, and Accuracy on Group Performance. *Journal of Applied Psychology, 88,* 866-878.

Bock, G. W., & Kim, Y. G. (2002). Breaking the myths of rewards: an exploratory study of attitudes about knowledge sharing. *Information Resources Management Journal, 15,* 14-21.

Brandon, D. P., & Hollingshead, A. B. (2004). Transactive memory systems in organizations: Matching tasks, expertise, and people. *Organizational Science, 15,* 633-644.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience and school*. Washington, DC: National Academy Press.

Castells, M. (1996). *The Rise of the Network Society,* Oxford: Blackwell.

Crown, D. F., & Rosse, J. G. (1995). Yours, Mine, and Ours: Facilitating Group Productivity through the Integration of Individual and Group Goals. *Organizational Behavior and Human Design Processes, 64,* 138-150.

Cruz, N. M., Perez, V. M., & Ramos, Y. F. (2007). Transactive memory processes that lead to better team results. *Team Performance Management, 13,* 192-205.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge.* Boston: Harvard Business School Press.

Faraj, S., & Sproull, L. (2000). Coordinating Expertise in Software Development Teams. *Management Science, 46,* 1554-1568.

Garner, J. T. (2006). It's not what you know: A transactive memory analysis of knowledge networks at NASA. *Journal of Technical Writing and Communication, 36,* 329-351.

Gersick, C. J. G., & Hackman, J. R. (1990). Habitual routines in task-performing groups. *Organizational Behavior and Human Decision Processes, 47,* 65-97.

Golden-Biddle, K., & Locke, K. D. (1997). Composing Qualitative Research. Thousand Oaks, CA: Sage Publications.

Hackman, J. R., & Morris, C. G. (1975). Group tasks, group interaction process and group performance effectiveness: A review and partial integration. In L. Berkowitz (Ed.). *Advances in Experimental Social Psychology* (pp. 47-99). New York: Academic Press.

Hollingshead, A. B. (1998). Retrieval processes in transactive memory systems. *Journal of Personality and Social Psychology, 74,* 659-671.

Hollingshead, A. B., & Brandon, D. (2003). Potential benefits of communication in transactive memory systems. *Human Communication Research, 29,* 607-615.

Huang, C. C., & Huang, T. J. (2007). Knowledge Sharing and KM Effectiveness in Technology R&D Teams: Transactive Memory System and Team-based Outcome Expectations Perspectives. *Proceedings of the 2007 IEEE IEEM,* 2124-2128.

Jackson, P., & Klobas, J. (2008). Transactive memory systems in organizations: Implications for knowledge directories. *Decision Support Systems, 44,* 409-424.

Jackson, M., & Moreland, R. L. (2009). Transactive Memory in the Classroom. *Small Group Research, 40,* 508-534.

Johnson, D., Johnson, R., & Smith, K. (1998). *Active Learning: Cooperation in the College Classroom*. Minnesota: Interaction Book Company.

Joseph, A., & Payne, M. (2003). Group Dynamics and Collaborative Group Performance. *Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education,* 368-371.

Lee, M. S., Trauth, E. M., & Farwell, D. (1995). Critical Skills and Knowledge Requirements of IS Professionals: A Joint Academic/Industry Investigation. *MIS Quarterly, 19,* 313-340.

Lewis, K. (2004). Knowledge and Performance in Knowledge-Worker Teams: A Longitudinal Study of Transactive Memory Systems. *Management Science, 50,* 1519-1533.

Lewis, K., Belliveau, M., Herndon, B., & Keller, J. (2007). Group cognition, membership change, and performance: Investigating the benefits and detriments of collective knowledge. *Organizational Behavior and Human Decision Processes, 103,* 159-178.

Lewis, K., Lange, D., & Gillis, L. (2005). Transactive Memory Systems, Learning, and Learning Transfer. *Organization Science, 16,* 581-598.

Liang, D. W., Moreland, R. L., & Argote, L. (1995). Group versus individual training and group performance: the mediating role of transactive memory. *Personality and Social Psychology Bulletin, 21,* 384-393.

Lunt, B. M., Ekstrom, J. J., Gorka, S., Hislop, G., Kamali, R., Lawsom, E., LeBlanc, R., Miller, J., & Reichgelt, H. (2008). Curriculum Guidelines for Undergraduate Degree Programs in Information Technology. *Association for Computing Machinery IEEE Computer Society*, 1-139.

Mason, J. (2002). Qualitative Researching. London: Sage Publications.

Mathieu, J. M., Maynard, T., Rapp, T., & Gilson, L. (2008). Team Effectiveness 1997 – 2007: A Review of Recent Advancements and a Glimpse Into the Future. *Journal of Management, 34,* 410-476.

Mercier, E., Goldman, S., & Booker, A. (2006). Collaborating to Learn, Learning to Collaborate: Finding the balance in a cross-disciplinary design course. *Proceedings of the 7th International Conference on Learning Sciences,* 467-473.

Moreland, R. L., Argote, L., & Krishnan, R. (1998). Training people to work in groups. In R. S. Tindale, L. Heath, J. Edwards, E. Posavac, F. B. Bryant, Y.

Suarez-Balcazar, E. Henderson-King, J. Myers (Eds.). *Theory and research in small groups* (pp. 36-60). New York: Plenum.

Moreland, R. L., & Levine, J. M. (1992). Problem identification by groups. In S. Worchel, W. Wood, J. A. Simpson (Eds). *Group process and productivity* (pp. 17-47). Newbury Park, CA: Sage.

Noll, C. L., & Wilkins, M. (2002). Critical Skills of IS Professionals: A Model for Curriculum Development. *Journal of Information Technology Education, 1,* 143-154.

Stasser, G., Stewart, D., & Wittenbaum, G. M. (1995). Expert roles and information exchange during discussion: the importance of knowledge who knows what. *Journal of Experimental Social Psychology, 31,* 244-265.

Tan, J., & Jones, M. (2008). A Case Study of Classroom Experience with Client-Based Team Projects. *Journal of Computing Sciences in Colleges, 23,* 150-159.

Wegner, D. M. (1986). Transactive memory: A contemporary analysis of the group mind. In B. Mullen & G. R. Goethals (Eds.), *Theories of Group Behavior* (pp. 185-208). New York: Springer-Verlag.

Wegner, D. M. (1987). Transactive memory: a contemporary analysis of the group mind. In B. Mullen, G. R. Goethals (Eds.). *Theories of group behaviour* (pp. 185-208). New York: Springer Verlag.

Wegner, D. M., Erber, R., & Raymond, P. (1991). Transactive memory in close relationships. *Journal of Personality and Social Psychology, 61,* 923-929.

Wegner, D. M., Giulliano, T., & Hertel, P. W. (1985). Cognitive interdependence in close relationships. In J. Ickes (Ed.). *Compatible and Incompatible Relationships* (pp. 253-276). New York: Springer-Verlag.

Wittenbaum, G. M., Vaughan, S. I., & Stasser, G. (1998). Coordination in task-performing groups. In R. S. Tindale, L. Heath, J. Edwards, E. J. Posvoc, F. B. Bryant, Y. Suarez-Balcazar, E. Henderson-King, J. Myers (Eds.). *Social Psychological Applications to Social Issues: Theory and Research on Small Groups* (177-204). New York: Plenum.

Yoo, P., & Kanawattanachai, Y. (2001). Development of transactive memory and collective mind in virtual teams. *International Journal of Organizational Analysis, 9,* 187-208

APPENDICES

Appendix A: Focus Group Questions

Knowledge of Others

1. Have you worked with each other before? If so, in what capacity? (i.e. outside of school, another group project, homework, etc.)

2. Do you interact with each other outside of meetings/work sessions? How often?

3. What do you know about each group member's knowledge outside of IS?

4. If you did not know each other before this project, how did you go about learning about each group member's skills/knowledge?

Group Structure

5. What formal roles have you agreed upon for this project?

6. How did you pick these roles?

7. How/when did you assign these roles to group members?

8. How many times per week do you meet? (with faculty advisor vs. without faculty advisor)

9. How do you divide up and assign tasks? (so far, or going forward)

Meeting Structure

10. Tell me about the structure of your first meeting (or first few meetings).

11. How are meetings typically conducted (thus far)?

12. Did you lay out any group rules/procedures/agreements at the start of the project? How did you do this?

Appendix B: Transactive Memory Systems Survey

Transactive Memory Systems (Lewis 2003)

Specialization

1. Each team member has specialized knowledge of some aspect of our project.
2. I have knowledge about an aspect of the project that no other team member has.
3. Different team members are responsible for expertise in different areas.
4. The specialized knowledge of several different team members was needed to complete the project deliverables.
5. I know which team members have expertise in specific areas.

Credibility

6. I was comfortable accepting procedural suggestions from other team members.
7. I trusted that other members' knowledge about the project was credible.
8. I was confident relying on the information that other team members brought to the discussion.
9. When other members gave information, I wanted to double-check it for myself.
10. I did not have much faith in other members' "expertise".

Coordination

11. Our team worked together in a well-coordinated fashion.
12. Our team had very few misunderstandings about what to do.
13. Our team needed to backtrack and start over a lot.
14. We accomplished the task smoothly and efficiently.
15. There was much confusion about how we would accomplish the task.

Note: All items in this scale use a 5-point disagree-agree response (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).

Appendix C: Data Collection Phases (by Group Member)

Group	Members	Phase 1	Phase 2	Phase 3
1	Bob	X	X	X
	Alex	X	X	X
	Sam	X	X	X
	Doug	X	X	X
	Matt	X	X	X
2	Sally	X	X	X
	Joe	X	X	X
	James	X	X	X
	Mike	X	X	X
3	Emma	X	X	X
	Alyssa	X	X	X
	James	X	X	X
	Amy	X	X	X
	Mark	X	X	X
4	Ashley	X	X	X
	Andrew	X	X	X
	Jacob	X	X	X
	Jen	X	X	X
5	Ben	X	X	X
	Jim	X	X	X
	Alice	X	X	X
	Brad	X	X	X
	Lindsey	X	X	X
6	Ali		X	
	Jack		X	
	Laura		X	
	Larry		X	
	Ralph		X	
7	Meredith		X	
	Rick		X	
	Guy		X	
	Ryan		X	
	Sarah		X	
8	Lisa		X	
	Neil		X	
	Jessica		X	
	Jeremy		X	
	Shawn		X	
9	Ellen		X	
	Terry		X	
	Keith		X	
	Chris		X	
	Luke		X	
10	Greg		X	
	Paul		X	
	Brian		X	
	Josh		X	
11	Claire		X	

	Dan		X	
	John		X	
	Jenny		X	
12	Kim		X	
	Kyle		X	
	Robert		X	
	Kate		X	
	Peter		X	
13	Mitch		X	
	Dave		X	
	Patrick		X	
	George		X	
	Connor		X	

Appendix D: TMS Survey Results

	Specialization					Credibility					Coordination				
Group	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**
1	4.2	4.2	4.4	4.6	4.8	4.6	4.2	4.2	3	2	3.8	3.8	2	4.2	2.2
2	5	4	5	4.3	5	4.8	4.8	4.5	2.8	1.5	3.8	3.5	1.3	4.3	2
3	4	3.4	4.4	4.6	4.6	4.8	4.6	4.4	3.6	1.6	4.2	3.6	1.8	4.2	2
4	3.8	2.8	3.8	4	4.3	4.5	4.3	4.3	2.5	2.3	4	4	1.8	4	2.5
5	3.2	3	3.8	4	4	3.8	3.6	3.2	3.8	2.6	3.6	2.8	2.6	3.2	2.6
6	4.2	3.6	4.2	4.4	4	4.2	4.2	3.2	3.2	2	4	3.4	1.4	4.2	1.8
7	4	3.8	4.2	4	3.8	4	4	4.2	3	2.2	4.4	3.8	2	4.2	1.6
8	3.2	3.8	3.8	3.8	3.4	4.2	4.2	3.8	3.2	2.2	3.6	3.2	1.8	3.4	2.8
9	4	4	4.4	4.4	4.4	4.6	4.6	4.6	2.4	1.4	4.6	4	1.2	3.8	1.8
10	4.5	3.8	4	3.8	4	4.5	4.3	4	2.8	2	4.3	3.3	1.8	3.5	2.3
11	3	3	2.8	3.5	3.5	4.3	4.3	4.5	2.3	1.5	4.3	3	1.8	3.8	1.5
12	3.8	3.6	4	4	4.2	4.2	3.6	3.8	4	2.2	3.2	2.2	1.8	3.4	2.8
13	4.6	4.2	4	4.6	4.4	4.6	4.2	4.6	2	1.6	4.4	4.2	1.6	4	1.8

Appendix E: Follow-Up Interview Questions

1. How is your project going so far?
2. Have you run into any problems over the course of this project? (group or project-related)
3. How do you deal with technical problems?
4. How do you relay problems to the rest of your group? (technical or process-related)
5. Have your formal roles changed at all since the beginning of the project?
6. Have any group member's responsibilities changed?
7. How has your meeting structure changed since the beginning of your project?
8. How many times per week do you meet as a group as a group? (Has this changed at all?)
9. How do you share information with the rest of your group?
10. What are you doing to coordinate as a group?
11. What skills did you want to build this semester?
12. How did you divide the work for the Team Project Review?

Appendix F: Top 10 Recommendations for Student Groups

1. Discuss your background, interests and experiences with your fellow group members and generally make it a point to learn about each other during your project.

2. Determine group and individual goals for the entire project. Revisit this conversation throughout the life of the project.

3. Review the individual skills assessments to better understand each other's backgrounds and skills.

4. Create a meeting structure that fits with your project and how your group members like to work. To do this, discuss the following as a group:

   a. Number of meetings per week

   b. Length of meetings with and without faculty advisor

   c. Structure of meetings with and without faculty advisor

5. Understand that your initial project/meeting structure may change during your project and be willing to make these changes as needed.

6. Assign formal roles based on your past experiences and what you want to learn during the project. Be sure that each role has a specific title and list of responsibilities.

7. Determine how your group will communicate with each other and your advisor. (e.g., email, face-to-face meetings, phone calls, online meetings).

8. Create a group policy that lays out how to deal with problems that may come up during your project. Be sure to address the following questions:

   a. How will you solve technical or project-related problems (e.g., using internet resources, meeting with fellow students, talking to IS faculty members)?

   b. How will you relay these problems to the rest of the group?

   c. How will you handle group-related issues (e.g., discuss issue as group, bring issue to faculty advisor, require group member to bring snacks to next meeting)?

9. Incorporate breaks or fun activities during your group meetings to relieve stress.

10. Challenge yourself to take on responsibilities within your group and learn new skills.