Disciplinarily Hetero- and Homogeneous Design Team Convergence: Communication Patterns and Perceptions of Teamwork

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ABSTRACT

In today's worlds of industry and academia, teamwork is becoming more and more prevalent and is becoming more and more desirable when addressing certain tasks. Intensified and growing competition in the global marketplace is forcing businesses to produce better products, thereby, requiring the input and expertise of various people with diverse backgrounds. Organizations have adopted a team approach in response to the technological advances that contribute to the complexity of many tasks in the workplace making it difficult for employees to work independently (Mathieu, Heffner, Goodwin, Salas, Cannon-Bowers, 2000).

The purpose of this research is to investigate the communication patterns of disciplinarily heterogeneous student design teams at the university level. A quasi-experimental design, specifically a non-equivalent control group design was used for this study. This study has two research questions: 1) what is the process that leads to convergence of a team-based mental model among disciplinarily heterogeneous team members? and 2) what are the factors associated with convergence that lead to effective disciplinarily heterogeneous teams? The results will allow the formation of guidelines that will assist such students in improving their effectiveness by allowing the convergence of the team members onto the same mental model(s). It must be noted that data collection for the experimental teams continued after the tragic events that occurred at Virginia Tech on April 16, 2007.

The results for this study were variable. Through examination of the fluctuation of the reliability scores across the three times it was administered, as well as the Pearson-Product Moment comparison, the Group Behavior Inventory is not the best instrument to use in an academic setting for student teams. The disciplinarily homogeneous teams disagreed more and the disciplinarily heterogeneous teams agreed more in terms of body language, while disciplinarily heterogeneous disagreed more through verbal utterances of sighs and pauses; however none of these differences were statistically significant. Certain agreement and disagreement indicators were significantly negatively correlated. Therefore, the corroboration of the Group Behavior Inventory constructs can only be applied to a specific disagreement indicator.

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Trust in the Lord with all your heart and lean not on your own understanding; In all you ways acknowledge HIM and HE shall direct your paths. ~Prov. 3:5-6

I can do all things through Christ who strengthens me. ~Phil. 4:13

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I would like give many thanks to my parents, Brenda and Roy, for all of their support and encouragement. You were there to listen when a roadblock suddenly appeared or when I wanted to share the accomplishment of a milestone, no matter how big or small. You'll never know how much I appreciate you. I Love You!!

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INTRODUCTION

1.1. Problem Statement

In today's world of industry and academia, teamwork is becoming more and more prevalent and is becoming more and more desirable for specific tasks and specific organizations. Intensified and growing competition in the global marketplace is forcing businesses to produce better products, thereby, requiring the input and expertise of a variety of people with diverse backgrounds. To survive and thrive in the present decade and beyond, organizations must reposition themselves and consider further implementation of work teams (Werner & Lester, 2001). Organizations have adopted a team approach in response to the technological advances that contribute to the complexity of many tasks in the workplace making it difficult for employees to work independently (Mathieu, Heffner, Goodwin, Salas, Cannon-Bowers, 2000). Teamwork appears to improve problem-solving processes, while also promoting creativity and originality, because 'the best way to get a good idea is to have lots of ideas' (Barak et al., 1999). Therefore, working in teams is displacing working alone. The use of preexisting knowledge and the development of new knowledge is an essential prerequisite to solving complex problems (Arts et al., 2002). The information explosion serves as another reason for the need of teams. The need to solve issues that are increasingly complex and increasingly multidisciplinary (Barak et al., 1999) requires the 'putting together of more heads.' Also, information flow is better due to increased communication and the horizontal,

rather than only the vertical, flow of information (Yancey, 1998). To utilize all relevant information possessed by various professionals from diverse fields to solve a particular problem, there will be an increase in the demand for effective collaboration and cooperation.

Despite the recognition of the increasing importance of technology in the business world, there has been little theoretical evidence that makes an attempt to identify the components of teamwork that should be implemented in technology education to prepare students for the transition into industry. There is even less effort placed on conveying methods for teamwork in technology education (Barak et al., 1999). There is an emergent need for university graduates who are able to rationalize and employ knowledge resourcefully to resolve complex problems (Segers, 1997). Over the past 10 years, reports commissioned by higher education stakeholders (AC Nielsen Research Services, 2000; Coopers & Lybrand, 1998) have acknowledged that a strong disciplinary knowledge base by itself does not secure a new graduate employment (Crebert et al., 2004). Harvey's research (1999) emphasized that in the UK "it was the 'graduate attributes' which were perceived to be the variable that determined the graduate's success in the workplace, rather than their specific degree" (Crebert et. al., 2004, p. 148). Therefore, the ability to transfer and apply knowledge from the university environment to an organization in industry is becoming increasingly imperative.

1.2. Research Justification

1.2.1. Team Mental Models

At the end of the 20th century, two major changes were beginning to occur in the workplace- organizations were shifting to team-based work structures and the amount of stress placed on employees was increasing (Ellis, 2006). In 1993, Cannon-Bowers et al. (1993) emphasized that to adapt quickly, team members should foresee what their teammates are going to do and what they are going to need to do it. Since it is "impossible for one person to have sufficient expertise to make a detailed choice between all the possible processes and mechanisms" (Singleton, 1987, p. 112)**,** it is important for the members working on disciplinarily heterogeneous team to share similar mental models concerning all aspects of the project. This study examines the concept of mental models in relation to student design teams. This study was designed to tackle the issue of how to teach disciplinarily heterogeneous teaming to university students. If such a process can be deemed successful, students will be more prepared to work on teams when they are employed by organizations. As the saying goes, 'knowing is half the battle'; therefore, students obtaining such knowledge while in school will also save organizations time and money by not having to learn these concepts at the company's expense.

1.2.2. Team Effectiveness

Despite the increase in the use of team-based work due to factors previously noted, teams have not lived up to expectations (Marks et al., 2002). Team-centered organizations have found that it is a challenge to develop well-designed training as a primary support system. Research surrounding team effectiveness is important because an increase in team effectiveness, at the

university and business level, will provide a decrease in the amount of time wasted on miscommunications and misunderstandings within a disciplinarily heterogeneous team, resulting in an increase in the quality of the deliverable and a more pleasurable experience for team members and all others that are involved.

1.2.3. Lack of Empirical Evidence

Empirical work concerning team mental models has lagged behind conceptual development of the theory. Mohammed et al. (2000) have suggested two reasons for this breach in the field, including “a lack of adequate conceptual development of the construct and confusion over how to measure cognitive structures at the group level” (Mohammed & Dumville, 2001, p. 91). The use of varied methodologies to study mental models can be viewed positively because the investigations of similar concepts are validated through an assortment of approaches. On the other hand, the utilization of many methods due to uncertainty of the optimal approach signifies a lack of concrete understanding pertaining to team mental models.

1.2.4. Research Support

This guidelines from this research that are intended to improve effectiveness of disciplinarily heterogeneous teams will assist university professors with the content material to present to their students concerning how to help students converge on similar mental models and thus, work effectively with disciplinarily heterogeneous team members. For example, concerning

technology and teamwork, Barak et al. (1999) recommended five guidelines that they felt should be followed to promote teamwork within the context of technology education. Some of these include 1) when planning the curriculum, it must not be forgotten that the goal is to teach the students how to work in a team and 2) to develop the skills connected with interpersonal relations in the team and to offer a common goal for students to serve as a suitable educational approach for team building. The results of this study will facilitate the interactions and thus, the success of future disciplinarily heterogeneous teams.

1.3. Research Purpose

This research investigated the communication patterns among disciplinarily heterogeneous student design teams at the university level for the purpose of developing guidelines to improve team effectiveness by allowing team members to converge onto the same mental model(s). The examination of communication patterns, specifically those signifying agreement and disagreement, and their possible role in determining the presence of convergence may allow the ability to confirm or contest a new method to establish existence of convergence. The results of this research will provide new information on guiding disciplinarily heterogeneous teams in academia and industry, toward the most effective techniques for communication and collaboration. Once an additional method for measuring the convergence of team mental models between two or more teams is established, university faculty will have ways to improve their student design teams and organizations also will be able to provide assistance to their work teams.

1.4. Research Questions & Hypotheses

This study was designed to address the following questions:

a. What is the process that leads to convergence of a team-based mental model among disciplinarily homogeneous and disciplinarily heterogeneous team members?

b. What are the factors associated with convergence that lead to effective disciplinarily heterogeneous teams?

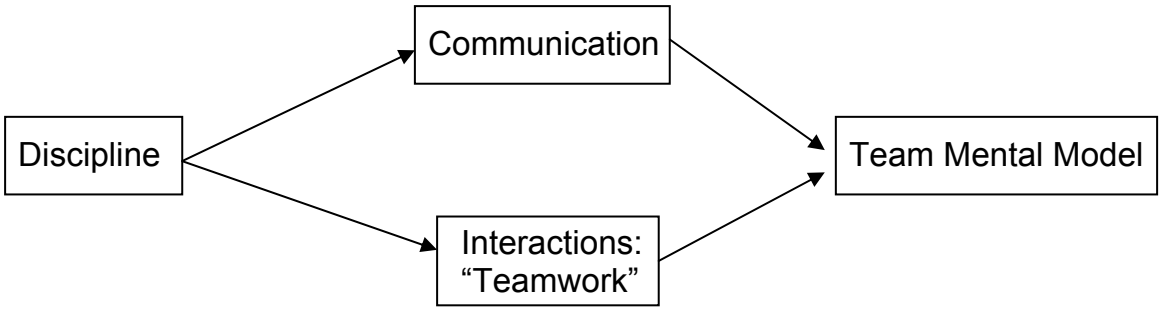

Figure 1. Hypothesized Process - Model of Disciplinarily Heterogeneous Teamwork for an Individual

The hypotheses for this study were:

H1: Disciplinarily homogeneous teams will have fewer utterances of disagreement and nonverbal actions representing disagreement than disciplinarily heterogeneous teams.

H2: The observed indicators of agreement and disagreement will be positively related to the Group Behavior Inventory scores.

LITERATURE REVIEW

2.1. Disciplinary Culture

The concept of an academic discipline is contingent upon the extent to which leading academic institutions recognize the specificity in "terms of their organizational structures and also on the degree to which a freestanding international community has emerged, with its own professional associations and specialist journals" (Becher, 1989, p. 19). Becher takes the stance that the attitudes, activities and cognitive styles of groups of academics that represent a particular discipline are very closely tied to compositions and characteristics of the knowledge domains.

Culture is understood to be comprised of four different elements- values, norms, institutions and artifacts- that are passed on from generation to generation. Culture can be examined through various contexts- anthropologically, religiously, and ethnical, among others. It can also be examined in terms of whole civilizations, geographic regions or segments of society. But

> "culture in higher education is defined as the collective, mutually shaping patterns of norms, values, practices, beliefs, and assumptions that guide the behavior of individuals and groups in an institute of higher education and provide a frame of reference within which to interpret the meaning of events and actions on and off campus" (Kuh & Whitt, 1988, pp. 12-13).

"Disciplinary subcultures tend to reflect the norms and assumptions of the major occupational areas for which the school provides preparation…" (Kuh & Whitt, 1988, p. 78). Disciplinary culture and subculture variations are impacted by the scholarly tasks among the disciplines, their institutional context, distinctions in missions and faculty commitment, the size and complexity of the institution and the structure of the administrative departments (Kuh & Whitt, 1988).

Helen Klein's cultural lens model supplies a framework for grasping the concept and origins of national culture (2004). Culture provides guiding principles to members of the group. It not only presents "rules about cleanliness and health care, but also the basis for verbal and nonverbal communication and guidelines for acceptable social behavior and emotional expression. Culture also provides cognitive tools for making sense out of the world" (Klein, 2004, pp. 253 & 254). This model (Figure 2) that captures dimensions that are characteristics of national group differences "provides a lens through which each member of a national group 'sees' the world" (Klein, 2004, p. 254). Klein's model can be used to support Kuh and Whitt's concept of disciplinary subcultures and how academic majors can also be considered cultures.

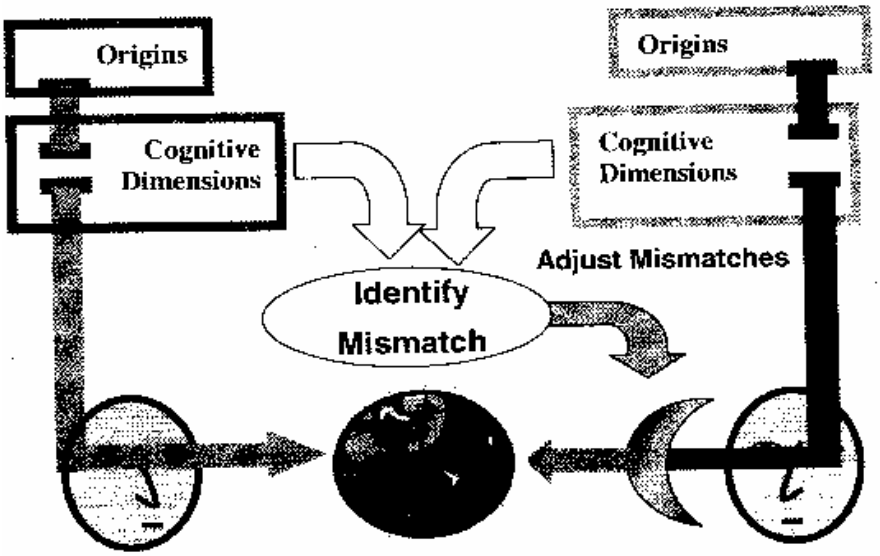

Figure 2. Cultural Lens Model (Copyright Permissions Approved by Elsevier JAI)

Culture and discipline can be viewed synonymously, as equivalent terms when referring to education. As culture is defined as being passed from generation to generation, as well as consisting of four pertinent, defining

elements, discipline also has visible aspects, both surface aspects and if further examined, aspects deep within, that link it to being a culture within itself. Not only can the term ‘discipline’ be placed on the same level as ‘culture’, but more specifically, individual disciplines have their own ‘cultures’ because they each consist of values, norms, languages, rituals, and structures that are adhered to by those in that discipline or by those wanting to be involved in that discipline. This study took the stance that an academic discipline (such as industrial engineering, biology, English, or mathematics) can also be considered a culture.

2.2. Schemas and Mental Models

People organize information that they acquire from birth within their long-term memory. This information is acquired through all channels (visual, auditory, tactile, gustatory and olfactory) and is stored in long-term memory to be retrieved at a later date. There are two main ways that are used to describe how people organize information- schemas and mental models. For the purpose of interacting with the environment, people construct mental models. When information is centered around particular concepts or ideas, the entire knowledge about a particular topic is referred to as a schema (Wickens, 2004). People have schemas about aspects of the world such as a vacation or a college major.

Mental models are not static or inert concepts, but rather are dynamic concepts, as are the systems that they describe. Since mental models allow people to predict and explain the behavior or the world around them and that world is ever changing by the second, the mental model will continually change.

The members of a team develop expertise and various degrees of understanding related to the team and the task at hand. Therefore, the team mental models, as well as the individual mental models, are continually forming and changing with the sharing and acquiring of knowledge.

Essentially, mental models serve to help people to illustrate, clarify, and predict incidents in their environment. Mental models are schemas of dynamic systems (Wickens, 2004). Mental models allow one to understand the components of a system and how it works as well as how to use it, which will then allow one to predict what will occur next if one interacts with the system in a certain manner. Mental models generate a set of expectancies concerning the system. Not all mental models will have the same degree of completeness nor will they necessarily be shared across a large group of people.

2.3. Team Mental Models (TMMs)

Within industrial companies, design projects are becoming more and more interdisciplinary, meaning people from various disciplines are ideally, working together and, ideally, learning from one another, then incorporating this knowledge to create a desired product. Various disciplines have their own practices and ways of thinking, processing and approaching problems. These may, in turn, conflict with those in other disciplines. People coming from various disciplines and having different academic backgrounds hold different mental models pertaining to interaction with others as a team and how a project is to be completed. The focus is on teams, which consist of differentiated and interdependent members (Cannon-Bowers, Salas & Converse, 1993) who are

expected to work together for a certain period of time, instead of groups, which are collections of individuals whose duration together and distribution of responsibilities can fluctuate significantly (Klimoski & Mohammed, 1994). According to the APA Dictionary of Psychology, the definition of a team mental model (as well as a shared mental model) in the field of ergonomics is:

> "a mental model of a work system that is held in common by the members of a team. Ideally, team members should have a shared mental picture of the system and its attributes, a shared knowledge of all relevant tasks, and a shared understanding of the team's progress toward its goal. Coordination, efficiency, and accuracy will increase as team members converge on a common mental model that is accurate and complete, yet flexible" (VanderBos, 2006, p. 926).

Terminology concerning various types of mental models and what those models encompass are not consistent across authors and differing terms are used and accepted. Langan-Fox, Anglim and Wilson specifically state that a difference lies between the terms 'shared mental model' and 'team mental model' (2004). A team mental model refers to "what is shared among the members of a team as a collectivity" (Langan-Fox, Anglim and Wilson, 2004, p. 335), while a shared mental model is "shared cognition amongst dyads of individuals" (Klimoski & Mohammad, 1994, p. 414). Petersen et al. (2000) state that shared mental models is a concept that "addresses the development of shared understanding among group members" (p. 299), but is referenced by different terms including group situation awareness (Wellens, 1993), team schema similarity (Rentsch & Hall, 1994), and intersubjectivity (Levine, Resnick, & Higgins, 1990). Such terminology differentiations were reported in a study by Klimoski & Mohammed (1994). Even though the concepts are slightly different,

what they hold in common is the idea that group members possess organized knowledge structures that relate to various features of the group's circumstances (Petersen, Mitchell, Thompson, & Burr, 2000). For this paper and the referenced literature, team mental model and shared mental model will have the same meaning.

Team members' knowledge and team organizational structure have been proposed to influence team processes (Mathieu et al., 2000). In 1993, Cannon-Bowers et. al. emphasized that to adapt quickly, team members should foresee what their teammates are going to do and what they are going to need to do it. The function of the team sharing the same mental model is to "allow team members to draw on their own well-structured knowledge as a basis for selecting actions that are consistent and coordinated with those of their teammates" (Mathieu et al., 2000, p. 274). Excessive workload, time pressure or other environmental conditions that hinder the lines of communication prevent shared mental models, and thus prevent team functioning, by not permitting team members to fully be able to "predict the information and resource requirements of their teammates" (Mathieu et al., 2000, p. 274).

It cannot go unsaid that a team can and most likely will have more than one mental model at any given time (Table 1). According to Klimoski and Mohammed (1994), there can be (and probably will be) multiple mental models simultaneously present among team members at any point in time. Mathieu et al. (2000) discuss four types of mental models that should be shared by a team: understanding the technology with which they are interacting, holding a shared

job/task model, holding shared conceptions of how the team interacts and the team member model. The shared mental models of team interaction and of the team members serve as pertinent aspects in investigating design team performance and success.

Table 1. Types of Shared Mental Models in Teams

Type of Model	*Knowledge Content*	*Comment*
Technology/Equipment	Equipment functioning Operating procedures System limitations Likely failures	Likely to be the most stable model in terms of content. Probably requires less to be shared across team members.
Job/Task	Task procedures Likely contingencies Likely scenarios Task strategies Environmental constraints Task component relationships	In highly proceduralized tasks, members will have shared task models. When tasks are more unpredictable, the value of shared task knowledge becomes more crucial.
Team Interaction	Roles/responsibilities Information sources Interaction patterns Communication channels Role interdependencies Information flow	Shared knowledge about shared team interactions drives how team members behave by creating expectations. Adaptable teams are those who understand well and can predict the nature of team interactions.
Team	Teammates' knowledge Teammates' skills Teammates' attitudes Teammates' preferences Teammates' tendencies	Team-specific knowledge of teammates helps members to better tailor their behavior to what they expect from teammates.

Note: Adapted from "Shared mental models in expert team decision making," by J.A. Cannon-Bowers, E. Salas and S.A. Converse, 1993, in *Individual and group decision making*, by N.J. Castellan, Jr. (Ed.), Hillsdale, NJ: Erlbaum. Copyright by Erlbaum. Adapted with permission.

Knowledge of roles and responsibilities, information sources and communication channels, as well as knowledge of teammates' skills, tendencies and attitudes will assist the process of expedited convergence of team members

onto the same mental model. According to Langan-Fox, Anglim and Wilson, the term team mental model embraces two notions, mental models and teamworking, with the latter meaning “groups having common valued goals, multiple tasks and complementary skills, internal interdependence and coordination, being mutually accountable for methods, resource use and outcomes, and taking on extended (managerial) responsibility” (2004, p. 335). Shared mental models imply that team members hold compatible models that lead to common expectations, rather than implying identical mental models (Cannon-Bowers, Salas, & Converse, 1993)

2.4. Operationalization & Additional Factors of TMMs

Research has investigated the many ways in which team mental models can be operationalized (Mohammed, Marks, & Rentsch, 2000). Similarity of mental models, meaning the degree to which members’ mental models are overlapping, and accuracy, meaning the degree to which members’ mental models adequately represent a given knowledge domain (Edwards, Day, Arthur, & Bell, 2006) have been investigated to determine their contribution to team performance. The study by Edwards et al. (2006) supports the findings that team mental models play a significant role in the development of complex skills and consequent team performance. They reported that similarity and accuracy of TMM are strongly related, accuracy of a TMM being a stronger predictor of team performance than similarity. It also found that as the teams acquired more skill and converged on the ‘true’ mental model with enhanced training, accuracy remained a stronger predictor of possible team performance than similarity.

Edwards et al. (2006) demonstrated that when the focus is only on taskwork mental models (one type of mental model from Cannon-Bowers et al., 1993), accuracy again proved a better predictor of team performance than similarity.

Rulke and Rau (1997) found that in the early formation of a group, its members spend a majority of the communication on planning, coordinating and identifying everyone's expertise. Such distribution assists the group in coping with tasks that are too complex for one individual to tackle alone. Not to take away from any individual's capabilities, it must be noted that not all information needs to be shared in order for a team to be successful (Petersen, Mitchell, Thompson, & Burr, 2000).

A study by Neuman and Wright (1999) acknowledges that expertise and cognitive ability play a role in enhancing a team's effectiveness, as do individual personality traits that shape group traits. Organizations use individual worker's characteristics to make decisions not only regarding individual selections, but also for teamwork selection and assignment. Neuman and Wright's study assessed effectiveness using cognitive aptitude, job-specific competence and personality traits concurrently to predict the work team performance at the individual, and more importantly, the group level. The study found that at the group level, Agreeableness and Conscientiousness predicted supervisor ratings of work team performance, and meeting objectives for work team accuracy and work completed. An interesting follow-up study to Neuman and Wright's study would be to investigate if individuals on a team possessing similar personality traits are able to more closely converge on the same mental model than those

possessing dissimilar traits, and if so, how quickly convergence could be achieved.

Stout, Cannon-Bowers and Salas (1996) examined a skill that has proved critical to complex team environments, team situational awareness. Team situational awareness has been defined as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” (Endsley, 1995, p. 36). Team situational awareness (Figure 3) can be considered comparable to team mental models. Just like mental models, there are several difficulties with the methodologies and concepts surrounding situational awareness. These difficulties are due to the lack of attention paid to team situational awareness (Stout, Cannon-Bowers, & Salas, 1996) and the absence of training strategies for enhancing team situation awareness (Salas et al., 1995). It has been shown that teams adjust their coordination strategies depending upon their task load and that those teams with team mental models that had greater convergence performed better in their tasks. Stout, Cannon-Bowers and Salas (1996) conceptualized team situation awareness (Figure 3), including the degree of shared understanding of the team.

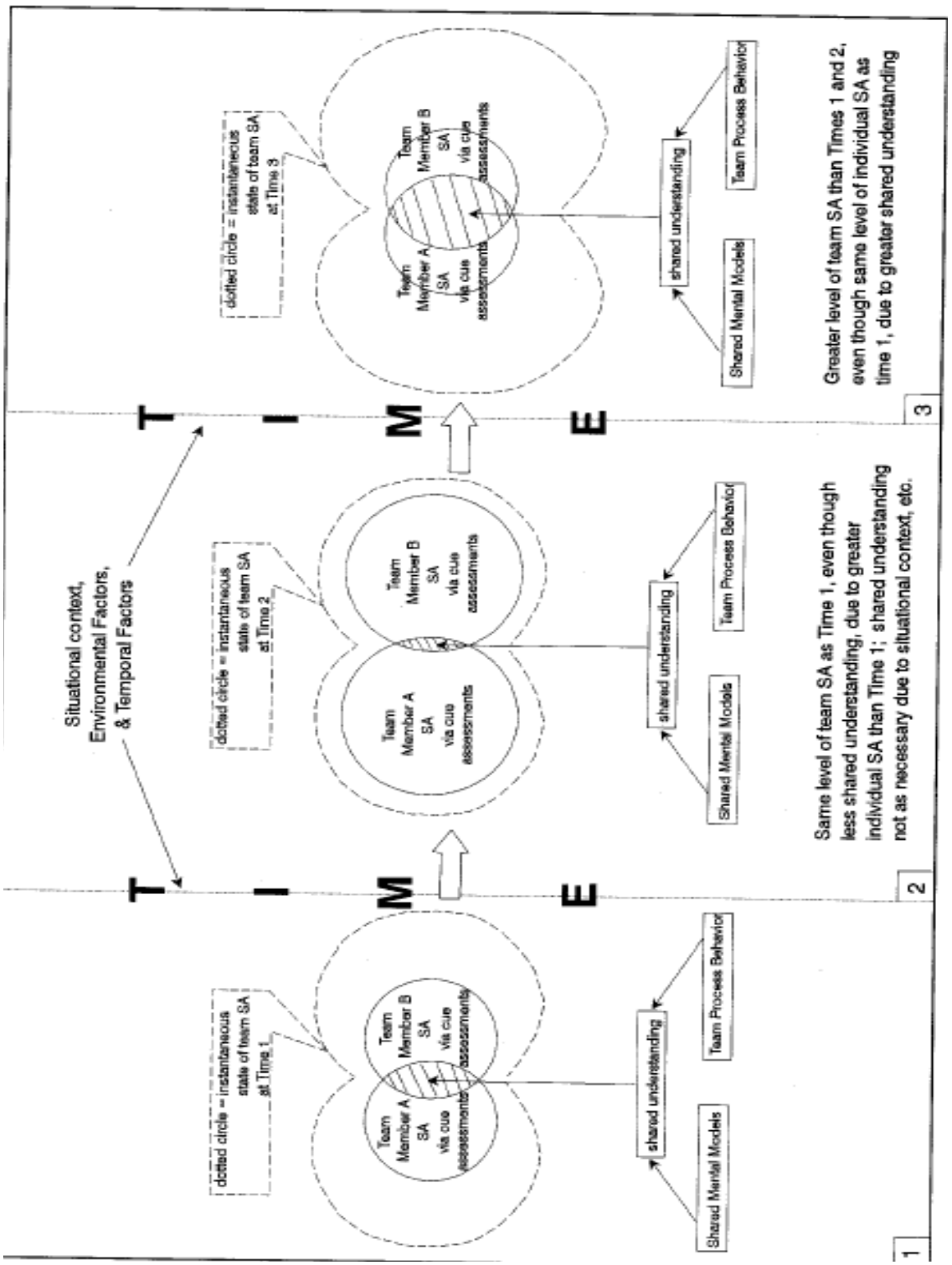

Figure 3. Dynamic Team Situational Awareness (Copyright Permissions Approved by Educational Technology Publications)

De Vries, Van den Hoof and Ridder investigated the relationship between team communication styles and knowledge sharing attitudes. The results showed that willingness and eagerness are both related to knowledge collecting and sharing behaviors (2006). Team members' agreeableness and extraversion have positive implications for the willingness to share knowledge with one's team members (De Vries, Van den Hoof and Ridder, 2006). The understanding of such knowledge sharing attitudes, as well as the diversity of the members on the team can subsequently enhance the effectiveness of a team. Such attitudes, along with other factors, can be fostered and encouraged to increase the effectiveness of the team.

In order for a team to even consider being synchronized on the same mental model(s), successful communication must be achieved. Team members must have some level of common ground. Common ground refers to "knowledge that the participants have in common, and they are aware that they have it in common" (Olson & Olson, 2000, p. 157). Common ground is established not only from general knowledge about a person's background, but also from specific knowledge from the person's appearance and behavior during the conversation. The foundation of common ground is a collaborative process in which the participants communally ascertain what they know so the conversation can proceed (Clark & Brennan, 1991). Common ground is created off the cuff. Those involved in the conversation gradually detect similarities and distinctions between themselves and then adapt accordingly. Since common ground is created from the cues that are present at that particular moment, the fewer the cues available,

the harder it is to reach such a level and the more likely misunderstanding will occur (Olson & Olson, 2000). Clark & Brennan (1991) generated a list of cues that various types of media provide that assist in reaching common ground (Table 2).

Table 2. Characteristics of Common Ground- The characteristics that contribute to achieving common ground that are inherent in various communication media (based on information in Clark & Brennan, 1991).

Medium	Copresence	Visibility	Audibility	Cotemporality	Simultaneity	Sequentiality	Reviewability	Revisability
Face to face	*	*	*	*	*	*		
Telephone			*	*	*	*		
Video Conference		*	*	*	*	*		
Two-way chat				*	*	*	*	*
Answering machine			*				*	
Email							*	*
Letter							*	*

2.5. Team Mental Model Development

Research thus far concerning team mental models places stronger emphasis on outcomes than process; however, it is important to understand the process through which team mental models are developed and modified. In the team mental model framework, shared understanding of the team is represented as something distributed among the team. The commonality of individual models and how they emerge within a team are of greater concern than individual mental models (Langan-Fox, Anglim, & Wilson, 2004). In 1998, Heffner found that team processes and performance were positively affected by the degree to which team members shared their tasks and team mental models. It also was found that the

team members' understanding of team processes contributed much more to team effectiveness than did their understanding of the task (Heffner, 1998). The Acquisition and Development of Team Mental Model (ADTMM) described by Langan-Fox (2003) is an integrated model that draws upon the teamwork, mental model, and skill acquisition literature. The model describes the shared understanding of the team about the team, task, and the team context. Figure 4 illustrates the progress of individual and/or team mental model acquisition and the various phases involved in becoming an expert. The development flows from the initial phase of attaining facts about the task to the final phase when the task is completed successfully.

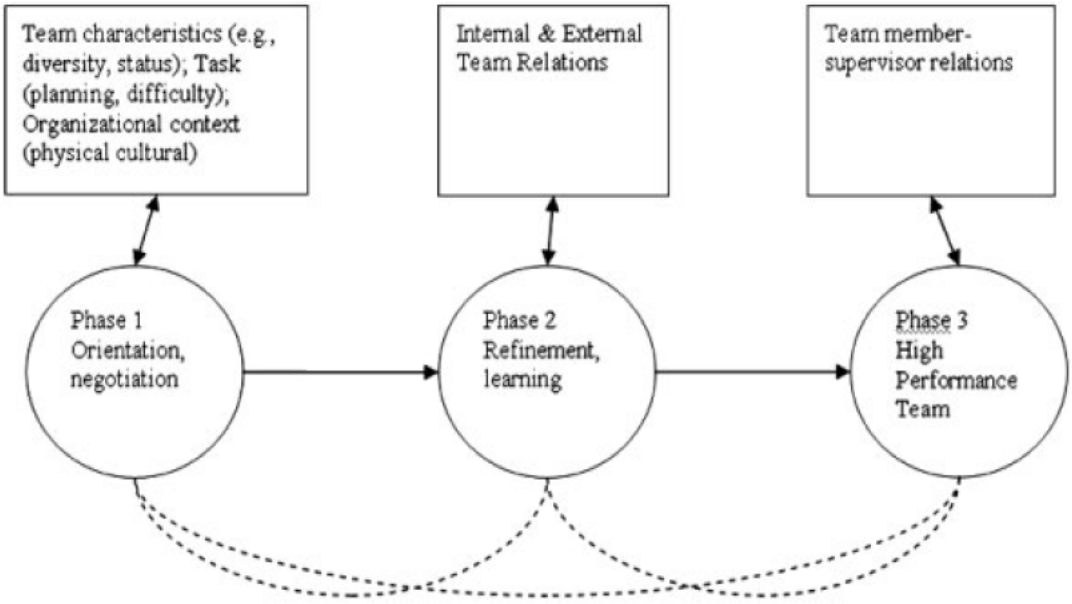

Figure 4. Integrative Skill Acquisition- Team Mental Model Development Framework. From Langan-Fox, Anglim, & Wilson, 2004; Source: Adapted from Langan-Fox, 2003. (Copyright Permissions Approved by John Wiley & Sons, Inc.)

Figure 5 depicts the operationalization of the theory and shows particular variables that would be measured at the different skill acquisition phases in Figure 4. Figure 5 serves as a possible integrative framework that would support

researchers in their interpretation of the team mental model literature, to develop hypotheses, and to provide a guide for research and practical applications.

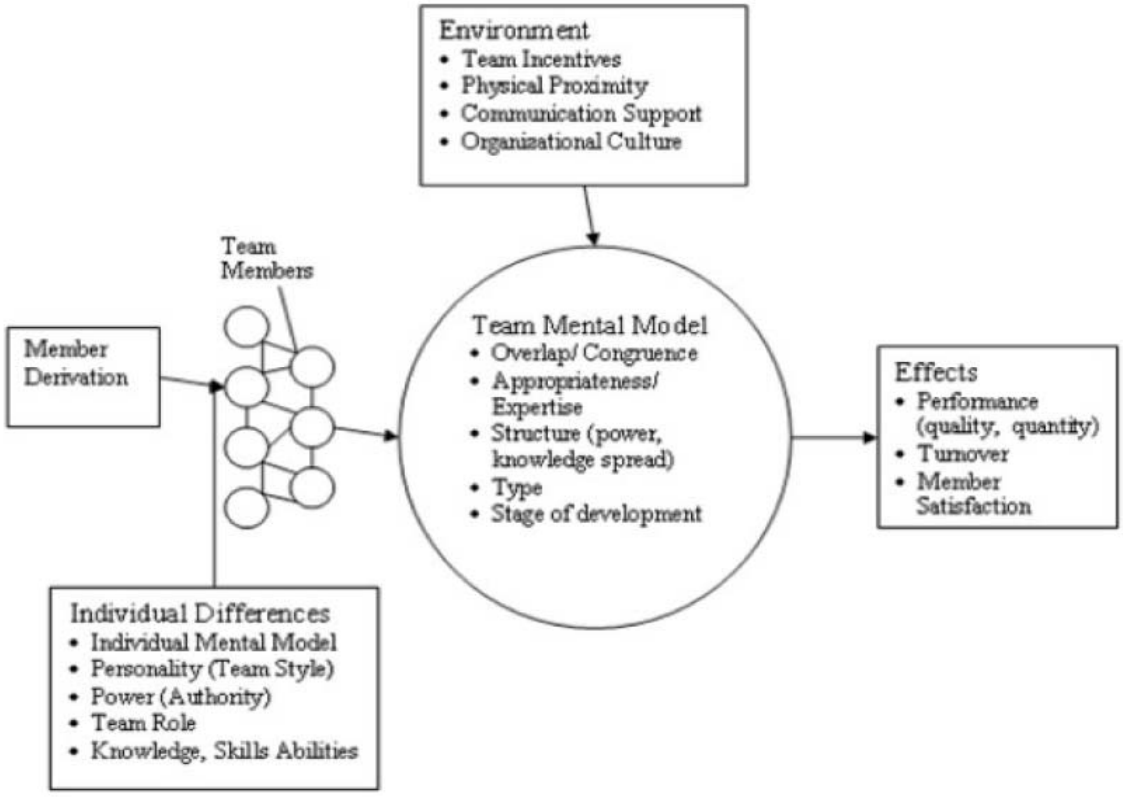

Figure 5. Proposed Theoretical Network of Causes and Effects in Relation to Team Mental Models. Langan-Fox, Anglim, & Wilson, 2004; Source: Adapted from Langan-Fox, 2003. (Copyright Permissions Approved by John Wiley & Sons, Inc.)

Once mental models are developed, the question of convergence of those models by team members becomes an issue. One of the common presumptions found throughout research is that team member mental models will converge over time and that increased interaction between the team members will make this convergence process more rapid (Clark & Brennan, 1991). Acton, Johnson, and Goldsmith (1994) assessed individual mental models, or structural knowledge, by comparing them to a referent structure, or an idealized

organization of knowledge. An ideal organization of knowledge is assumed to be that which best reflects the structure of the domain, and that cognitive structures become more similar to the referent structure with an increase in experience. The results of Acton et al.'s (1994) study suggested that the structures of knowledge became more similar with expertise and that as individuals develop expertise in a particular domain, their knowledge structures converge towards a true representation of that domain. Day, Arthur, & Gettman (2001) specified the difference between knowledge structures and declarative knowledge, with the former symbolizing the organization of knowledge and the latter indicating the amount of knowledge learned.

2.6. Measurement of Mental Models

An important predictor of team effectiveness, through team mental model research, has pointed to convergence/similarity/agreement/compatibility/overlap among team member knowledge (Cannon-Bowers et al., 1993). According to Cooke, Salas, Cannon-Bowers, & Stout (2000), the definition of sharing (ex. the workload) is most appropriate for heterogeneous teams where distinct team roles require information unique to particular individuals. Empirical research as examined the similarity among all team members' understanding of the relationship between the concepts, but several studies have failed to find the significant relationship between measures of convergence of mental models and various dimensions of team effectiveness (Adelman, Zirk, Lehner, Moffett, & Hall, 1986). The most common methodologies for elicitation for the study of team mental models are Likert-scale questionnaires and similarity ratings, while

elicitation methodologies include Pathfinder and concept mapping (Mohammed et al., 2000). Webber and her colleagues (2000) presented a new method for assessing team mental models and that allows for the measurement of team mental model accuracy and similarity. Contingent upon the type of mental model and whether the content and/or structure of the mental model are to be captured (Mohammed et al., 2000), measurement may require the development and use of multiple types of measurements (Kraiger & Wenzel, 1997). Convergence may not be as strong an area of study within the concept of team mental models as similarity or compatibility. If it is found that the verbal and nonverbal cues signifying agreement are related to team members 'being on the same page', then such cues may lead to a viable method of establishing team convergence on a mental model. Previous research in the measurement of team mental models has had people articulate them and then compare those articulations amongst the team members or against a higher authority. A potential alternative approach to measuring the convergence of team mental models, verbal and nonverbal cues, will be used in this study.

Channels of communication may lie in one of two areas, verbal or nonverbal, and the communicator will often jointly utilize both. One may communicate feelings of frustration, happiness, disgust, anxiety, nervousness, agreement or openness through what one says or does. Bull (1987) found that agreement is accompanied by sideways leaning (relaxation), while disagreement is accompanied by cross the arms or slouching. People are moderately relaxed with those whom they like and very relaxed with those who are not liked or

respected (Argyle, 1988). Mehrabian (1969, p. 366) noted that "shoulder orientation alone can be used as a summary index of the body orientation of standing or seated communicators." Head movements, nodding and shaking, are a major mode of communication during listening turns. The most obvious occurrence is head movements signaling 'yes' and 'no' (Jakobson, 1972). Hadar, Steiner, and Rose (1985) found that more head nods were associated with 'yes' and head shakes for 'no' were a direct negative answer to a question.

Certain actions that are present in nonverbal communication can predetermine whether a negative response, or a disagreeing statement, is forthcoming from the recipient. Regarding pauses, Pomerantz (1984, p. 153) stated that a “recipient may be hesitant to respond coherently because he or she does not support, or agree, with the speaker’s assertion.” The length of such pauses may vary. Hesitating noises such as “uh” or “um” are also precursors to a disagreeing statement. Other paralinguistic events, such as sighs during conversation precede and indicate a forthcoming vocalization of disagreement or “a sign of distress or unhappiness” (Eide et al., 2004, p. 82). The above mentioned verbal and nonverbal cues may serve an additional approach for measuring the convergence of team mental models.

In summary, cultures consist of values, norms, institutions and artifacts, and comparable structures exist in academic disciplines. According to Kuh and Whitt (1988), disciplinary subcultures tend to reflect the assumptions and norms that are associated with cultures. Therefore, when discussing and referring to an educational field, discipline and culture can be used synonymously. People from

different disciplinary backgrounds are often brought together to work in teams. When diverse groups of people are working together, they can work most effectively when they possess similar mental models. Mental models, vary from person to person and from culture to culture, A mental model allows people to understand the components of a system, how it works, as well as how to use it. Such information will allow one to predict what will occur next if one interacts with the system in a particular manner. When working in teams, the existence of a team mental model is thought to be beneficial to the team's effectiveness. According to Cannon-Bowers, Salas, & Converse (1993), teams consist of differentiated and interdependent members. Terminology problems have been discovered when dealing with the terms 'team mental model' and 'shared mental model'; thus, for this paper, the terms will have similar meaning. The operationalization of team mental models continues to be an on-going task in its attempts to establish the factors involved in team effectiveness. Various factors are considered an asset to team effectiveness. These include acknowledging that a team mental model needs to be established as well as numerous training strategies (ex. cross-training, planning training).

The purpose of this research was to investigate the communication patterns of disciplinarily heterogeneous student design teams at the university level to create guidelines that would assist such students in improving their effectiveness by allowing the convergence of the team members onto the same mental model(s). The research questions were as follows: 1) What is the process that leads to convergence of a team-based mental model among disciplinarily

homogeneous and disciplinarily heterogeneous team members and 2) What factors are associated with convergence that leads to effective disciplinarily heterogeneous teams? The results of this research will be able to guide disciplinarily heterogeneous teams, in academia as well as in industry, in the most effective means and techniques in which to better evolve, communicate and collaborate.

METHODS

This study was designed to address the following questions:

a. What is the process that leads to convergence of a team-based mental model among disciplinarily homogeneous and disciplinarily heterogeneous team members?

b. What are the factors associated with convergence that leads to effective disciplinarily heterogeneous teams?

Two hypotheses were developed to address the two research questions. For research question one, the hypothesis was disciplinarily homogeneous teams will have fewer utterances of disagreement and nonverbal actions representing disagreement than disciplinarily heterogeneous teams and for research question two, the hypothesis was the observed indicators of agreement and disagreement will be positively related to the Group Behavior Inventory scores. This study used body language indicators that signified agreement and disagreement to determine which type of team was more on a similar mental model. History compromised the internal validity for this study due to the tragedy that occurred at Virginia Tech on April 16. 2007. Data collection for the

experimental teams was resumed after this event, while the control teams had been completed prior to this event.

3.1. Experimental Design

A quasi-experimental design was used for this study, but more specifically, a nonequivalent control group design. This particular design consisted of both an experimental group and a control group, each being given a pretest and a posttest. But both teams did not have pre-experimental sampling equality (Campbell & Stanley, 1963), because the teams were not randomly assigned. The assignment of treatment (X) to one of the groups, the experimental group, was presumed to be under the researcher's control. The treatment, X, is the differentiation of the two types of teams by discipline. The nonequivalent control group design will be as follows (O signifies observation):

O X O.
O O

The use of Campbell and Stanley's nonequivalent control group design presents threats to internal and external validity. According to Campbell and Stanley (1963), the nonequivalent control group design controls the factors of internal validity: history, maturation, testing, instrumentation, selection and mortality. History was being controlled by specifying when and how long each group would meet for the duration of the study. Maturation and testing validities were most likely not to occur between measurements because they are relatively close in time. It was possible that intra-session maturation (such as hunger or tiredness) occurred during the teams' sessions. There was not an effect on the

testing scores of the GBI between the first and the second measurements because the GBI evaluated two different points in time, prior team experience and current team experience. The same instrument was used for all measurements and the same two people were used for the coding of the videotape and any questions that arose. The instruments were calibrated to an academic and team environment. Students were assigned to teams based upon the instructors' discretion or based upon with whom they had previously worked in the class. An identified weakness was the interaction of the sources of invalidity due to the nature of the nonequivalent control group design (Campbell & Stanley, 1963).

Four student design project teams were observed (recorded and videotaped) working on a senior level design project; two teams consisted of students from the same major (homogeneous) and the other two teams consisted of students from various majors (heterogeneous). The treatment (X) in this quasi-experimental design was the differentiation factor of the two teams, uniform by discipline or variable by discipline. The schedule of events for this study is depicted below (pre-test GBI before O1 and post-test GBI after O4):

Team 1 (homogeneous team)	KA/GBI	O1	O2	O3	O4	PMI/GBI
Team 2 (homogeneous team)	KA/GBI	O1	O2	O3	O4	PMI/GBI
Team 3 (heterogeneous team)	KA/GBI	O1	O2	O3	O4	PMI/GBI
Team 4 (heterogeneous team)	KA/GBI	O1	O2	O3	O4	PMI/GBI

KA = Knowledge Assessment, GBI = Group Behavior Inventory, PMI = Post-Meeting Interview

3.1.1. Independent Variables

The independent variables for this study were duration and frequency of the students' team meetings, as well as the type of teams involved, control teams

(disciplinarily homogeneous) and experimental (disciplinarily heterogeneous) teams.

3.1.2. Dependent Variables

The dependent variables were the reported factors of effectiveness from the post-meeting interviews, the responses to items in the Group Behavior Inventory, and the responses to the Knowledge Assessment, as well as the responses from the professors on the team evaluation. Another dependent variable was the frequency of indicators of agreement and disagreement acquired from the observations, which was measured based on a hypothesized process examining a specific aspect of communication patterns.

Dickinson & McIntyre (1997) have included communication as an input, throughput and output for their teamwork model prior to identifying and defining six additional core components of teamwork, which are team orientation, team leadership, monitoring, feedback, backup and coordination. Communication involves the active exchange of information between two or more members of the team, as well as individual team members providing information to other team members in an appropriate style. As a rule of thumb, communication is the linking mechanism between the previously listed components of teamwork (Dickinson & McIntyre, 1997). This emphasis on communication has driven the hypothesized process that convergence of team members on similar mental models can be examined through the observation and notation of the frequencies of agreement and disagreement. Utilizing such a method may result in being

deemed an appropriate manner in which to measure the convergence of team members on similar mental models.

Kraiger and Wenzel (1997) developed a preliminary framework for depicting the relationships among the latent construct of a shared mental model, their determinants and outcomes, and potential measures. “A shared mental model is an appealing way to characterize the process(es) in the manner in which team members share task information and mutual expectations for complementary task behavior” (Kraiger & Wenzel, 1997, p. 65). Proposed measures for shared mental models are processing information, structuring knowledge, common attitudes and shared expectations (Kraiger & Wenzel, 1997). With the intention of assessing the degree of shared attitudes, Kraiger and Wenzel suggest that team members should complete an assessment of their own perception of the team level attribute and then rate how they believe others perceive their attitudes (1997). This study was designed to assess common attitudes of team members to determine convergence, not necessarily the degree of convergence, therefore, team members were only asked to complete an assessment of their own perception.

3.2. Participants

Virginia Tech undergraduate students that were involved in the exploratory course, Electrical & Computer Engineering: Special Studies, and the Electrical Engineering course, Design in Power Engineering, for the 2007 Spring semester served as participants. The sample consisted of males and females and the students were in their fourth year of their university studies. The academic

disciplines that the students were involved in were Electrical & Computer Engineering (ECE & CPE) and Industrial Design (ID). The control teams' project involved developing improvements for the design of converting the university's solar house into a research facility for students, while the experimental teams' projects involved designing safety equipment for those who work in construction. Four student design teams were observed while working on a senior level design project. Two smaller teams were in each type of team (control and experimental). The disciplinarily homogeneous teams consisted of two teams of three students each, one with a team of three males and another with two males and one female, while the disciplinarily heterogeneous teams consisted of one team of two students (one male and one female) and one team of four students (one female and three males).

3.3. Equipment and Apparatus

The student team meetings and interviews were videotaped and audio recorded, respectively, for content. Since the students were in an academic setting, they were instructed to conduct their meetings in a quiet, non-distracting location, such as a study room.

3.4. Instruments

Five types of instruments were utilized in this study: 1) a knowledge assessment (Appendix A), 2) a 71-item inventory concerning behavior, 3) interview questions (Appendix B), 4) coding of videotaped meetings (Appendix C), and 5) a team evaluation by the instructor (Appendix D). A knowledge

assessment was used to organize the control and heterogeneous groups. This knowledge assessment was intended to create groups within the classes that are as equivalent as possible. The interview questions were geared to probe the students' minds and obtain their feedback regarding their current teamwork experiences, and more specifically the manner in which agreement and disagreement played a role in progress of the team meetings.

The utilization of the knowledge assessment assisted in constructing disciplinarily heterogeneous teams. According to Biglan (1973), three characteristics of academic subject matter are defined by dimensions, one of the most prominent being distinguishing hard sciences from humanities and social sciences or "hard-soft" disciplines (p. 201), which is termed the degree to which a paradigm exists. The other two dimensions, which characterize the subject matter in academic areas, are the degree of concern with application and concern with life systems (Biglan, 1973). Keeping these three dimensions in mind, it can be viewed that different disciplines, or academic subject matter, conduct themselves in a manner that best suits the discipline's beliefs, practices and standards. Therefore, it was plausible to say that the knowledge assessment would create roughly equivalent groups mainly determined by discipline, but also taking into consideration the student's prior experience, or lack thereof, in working in disciplinarily heterogeneous teams or even with those particular students in their class.

Maintaining Biglan's most prominent dimension that defines academic subject matter characteristics, the variation between 'hard' and 'soft' sciences,

the post-meeting interview questions (PMI) were geared to elicit qualitative responses from the students concerning their experiences in working with students from other majors, working on a team that did not communicate effectively and identifying strengths and challenges of the team they are currently working with. Such information assisted with identifying factors that may be associated with convergence, from actual team members' perspectives.

The Group Behavior Inventory was developed by Frank Friedlander (1966) with the intent to measure the performance and interactional dimensions of organizational work groups. Most of the items in the GBI were derived from a series of interviews with members of the highest-level group. Detailed notes were taken during these interviews and the verbatim comments were rephrased into questions to form the main body of the questionnaire. Additional items were obtained from observations, discussions and further literature on group behavior. While refining the initial questionnaire during the testing and retesting phases, variables were deleted that group members perceived as ambiguous or that gave an indication of low reliability. Internal consistency measures were computed by Friedlander (1966) using Kuder-Richardson Formula 20 and test-retest measures. In the original study, the Kuder-Richardson Formula 20 revealed the following reliability coefficients for each dimension:

- group effectiveness – 90
- approach versus withdrawal from leader- .91
- mutual influence- .72
- personal involvement and participation- .71
- intragroup trust versus intragroup competitiveness- 73
- general evaluation of group meetings 89
- submission versus rebellion against leader- .52
- leader control- .55

- role and idea conformity- .52

The first six group dimension scales (group effectiveness, approach versus withdrawal from leader, mutual influence, personal involvement and participation, intragroup trust versus intragroup competitiveness and general evaluation of group meetings) were deemed sufficiently high, while the last three dimensions (submission versus rebellion against leader, leader control, and role and idea conformity) were judged too low for statistical analysis to be conducted (1966). Responses to the GBI questions ranged from 'strongly disagree' to 'strongly agree' on a 5-point Likert scale. Certain questions deviated from this scale and instead, indicated that a number should be entered into the blank space provided. Objective measures specific to task and type of team were used to capture overall performance. The GBI questions focused on the members' perceptions of the team's overall performance. Many attitudinal measures were captured such as satisfaction, commitment to the organization and intent to leave (Cohen & Bailey, 1997).

The Group Behavior Inventory was suitable for measuring group effectiveness, as was intended by Friedlander (1966), for this particular study because it focused on the members' interactions at and attitudes towards work group meetings (Kaplan & Greenbaum, 1989). A pertinent aspect of this study was the examination of student team meetings. The inventory language was altered to better suit the academic and classroom atmosphere. An alternate method for measuring group effectiveness, the Team Interaction Profile (TIP), is more suitable for an organizational context because it measures performance

and behaviors that occur on the job as well as outside of the job. The Job Reaction Questionnaire (JRQ) was designed in 1980 to assess the effects of employee involvement programs on employees' perceptions of their work life (Kaplan & Greenbaum, 1989). It also may provide insight to problem areas and a focal point for change within the organization. The Group Behavior Inventory is more versatile as to the types of group/team it measures and its context.

A working hypothesis (hypothesis 2) was examined to determine if convergence was established by communication patterns, specifically, the frequency of indicators of agreement and disagreement (verbal and nonverbal) from video analysis. Ideally, the results of the communication patterns should corroborate the results of the Group Behavior Inventory. The frequencies of nonverbal indicators of agreement and disagreement identified on the videotape for all of the groups were noted. Even though it provides only one perspective of events, Hindmarsh and Pilnick found the use of video recording quite beneficial because it provides a continuously available resource (2002). The video allows for conclusions to be drawn with "both verbal and nonverbal elements of collaborative work and to analyze the ways in which these different elements of conduct are interwoven in action and interaction" (Hindmarsh & Pilnick, 2002, pp. 144). The informal interviews conducted by Hindmarsh and Pilnick provided them with a more thorough knowledge of the activities in which the participants were engaged to understand the way that they were coordinated and organized (2002). Individual interviews conducted for this study allowed the participants the opportunity to vocalize any concerns, major foci, or inputs that they thought were

relevant during their team's interactions pertaining to communicating with their team members and teamwork in general.

According to the APA Dictionary of Psychology, a group is defined as "in social psychology, two or more interdependent individuals who influence one another through social interaction" or in broader terms, "any collection or assemblage, particularly of items or individuals" and a team is defined as "an organized task-focused group" (VandenBos, 2006, p. 419). The APA defines a team as "an organized task-focused group. Members of such groups combine their individual inputs in a deliberate way in the pursuit of a common goal and are typically cohesive and united" (VandenBos, 2006, p. 926). Cannon-Bowers, Salas and Converse state that a team consists of differentiated and interdependent members (1993), while Klimoski and Mohammed define groups as collections of individuals whose duration together and distribution of responsibilities can fluctuate significantly (1994). As stated earlier, the inconsistency of terminology within the field is an aspect that needs to be addressed. It is correct that groups and teams are not the same by definition, but throughout the literature, the terms are used synonymously, by some researchers (not all). It is appearing that the term 'group' possesses aspects and features that are particular to teams. Also, when searching for the term 'group,' the results displayed articles and editorials in which the authors utilized both terms. When searching for the term 'team,' it was noticed that the authors specifically make a distinction between the terms 'group' and 'team' and emphasize that their discussion is concerning teams, not groups. Therefore, the

Group Behavior Inventory (although titled ‘group’) remains applicable to be administered to ‘teams’ as well as to ‘groups.’ So as to reduce confusion for this study, the focus was on teams, but the term ‘group’ was applicable to ‘team,’ while the term ‘team’ remained defined as stated above and was regarded higher in functionality than a group.

PROCEDURE

Prior to the teams’ first meetings, each student was administered a paper-based knowledge assessment (Appendix A) and paper-based Group Behavior Inventory. After the fourth observation, the Group Behavior Inventory (GBI) was administered once again to assess attitudinal measures of team effectiveness, in addition to the interview (Appendix B). The post-meeting interviews (PMI- Appendix B) allowed the students to provide feedback on their team processes and interactions up until that point, as well as previous experiences with team interaction. They were allowed to express their opinions about what worked for their team, what didn’t, and what they felt would help enhance the team’s effectiveness. The results were used to assist in determining what team members thought was needed to help them converge on the same mental model, and thus, become more effective.

The teams met in closed locations such as study rooms, department conference rooms and design studios. The researcher and camera were positioned at the front of the room with the intention to see all of the team members equally. In some team meetings, the researcher had to hold the camera and move around the room due to the repositioning of the team

members. Figure 6 shows examples of layouts of the teams during their meetings.

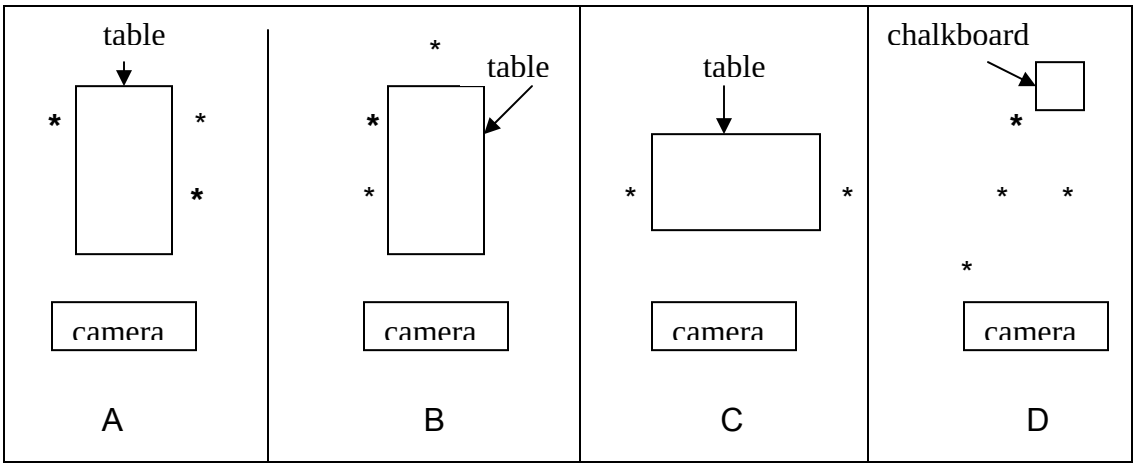

Figure 6. Layout of Team Meetings- A) Homogeneous Team 1, B) Homogeneous Team 2, C) Heterogeneous Team 1, & D) Heterogeneous Team 2. The asterisks represent the location of the students in relation to the camera.

DATA ANALYSIS

Data analysis of the videotaped group meetings consisted of two parts: 1) noting the frequencies of pauses and sighs in the team meetings and 2) having two coders, independently note the number of incidences of nonverbal body language indicators of agreement and disagreement for all of the teams' meetings, then agreeing on that number. All of the videos were watched in their entirety and paused each minute by the researcher to allow the coders to compare frequencies and come to an agreement. Graduate level students were solicited via email to participate as coders. The coders were one male and one female from the graduate program in Industrial & Systems Engineering. Once coders were available, a practice session was conducted where the two coders observed a team meeting (unrelated to the study) and had to reach agreement on the frequency of indicators within 80% correct to the researcher's observed frequencies. Greatbatch, Heath, Luff, & Campion (1995) examined how

conversation analysis may contribute to the understanding of the 'interaction' between individuals and computer systems. The primary sources of data for conversation analysis studies are audio and audio-visual recordings of "naturally occurring" interactions (Greatbatch et al., 1995, p. 202). Recordings allow the researcher access to the richness and complexity of social action, allowing particular events to be repeatedly dissected and thoroughly inspected. Such recordings are augmented by other methods for collecting data, such as, in this study, by using a questionnaire. Even though conversation analysis is a form of linguistics, it is not concerned about language in isolation. It focuses on the "situated organization of talk and involves the detailed inspection of the organization of utterances from within the situation in which they are produced and rendered intelligible" (Greatbatch et al., 1995, p. 203).

Content analysis was used to evaluate the voice-recorded student interviews. It is a research tool used to determine the presence of certain concepts within text. Krippendorff described the units of analysis, in particular, context units. Such units are "units of textual matter that set limits on the information to be considered in the description of recording units" (2004, p.101). "Units that are distinguished for separate description, transcription, recording or coding" are called recording/coding units (Krippendorff, 2004, p. 100). Live coding, a method developed by Dennis List, in which transcription of an interview is not prepared was utilized (2002). List's coding frames, a set of groups into which comments can be divided, were previously established and were defined as the six types of questions asked of the students (2002). The questions that

allowed the students to express their opinions concerning strengths and weaknesses of teamwork, in general and within their own team, were focused upon. The recordings were replayed and paused each minute to summarize the students' responses. The frequency of the students' answers was not emphasized due to the small sample size (6) in each type of team, therefore, all of the students' responses were reported.

Each coder had a protocol to follow (Appendix C), based upon the literature, concerning indicators of agreement and disagreement that were looked for and counted within each team's meetings. Three types of nonverbal indicators were looked for during the coding of the videotapes: body posture, body orientation and head movement. Guidelines and operational definitions were provided for the coders to apply during the video analyses. The body language indicators were counted as occurring while a team member is speaking. If no body movement was made from the listeners, no indicator was coded. The speaker was defined as the person who had been talking the most in the previous five seconds. In the team of four students, if they paired off into two and one person began speaking, the indicators were counted separately as ½ frequencies. If more than one team member was speaking at a time, the physical center of the group was considered "the speaker". The coders had to agree on the frequencies of each indicator for each video. If discrepancies occurred, the verbal conversation were listened to more closely while considering the body language in the context of what was being said. Bull and Connelly found that mainly a wide range of mainly hand/arm movements were selected by the

subjects as communicating emphasis, it was movements of all parts of the body that were related to vocal stress (1985). Condon and Ogston (1966) described a phenomenon called interactional synchrony, which is how the body of the listener moves closely in time with the speech and body movements of the speaker. If the speaker aims to draw the listeners' attention to a laptop or chalkboard and the listener follows, such an incident can be coded as an agreement indicator. For example, if the speaker is referring to an image on his/her computer and the listener turns towards the computer, then the action could be coded as one frequency of 'body orientation towards speaker.' A descriptive conclusion was made concerning the teams' state of convergence, not the degree of convergence, in relation to the other teams and understanding based upon those frequencies indicated by the coders. Pauses and sighs were observed by the researcher, while coders were only observing body language. Pauses and sighs were examined using a t-test while all nine constructs from the GBI and all of the agreement/disagreement indicators (nonverbal and verbal utterances) were examined with a Pearson correlation. The frequencies of body language indicators as well as the pauses and sighs were calculated into ratios by placing each frequency over the total length of the meeting. Utilizing ratios was necessary due to the varying lengths of the student design team meetings.

The scores of the knowledge assessment, which were administered prior to the creation of the teams, were compared using a t-test, therefore, allowing the comparison of homogeneous and heterogeneous teams. The interview questions were more open-ended and the responses were compiled to determine what the

students felt were the strengths/challenges and possible recommendations concerning teamwork. The scoring of the instructor evaluations (Appendix D) was used to determine any differences in between the two types of teams. The Group Behavior Inventory item responses were analyzed using a t-test and a Pearson correlation. The t-test was used to determine differences in the answers to questions on the GBI between the control groups and the disciplinarily heterogeneous groups. The Pearson correlation was used to determine if specific questions were related to one another, for example if a high response for one question would lead to a high response in another question. In addition, prior to the analysis of the GBI, Cronbach's alpha test for reliability was conducted to determine the reliability of Friedlander's dimensions concerning student teams, as opposed to organizational work groups. The Cronbach's alpha value of 0.70 was deemed an acceptable internal reliability coefficient (Nunnaly, 1978).

RESULTS

4.1. Hypothesis 1

The age range for all observed participants in the study was 21 to 24 (M = 22.42, SD = 1.16), while the age range for the control teams was 22 to 24 (M = 23.17, SD = 0.98) and the age range for the experimental teams was 21 to 23 (M = 21.67, SD = 0.82). The experimental team (both teams together) was 33% industrial design students and 67% Computer Engineers (CPE). The study involved 90% male engineers and 10% female engineers (Figure 7). The control team was 80% male and 17% female (Figure 8), while the experimental team was 67% male and 33% female (Figure 9).

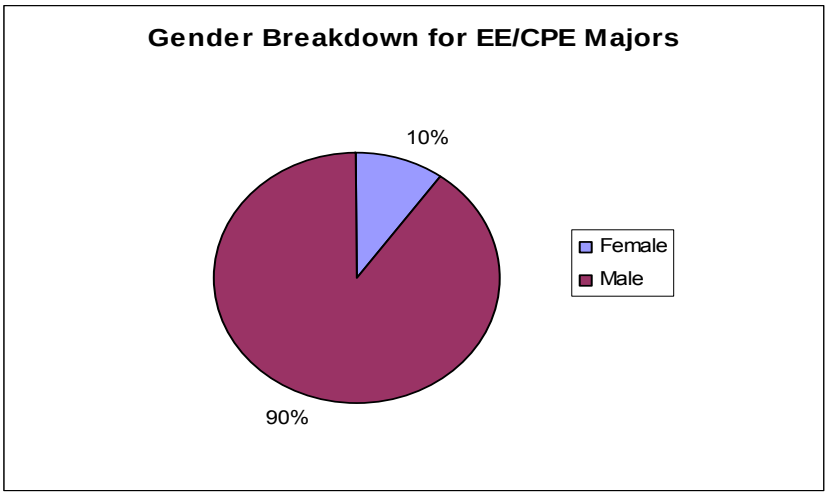

Figure 7. Gender Breakdown for EE/CPE Majors

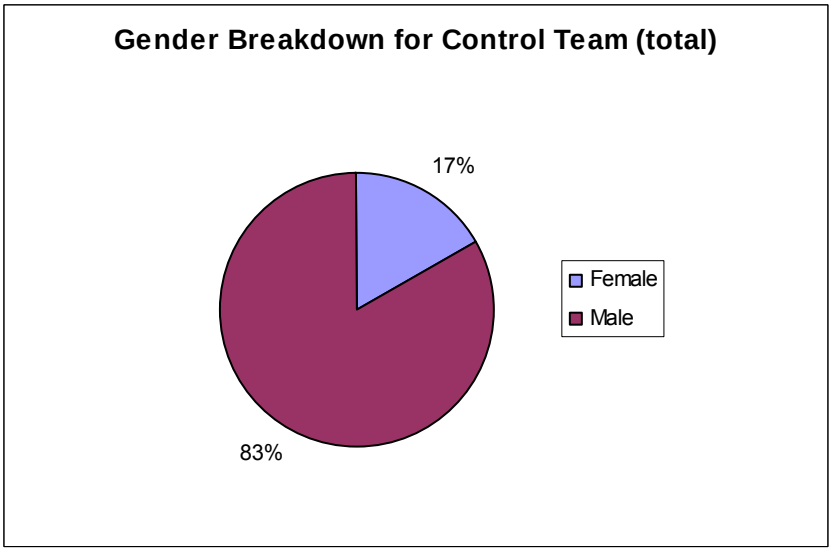

Figure 8. Gender Breakdown for Control Team

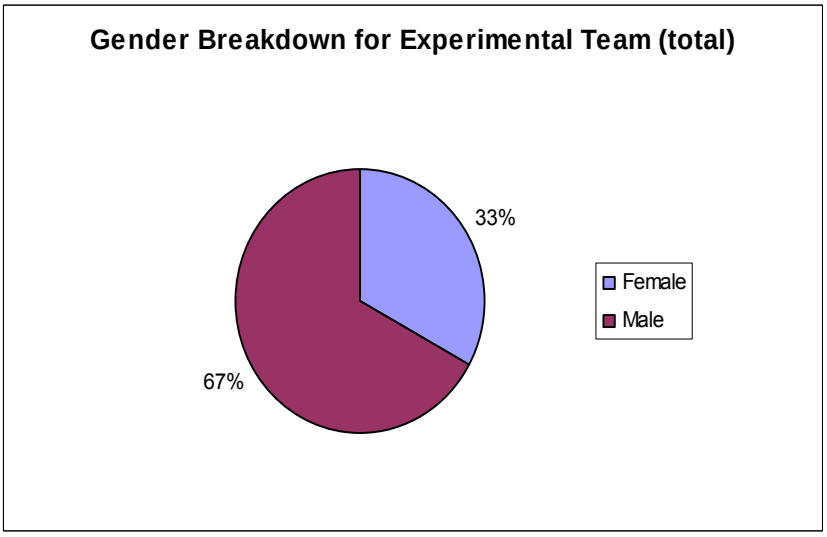

Figure 9. Gender Breakdown for Experimental Team

The knowledge assessment was administered to the students of each of the four teams for a total of 12 knowledge assessments. The mean score was 3.771 (*SD* = 0.37) with 1 indicating strongly disagree and 5 indicating strongly agree. The independent samples t-test (paired) between the control and the experimental teams resulted in a significant difference, $t(2) = 11.23$, $p < 0.05$, with the control group being higher.

Negatively worded questions in the Group Behavior Inventory were recoded to be analyzed consistently on a positively directed scale. The GBI was analyzed on the basis of nine constructs:

1. Group Effectiveness (#3, 9, 10, 11, 16, 26, 27 & 35)
2. Approach vs. Withdrawal from Leader (#39, 40, 41, 42, 44, 48, 53, 55, & 17)
3. Mutual Influence (#54, 43, 56, 45, & 46)
4. Personal Involvement and Participation (#52, 51,14, 7 & 29)
5. Intragroup Trust vs. Intragroup Competitiveness (#23, 25, 2, 6, & 37)
6. General Evaluation of Group Meetings (#65, 66, 67, 68, 69, 71)
7. Submission vs. Rebellion against Leader (#47, 50, 30, 36, & 70)
8. Leader Control (#1, 20, 70, & 5)

9. Role and Idea Conformity (#38, 12, & 15)

Questions 58-64 were dropped from the analysis due to the inconsistent answers that were given, therefore, not included in the constructs as originally calculated by Frank Friedlander (1966). Reliability of the constructs and an independent samples t-test were conducted on questions 1-57 and 65-71 for the pre-test and post-test GBI. The pre-test was given to 11 people, while the post-test was given to 12 due to one participant who neglected to answer questions when administered the pre-test. Friedlander dropped constructs 7-9 from his analyses due to their low reliability. These three constructs were tested in this study since its focus was on students instead of employees in an organization. The reliability was also found to be low, so the last three constructs were also dropped from this study. For the pre-test Group Behavior Inventory, the alpha value between the control and experimental teams was not significant, $t(2) = 0.30$, $p > 0.05$. The post-test Group Behavior Inventory for the independent samples t-test (paired) between the two types of teams was also not significant, $t(2) = -0.50$, $p > 0.05$.

The group behavior inventory was administered to 64 students to compare it to the reliability of the constructs in the pre-test GBI and post-test GBI. The reliability of the Constructs 1-9, respectively, were 0.831, 0.736, 0.124, 0.502, 0.591, 0.833, 0.195, -0.227 and 0.001. The reliability for questions 1-57 and 65-71 was 0.912.

The reliability of the pre-test and post-test given to the students on the 4 observed teams and the GBI given to the large group of students, as well as the test-retest values are shown below (Table 3). For the GBI given to the large

group of students, denoted as “All GBI Cronbach” in the table below, if question #37 was removed from Construct #5- Intragroup Trust vs. Intragroup Competitiveness, its reliability increased to 0.71. Examining the reliability for both the ‘All GBI Cronbach’ and the ‘Post-GBI’ columns, the GBI produced acceptable reliability for three of the six constructs, Group Effectiveness (1), Approach vs. Withdrawal from Leader (2) and Intragroup Trust vs. Intragroup Competitiveness (5). The reliability of the GBI changed for certain constructs from pre-test to post-test for the observed teams. The pre-test GBI was aimed to measure experiences and attitudes of previous teamwork, while the post-test GBI was aimed to measure experiences and attitudes of the team with which the students were currently involved. Reliability became acceptable (≥0.7) from pre-test to post-test for the Group Effectiveness, Approach vs. Withdrawal from Leader, Intragroup Trust vs. Intragroup Competitiveness, and General Evaluation of Group Meetings. Reliability became unacceptable (≤0.7) from pre-test to post test for the construct of Leader Control. There were significant differences between the pre-test GBI and the post-test GBI for constructs one, two, and five.

Table 3. Reliability of Group Behavior Inventory

Construct	Pre-Cronbach	Post-Cronbach	All GBI Cronbach	Pearson-Product Moment between Pre & Post (df = 9)
1	0.67	0.87	0.83	0.74**
2	0.41	0.78	0.74	0.65*
3	0.12	0.09	0.12	0.39
4	0.47	0.13	0.50	0.09
5	0.57	0.78	0.59	0.66*
6	0.32	0.74	0.83	0.41
7	0.80	0.30	0.20	0.68*
8	0.46	0.28	-0.23	0.02
9	-0.20	0.76	0.00	0.09

$p < 0.05$*
$p < 0.01$**

The control team had one professor conducting the course while the experimental team had three professors conducting the course. All four professors were asked to evaluate the respective teams in their course. For the t-test, to reduce confusion, the evaluations of the main professor for the experimental teams were used along with the evaluation of the professor for the control teams. The t-test resulted in no significant difference in the evaluation of the teams, $t(2) = -1.86$, $p > 0.05$. Cohen's kappa was utilized to determine the reliability of the evaluations between the three professors for the experimental teams. Professor A, who has a background in engineering, was the main professor, while Professors B and C, with backgrounds in design, were secondary. The reliability (Cohen's kappa) between Professor A and B was 0.03, between Professor A and C was 0.13 and between Professor B and C was -0.05. These discrepancies indicated that when a disciplinarily heterogeneous project-based course is administered by more than one professor, their grading perceptions of the teams' performances may vary.

The frequencies of pauses and sighs were counted by the researcher. Due to the varying lengths of team meetings by both the disciplinarily homogeneous and disciplinarily heterogeneous teams, ratio values were necessary. The frequency counts of sighs and pauses were placed over the total length of all team meetings for each type of team (disciplinarily homogeneous and disciplinarily heterogeneous). Table 4 shows the total frequencies of both types of teams, regardless of the total meeting lengths. The comparison of the ratios of sighs and pauses for each type of team to the total meeting length is depicted in Figure 10.

Table 4. Total Frequencies of Sighs and Pauses

	Sighs	**Pauses**
Homogeneous	39	124
Heterogeneous	30	78

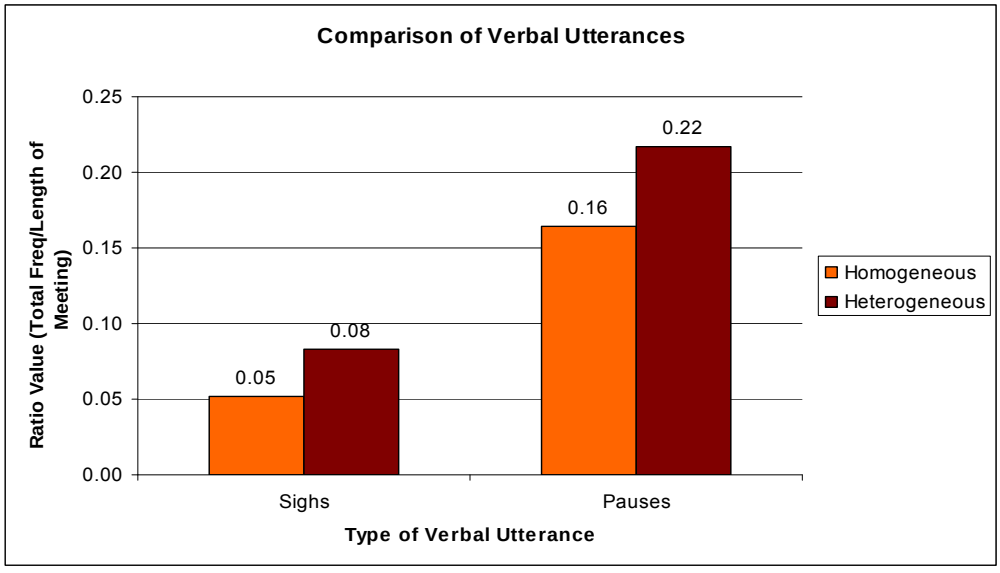

Figure 10. Comparison of Verbal Utterances

The sighs ($t(2) = -0.18$, $p > 0.05$) and pauses ($t(2) = -0.09$, $p > 0.05$) were also compared statistically, with neither being significant between the disciplinarily

homogeneous and disciplinarily heterogeneous teams. The total length of meetings for each type of team includes the total lengths of all four meetings of both teams. The disciplinarily homogeneous team met for a total of 754.66 minutes, while the disciplinarily heterogeneous team met for a total of 359.40 minutes (Figure 11). Due to the skewed distribution of the meeting lengths of the teams, a Mann-Whitney U test was run on the mean ratings and it showed that the time spent was significantly different between the two teams (U = 1.00, $p < 0.05$) with the control team being higher. Specifically, when taking into consideration the total length of the meetings for each type of team, the disciplinarily homogeneous teams disagreed more and the disciplinarily heterogeneous teams agreed more in terms of body language, while disciplinarily heterogeneous disagreed more through verbal utterances of sighs and pauses, the hypothesis is rejected.

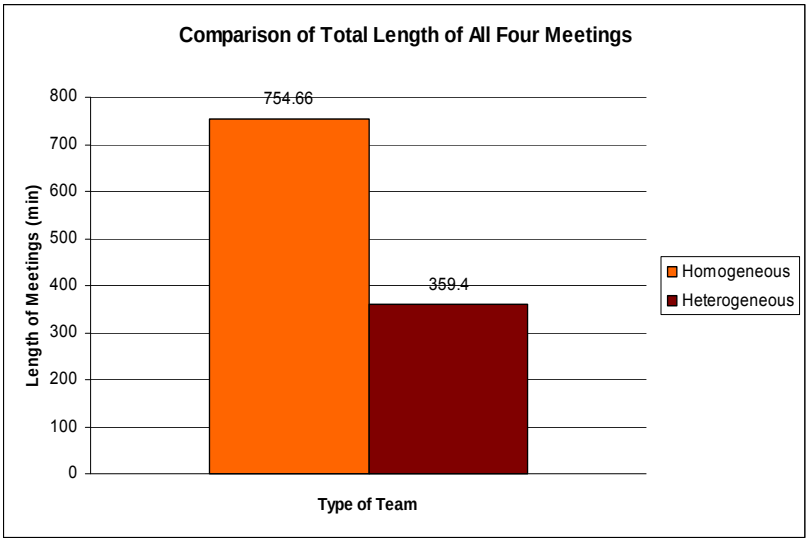

Figure 11. Comparison of Total Length of Meetings

The average time to the first verbal disagreement for the disciplinarily homogeneous teams was 21 minutes 57 seconds (*SD* = 3.39) into the meeting

while the average time for the disciplinarily heterogeneous teams was 12 minutes 11 seconds (*SD* =0.79) into the meeting. Each team's average time to the first verbal disagreement was similar with the exception of the second disciplinarily homogeneous team, whose average time was about three times as long as the other three teams. A verbal disagreement or a verbal conflict was defined as "an intense disagreement process between a minimum of two interdependent parties when they perceive incompatible interests, viewpoints, processes, and/or goals in an interaction episode" (Ting-Toomey, Yee-Jung, Shapiro, Garcia, Wright & Oetzel, 2000, p.48). Two examples of verbal disagreements from a heterogeneous team and a homogeneous team are shown below:

Heterogeneous Team 1:

Member 1: "Don't we have to have something posted on the website by tonight?"
Member 2: "This is my feeling on that"
Member 3: "I think he said 5pm by"
Member 1: "I thought he said 5pm by today, wasn't it?"
Member 2: "Well, whatever."
Member 4: "Well, we're past that anyways, so."
Member 3: "He said once a week."
Member 2: "This is my feeling."
Member 3: "No, he said, weekly reports Wednesday by 5pm."
Member 4: "Yeah, that's right."

Homogeneous Team 1:

Member 1: "We need to talk to them about what they really want. I'm assuming it's Dr. C because he's in charge of"
Member 2: "You got the names? We can divide up the names and find out"
Member 3: "No! The problem is, like, Dr. C, lets just assume he's the guy to talk to, he's organizing all the projects on this"
Member 1: "Right, right, yeah"
Member 3: "He's told us to do whatever you want. So we can't get much more from him as far as"
Member 1: "Well, that's the thing. We have to corner him to tell us what exactly he wants from us"

Member 3: “I don’t think that’s what he wants. I think what he wants is for us to decide and come up with ideas, not necessarily”

Member 2: “Well, we can’t decide it out of nothing. We gotta take suggestions from other people.”

The video analysis involved observing and noting the frequencies of a total of six nonverbal body language indicators, three signifying agreement (body orientation towards the speaker, nodding one’s head up and down and having erect posture) and three signifying disagreement (body orientation away from the speaker, shaking one’s head left and right and slouching and/or folding one’s arms across the chest. The indicators can be considered opposites of one another. Table 5 depicts the ratio values of each body language indicator for each of the two types of teams (control and experimental), while Figure 12 provides a clearer visual of the differences of the indicators between the disciplinarily homogeneous (control) and disciplinarily heterogeneous teams (experimental). The first three indicators signify agreement and the latter three, disagreement. The independent samples t-test indicated no significant differences between the teams pertaining to neither sighs nor pauses.

Table 5. Ratios for Body Language Indicators

	Body Orientation Towards	**Nodding Head Up and Down**	**Erect Posture**	**Body Orientation Away**	**Shaking Head Left and Right**	**Slouching/ Arms Folded**
Homog.	0.02	0.64	0.02	0.01	0.18	0.07
Hetero.	0.03	1.65	0.01	0.01	0.15	0.03

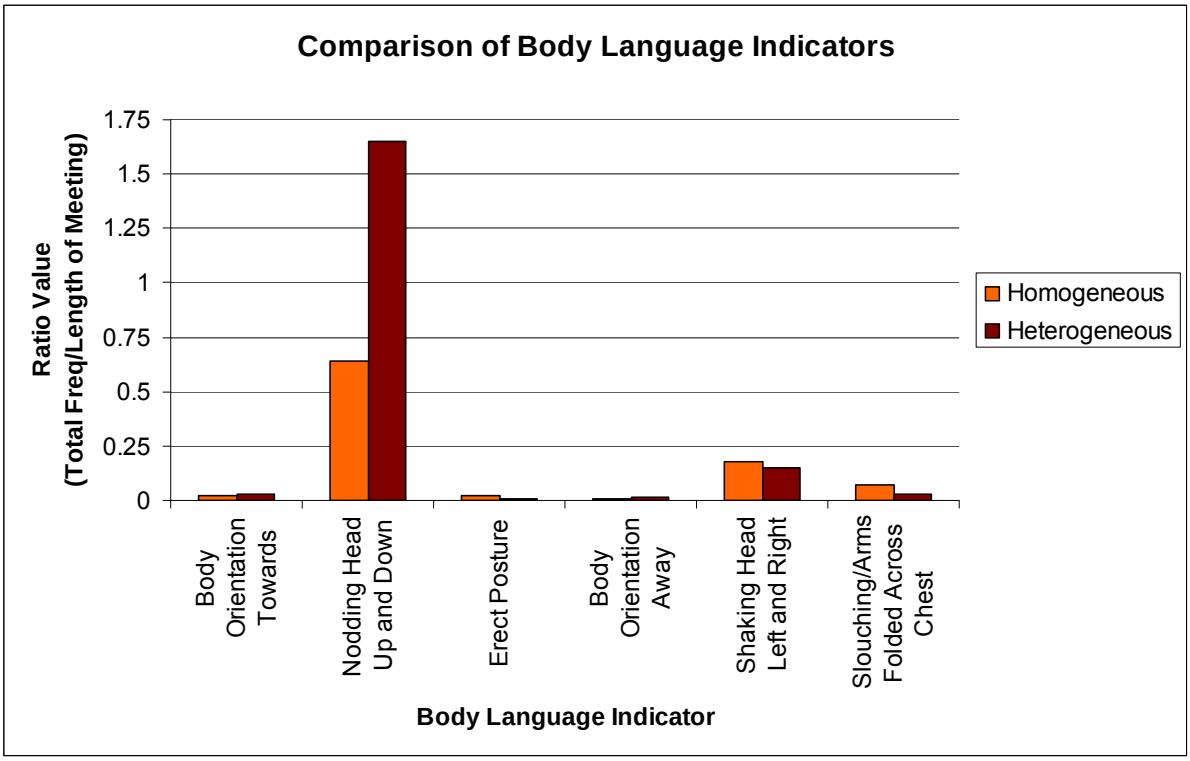

Figure 12. Comparison of Body Language Indicators

4.2. Hypothesis 2

The relationship between the Group Behavior Inventory constructs and the body language indicators (agreement and disagreement) produced fascinating results. Correlations (two-tailed) were shown significantly negative between Approach vs. Withdrawal from Leader (construct 2) and Erect Posture ($r(2) = -0.95$, $p < .05$), Intragroup Trust vs. Intragroup Competitiveness (construct 5) and Slouching ($r(2) = -0.97$, $p < .05$), and General Evaluation of Group Meetings (construct 6) and Nodding Head Up and Down ($r(2) = -0.98$, $p < .05$). Also, an interesting significant negative correlation was found between Slouching/Folding Arms Across Chest and Pausing ($r(2) = -0.96$, $p < .05$.

The student interviews (Appendix B) allowed the students on both of the observed teams to articulate their opinions and experiences concerning teamwork. Allowing the students to have an input into what they feel would be beneficial when working with disciplinarily heterogeneous teams will help students in the future who will be in similar situations. The students on the disciplinarily homogeneous teams and on the disciplinarily heterogeneous voiced some of the similar opinions, yet there were strong differences.

From the perspectives of the students on the disciplinarily heterogeneous teams, certain issues served as both positive and negative aspects of such an environment. Communication and compromise are very important, as with any type of interaction, but especially so when working with people from different backgrounds. Due to the different backgrounds, a lack of understanding concerning principles, approaches and methods from others is expected. The need to explain and clarify your point of view and reasoning when approaching a problem will help teammates from other disciplines look at the problem in a new light. Being respectful of other's views and remaining open to the possibilities that one's teammates can bring to the project will assist with the comfort level of the teammates and the flow of ideas. To enhance the openness of communication in the disciplinarily heterogeneous, one student went so far as to suggest that a social activity be planned by the students on the team prior to the start of the course project so as to help the students break the ice and get to know one another which will help lower personal barriers and reservations.

Communication was not only a positive aspect, but also was acknowledged as an obstacle for the disciplinarily heterogeneous team members. Possessing a background in a different discipline than one's teammates is an issue by itself. One's level of understanding of another discipline without having completed coursework in the particular field may be low, as well as one's comprehension of terminology. The lack of technological knowledge was vocalized as an issue for the engineers who were working with the industrial designers. The male/female composition of the disciplinarily heterogeneous teams was brought to light by a female industrial design student. The student's pre-collegiate academia consisted of schooling in an all female environment; therefore, working with males, engineers in particular, was a noticeable difference. This student's concern was the male engineers' reaction to working with not only an industrial designer, but a female. Although positives and negative aspects were addressed with the disciplinarily heterogeneous teams, the team members agreed that it is a very good experience and wished that more opportunities were offered to collaborate with others outside of their major. Such experiences in an academic setting will further prepare the students for real-world teaming.

The disciplinarily homogeneous teams expressed somewhat similar opinions concerning teamwork. Aspects that they found positive and conducive to the effectiveness of their teams were member being open to suggestions, communication, flexible schedules, compromising when conflicting ideas arose and being able to challenge one another's ideas and perspectives. The team

members also felt favorably towards their varying experiences within their field, the same level of academic knowledge (all senior level) and having a mutual respect for one another. There were many areas that needed improvement that would help the team thrive, some of which were personal issues, while others were pertaining to the group. Personal issues that were mentioned by specific people in general included missing scheduled team meeting with the professor, having more team meetings, accomplishing more during team meetings and sometimes straying off of the assignment topic to discuss irrelevant matters. Obstacles that the disciplinarily homogeneous team members vocalized included the communication between them containing “too much friction in conveying concepts” that led to very heated arguments, possibly due to the team members “having the same personalities,” all three being strong-minded and blunt, under-estimating the amount of work the project entailed and not having the best time management. Along the lines of gender composition of the teams, one male team member on an extremely contentious, all male team mentioned that if there was a female on the team, might work better together and be more productive. Cultural diversity, one’s accent/dialect of language, also caused difficulties in the disciplinarily homogeneous teams. If one’s native language is not English, the pronunciation of certain words or the usage of a word that may not be quite correct will cause confusion and misunderstanding with the other team members. (See Table 6 below for Synopsis)

Table 6. Guidelines for Student Design Team Members

Featured Aspect	Data Source	Finding	Recommendation
Communication	Interviews & Observations	Students from both types of teams mentioned having the ability to explain and clarify your point of view and reasoning will help your team members understand and exchange ideas.	Emphasize communication between team members to keep channels open.
Compromise	Interviews & Observations	The students realized that deciding what about the project you can live with and what you cannot live without will help move the project along and reduce strife.	As with working with other people, you cannot always get what you want. Pick your battles wisely.
Body Language	Observation, correlation & t-test	The disciplinarily homogeneous teams disagreed more, while the disciplinarily heterogeneous teams agreed more in terms of nonverbal communication (body language).	One's body language tells even more information in addition to what their words are saying. If you have a feeling or can tell that someone is bothered by what is being said, deal with it in a sensitive manner.
Respect	Interviews	The students articulated that although disagreements arose throughout the duration of their projects, they felt that showing consideration for others and their opinions was not compromised, even though it may have appeared so from an outsider's perspective.	Regardless of various differences between you and your team members, remain respectful towards everyone, just as you would expect in return.
Being Open to Others' Ideas	Interviews	Members from both teams voiced that approaching the problem/project from another perspective may enrich and enhance the deliverables for the assignment. Some students in the disciplinarily homogeneous team had a tremendous amount of difficulties with this concept.	Address the situation and look at everything from all perspectives. A new idea from another area may be just the aspect to enhance the deliverable.

Social Activity Outside of Class/Work	Interviews	An engineering student, in particular, stated that an ice breaker outside of class would allow the team members to get to know one another and feel more comfortable around one another, which will in turn ease the flow of ideas and diminish the hesitance of sharing one's ideas with the team	Once you are in your teams, take time to get to know each other outside of the course by hanging or going to dinner.
Differences in Discipline (ex. principles)	Interviews	Disciplinarily heterogeneous team members expressed this feature as not only a positive impact, but also a negative, on teamwork.	Compiling knowledge from more than one academic area will bring richness to the experience, as well as the project.
Knowledge/Back-ground Experiences	Interviews	Homogeneous team members utilized knowledge from internships or summer jobs that are not learned from classroom experiences. These experiences not only have an impact on the project's deliverable, but also the enhancement of all of team members' knowledge.	Attempt to utilize everyone's knowledge in spite of how minimal you feel it may be or how unrelated you may feel it is.
Gender	Interviews	Within the disciplinarily heterogeneous design teams a female designer expressed her views of working with males in an academic realm. Her pre-college, all-female educational environment impacted her comfort level and the manner in which she worked with her male engineer teammates.	Being aware of the gender of your team members, as well as any stereotypes that you may have towards them, will assist with the team dynamics.
Culture	Interviews	The disciplinarily homogeneous teams consisted of students from various countries. Strong cultural differences, mannerisms and language barriers caused confusion within the team.	If your team members are from various cultures, ask them how things are done in home country or how they were taught if they did not have a US-based education.
Personality	Interviews & Observation	Conflicts in personality (ex. blunt, head-strong,	Not only asking your team members how best they

		shy, talkative, sensitive) were strongly evident in the disciplinarily homogeneous teams. Such students acknowledged that not taking into account and being aware of such differences may lead to hurt feelings or various degrees of arguments or disagreements.	work with teams and also how they prefer to start projects will give you a little insight to how they are as a person. As your interactions continue, pay close attention to the reactions of your teammates to certain situations.
* Note that this list is not exhaustive.			

DISCUSSION

5.1. Hypothesis 1

The demographics and knowledge assessment was originally intended to assist with the formation of the teams with willing participants who completed the assessment. The t-test results indicated that the control and experimental teams were unequal on the basis of the knowledge concerning teams from the start of the experiment. This was due to the quasi-experimental design of the study. The difference in knowledge about teams between the students in the control and experimental teams may be a result of differing academic and real-world experiences. Some students had completed an internship or had prior working experience in which the employer may have addressed teamwork. The differing experiences may have been impacted by the age of the students. The mean age of the control team was approximately two years older than the experimental team; therefore, that two year age difference may have allowed them more time and opportunities for non-university related, teamwork-based projects or employment.

The Group Behavior Inventory was originally designed for organizational work groups. The disciplinarily homogeneous and disciplinarily heterogeneous teams were not significantly different in their GBI scores for the pre-test or the post-test. A potential reason for this lack of difference between the two types of teams may lie in the confusion and misunderstandings of the terminology used in the instrument. Since the instrument was left in its original 1966 format, with the exception of changing ‘chairman’ to ‘chairperson’ and ‘group’ to ‘team,’ the students may have had difficulty understand what the questions were asking. Adults from the participating organizations in the original study may have had fewer misinterpretations with the terminology that was used. A particular question that the students repeatedly posed to the researcher was concerning the definition of a team leader. There were also questions concerning the meaning of the term ‘policy’ within the GBI questions. As a result of the uncertainty of what was being asked, the responses to certain questions in the GBI, in actuality, may not clearly reveal the students’ feelings and opinions. Through examination of the fluctuation of the reliability scores across the three instances it was administered, as well as the Pearson-Product Moment comparison, the Group Behavior Inventory may not be an appropriate instrument to use in an academic setting for student teams.

The professor evaluations of the teams were deemed not significantly different, even though the raw scores indicated otherwise. The teams were evaluated on the same scale by the professor of the control team and Professor A for the experimental team. According to MacKenzie, Shapiro and Eastham’s

(1985) guidelines for interpreting kappa statistics, the strength of Professor A and Professor B is ‘fair’ and the strength of both Professor A and Professor C and Professor B and Professor C is negligible (Neale, Rokkas, & McClure, 2003).

The first hypothesis for this study was that the disciplinarily homogeneous teams would have fewer utterances of disagreement and nonverbal actions representing disagreement than disciplinarily heterogeneous teams. Without taking meeting duration into consideration, disciplinarily homogeneous teams had more utterances of disagreement. Once the ratios were calculated, the disciplinarily heterogeneous teams had more verbal utterances signifying disagreement (sighs and pauses) per minute than the disciplinarily homogeneous teams, even though the ratio of sighs and pauses were not significantly different between the two types of teams.

A strong possibility for the discrepancies in the agreement and disagreement, verbal and nonverbal indicators could have been due to the teams being in different developmental stages. The framework of team developmental phases is useful for understanding the counterintuitive results. Groups advance through four main developmental stages (Tuckman, 1965) at various durations and at various intensities, therefore, the frequencies of agreement and disagreement indicators may differ depending on which stage the teams are in. Tuckman (1965) found that natural and laboratory groups develop through four phases: testing and dependence (forming), intragroup hostility (storming), development of group cohesion (norming) and functional role-relatedness

(performing). Tuckman and Jensen (1977) revised the developmental model and added an additional, fifth phase, adjourning.

Via observation, the dynamics of certain teams and the interaction between the members fluctuated. Certain teams appeared to remain in certain developmental phases much longer than other teams. It appears that homogeneous team #1 remained in Tuckman's intragroup hostility, or storming, phase for a majority of the duration of the project, while homogeneous team #2 seemed more complacent with allowing one member to take control and lead the team. There was a possibility of two ideas concerning homogeneous team #2; they either remained in the forming stage and worked in that manner or they expeditiously progressed through all four phases with minimal visibly noticeable differences signifying those phase progressions, with the latter being more probable. During the duration of the study, the teams may or may not have reached certain team phases or if even possible, may have skipped phases. Future studies may be able to determine the definitive times at which teams change from phase to phase, if certain phases are skipped, and if once a team has passed through a particular phase, can digression occur and the team reenters a previous phase. Although previous studies have not indicated such, a possible reason for such conflict within disciplinarily homogeneous team #1 may be due to intragroup conflict. Team members within the same major may be, consciously or unconsciously, competing against one another to prove one's knowledge in the field as superior to the other team members. Becoming stuck in the intragroup hostility phase may have led to the large amount of time that the

disciplinarily homogeneous team #1 spent meeting and basically, not accomplishing very much.

Agazarian & Gantt (2003) conceptualize the phases of group development based upon Agazarian's theory of living human systems (1997) and K. Lewin's field theory (1951), which consist of three phases- the Authority Phase, the Intimacy Phase, and the Interdependent Work Phase. In the 1960s, Agazarian and Gantt discriminated the behavioral modes that characterized the different phases of group development using SAVI. SAVI is a verbal observation system that codes verbal behavior into categories, which results in a matrix of nine classes of behavior that discriminate between the verbal behaviors that facilitate the transfer of information and those that introduce noise into the system (Agazarian and Gantt, 2003). The discrimination of the phases was done in the 1960s by having students generate explicit and replicable patterns of verbal communication behaviors that denoted fight or flight phases in group development. The patterns that surfaced indicated diverse frequency counts of the verbal behaviors distinguishing of each phase. For example, the SAVI pattern of a group in flight was distinguished by a high frequency of storytelling and small talk, while a high frequency of "yes, buts" and blame were distinguishing of a group in the fight phase (Agazarian and Gantt, 2003).

The importance of the understanding of deviant behavior in the context of the group's phase of development was clearly elaborated upon. Agazarian and Gantt (2003) arrived at the conclusion that when deviance is understood as a deviation from the normal verbal behaviors that should occur within each

developmental phase, the leader will be able to evaluate the consequences of their interventions and judge their methods based upon what happens after their intervention. With respect to the examination of communication patterns in this study and the concept of developmental phases in groups (regardless of the number of stages in comparison to Tuckman, 1965), SAVI could be utilized in addition to nonverbal communication patterns to determine team mental model convergence. Although the focus was only on verbal communication, Agazarian and Gantt (2003) substantiated the need to examine polar aspects of communication, referring to fight or flight, which aligns with this study's focus of agreement and disagreement.

5.2. Hypothesis 2

The second hypothesis for this study was that the observed indicators of agreement and disagreement will be positively related with the Group Behavior Inventory scores. The post-test GBI scores by construct for each team were related to the observed indicators of agreement and disagreement. The negative relationship between the body language indicator that signified disagreement and a certain Group Behavior Inventory construct corroborate the hypothesis, but the negative relationship between body language indicators that signify agreement and the particular GBI constructs do not. The perception of Intragroup Trust increases while the occurrences of one slouching or folding one's arms across the chest while someone is speaking decreases. The perception of being able to approach the team leader decreases as the occurrences of erecting one's body posture (suggesting agreement) while someone is speaking during a meeting

increases and the positive general evaluation of the team meetings decreases as the occurrences of nodding one's head up and down (also suggesting agreement) increases. There was an interesting negative relationship between two body language indicators that represent disagreement- slouching or folding one's arms across the chest in the midst of another team member speaking and pausing before responding to another team members' question or comment. One reason for this particular phenomenon may be that one or both of these indicators do not always represent disagreement. Such an action being displayed in the midst of another team member speaking could be pure coincidence, have the potential of signifying lesser emotional reactions, such as restlessness, or signify merely a change to a more comfortable body posture. Therefore, the corroboration of the Group Behavior Inventory constructs can only be applied to the one disagreement indicator.

Due to no significant differences between the teams on the bases of the post-test Group Behavior Inventory scores and the agreement/disagreement body language indicators, including the verbal utterances, the hypothesized process (Figure 13) requires further investigation to be able to confirm this process. An aspect that needs to be examined in relation to this process is the developmental phases for groups. The frequencies of agreement and disagreement indictors (both verbal utterances and nonverbal communication) may vary depending upon the developmental stage that the team is in. Consequently, the process can be examined by stage or an aggregate can be

compiled in order to determine the results for the team as a whole and for the duration of the teams' time together from forming to adjourning.

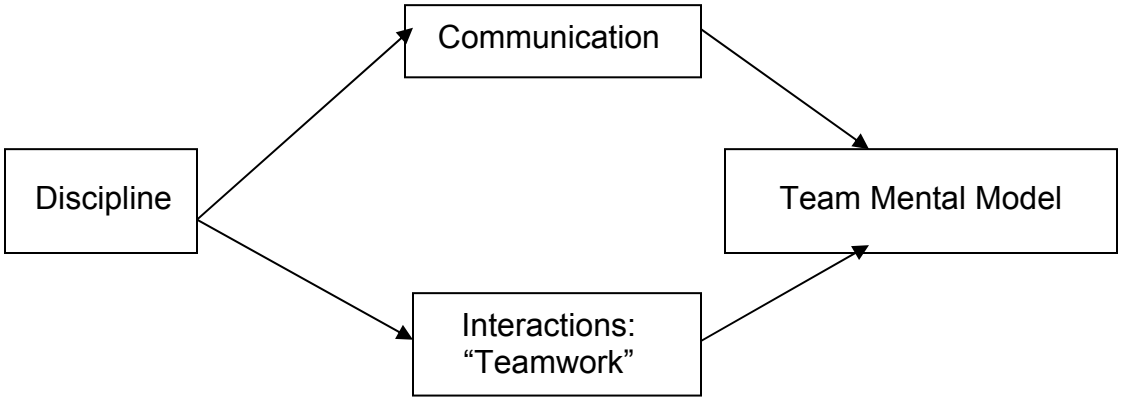

Figure 13. Hypothesized Process- Model of Disciplinarily Heterogeneous Teamwork for an Individual

It has been found that the verbal message does not always correspond to the displayed nonverbal actions (Eskritt & Lee, 2003). The concept of agreement and disagreement in teams can be prescribed to telling the truth as opposed to telling a lie. The verbal-nonverbal consistency principle is used to infer the truth from a lie (Friedman, 1979). The principle stipulates that the "perceived truthfulness of a person varies as a function of the consistency between the affect exhibited in verbal communication and the affect exhibited in nonverbal communication" (Rotenberg, Simourd, & Moore, 1989, p. 309). The usage of the principle stems from the comprehension that verbal and nonverbal communication *should* convey the same fundamental emotional state and that inconsistency in the emotion displayed implies that there is dishonesty (Rotenberg, Simourd, & Moore, 1989). In this study, the verbal utterances did not correlate with the nonverbal communication (body language indicators); therefore, it can be inferred that the verbal utterances may not only have signified disagreement, but possibly frustration, tiredness, anxiety or anticipation. The

discord between these two types of communication is not to say that the person is consciously lying via their verbal utterances, but merely stating that disagreement may not be the only definition. In this case, there is a possibility that ‘actions do speak louder than words’ and that the nonverbal message divulges the actual intentions of the speaker (Demorest, Meyer, Phelps, Gardner, & Winner, 1984).

Words and nonverbal signals are used together to convey information, but nonverbal signals appear to be particularly important in conveying affective information (Argyle, Salter, Nicholson, Williams, & Burgess,1970). Even though the verbal and nonverbal messages may not be congruent, context should be taken into consideration as well, when attempting to decipher and understand another person. Shapiro (1968) found that some individual differences in judges’ abilities to rate cues of emotion could be due to personal preferences for information through verbal or nonverbal cues. The need to attend to both verbal and nonverbal communication, instead of merely one channel, is that Vande Creek and Watson (1972) found that when conflicting cues are present concerning the degree of stress that a person is experiencing, others may differ reliably in their assessment of the stress. In addition, Mehrabian and Ferris (1967) found that attitudes gathered from two-channel facial-vocal attitude communications are a linear function of the attitude communicated in each component, with the facial component receiving approximately 1.5 the weight received by the vocal component. The linear model suggested that the effect of redundancy is to strengthen the feeling that is communicated in any one of the

component channels. It is also suggested that the collective result of concurrent verbal, vocal and facial attitude communications is a weighted sum of the individual components (Mehrabian & Ferris, 1967). Mehrabian and Wiener (1967) found that the variability of presumptions about communicator attitude based on the information available in content and tone joined is mainly contributed by variations in tone alone. In line with the work of Mehrabian and Wiener (1967), Walker and Trimboli (1989) made the assumption that the affective tone of the interaction can be established by examining the communicational context for any given message; therefore, mixed messages were analyzed for channel dominance. The study revealed that affective messages are, at times, intricate combinations of cues in which the roles of the verbal and nonverbal channels are intertwined to communicate several messages synchronously (Walker and Trimboli, 1989).

5.4. Recommendations

The various channels that were utilized to elicit information pertaining to teamwork allow for the formation of a list of guidelines that will assist disciplinarily heterogeneous design teams to work more effectively. The results of the study brought to light of what aspects team members should be aware when working on a team, specifically a disciplinarily heterogeneous team. Various disciplines have their own principles, methodologies, and practices, therefore, when people from these various disciplines come together to achieve a common goal, there are certain things that may be more salient of those coming from outside of their discipline. Some aspects may help or hinder a team if not properly addressed

and utilized accordingly. Table 6 (previously shown) recaps the facets to which team members should pay attention in order to work well together. The guidelines for design teams can be utilized by professors and students at the university level in various ways. The professors may introduce the guidelines at the start of the course when discussing the course expectations and project/assignment regulations and procedures. If the professor feels that further explanation is needed for the students in the course, a workshop or lecture series may be deemed appropriate and most beneficial. Organizations may also familiarize their employees to such guidelines through workshops or through an in-house certificate course.

5.5. Limitations

5.5.1. Design

The quasi-experimental design used in the study served as a limitation, especially concerning the intention of forming the teams under certain stipulations, which did not occur. The control teams, formed by the researcher, consisted of students who had not worked together on the previous course assignment. Very few students were interested in participating; therefore, there were just enough students to barely form two teams. The course's three professors formed the experimental teams. The professors formed the teams on the basis of how strong each individual student was in their respective academic area. For example, two very strong industrial designers were not placed on the same team with electrical engineers; they were, instead, interspersed among the

teams with the engineers. There were more engineering students enrolled in the course than industrial design students. The professors aimed to place one strong industrial design student on a team with more than one engineering student.

A sacrificing of external validity would allow for more researcher control over additional independent variables. The formation of the teams by gender, cultural background or based upon the participants' knowledge of teamwork would allow for differences due to such components to possibly become more salient. The administering of a uniform task to all teams may uncover true differences between certain aspects on which the teams were formed. The amount of time that the teams would have to work on the task would also be uniform across teams. Compromises between control and generalization could be made to determine the impact of certain aspects addressed by the researcher.

5.5.2. Team Size

Although this study utilized the team-level of analyses, the sizes of the individual teams within the disciplinarily homogeneous and disciplinarily heterogeneous teams posed some concern. In a study by Laughlin, Hatch, Silver and Boh (2006), it was found that groups of 3, 4, and 5 did not significantly differ from each other on either trial to solution or letters per equation. It was also found that three-person groups performed better than two-person groups (Laughlin et al., 2006). The Laughlin et al. study (2006) did not state whether the process quality was different between teams of 3, 4 or 5. Groups of 3 are "necessary and sufficient to perform better than the best of an equivalent number of individuals..."

(Laughlin, 2006, p. 650). Holloman and Hendrick stated that since groups of 6, 12, and 15 were equal in accuracy, "considerations of economy point to the use of groups of approximately 6" (1971, p. 500).

Whereas the two teams within the disciplinarily homogeneous and disciplinarily heterogeneous teams varied from two people to four people, they were compared as only two types of teams, equaling six students each (in some cases five students versus 6 students); therefore, the smaller team size of two students may have impacted the contribution to the construct of team mental models. A team can consist of two people, but a shared mental model is more applicable to such conditions, while a team mental model can be addressed with three or more people.

5.5.3. Group Behavior Inventory

Due to the fact that the GBI was created for use in an organizational atmosphere, university level students had some problems and confusion with certain terminology and wording in the document. Particular constructs that the Group Behavior Inventory addressed as not clearly present, if at all, in a student design team. In such an environment, one main point of contention is the idea of a team leader. A team leader is not directly specified in the manner in which it is so in an organization (ex. Project manager). The questions asked and the responses received varied within three categories- the professor is the team leader, any random team member is the team leader or we don’t have a team leader. Without a clear, consistent definition of a team leader, the results for the constructs of approach vs. withdrawal from leader, submission vs. rebellion

against leader and leader control are not as structurally sound. Intragroup competitiveness is also a questionable construct when pertaining to students versus employees in an organization because the students are graded as one team. They are not given an individual grade from the professor in addition to the team's overall grade. Employees in an organization do not receive grades, per se, but they are evaluated based upon certain criteria, which in turn, may impact their salaries or chances for a raise.

5.5.4. Eye Gaze & Contact

Eye gaze and contact would have been a more sensitive indicator to evaluate from the video if proper equipment and resources were available. Kleinke (1986) noted the most common procedure for measuring eye gaze in an experimental setting would be to have at least two observers behind a one-way mirror press buttons connected to clocks and counters or to recording pens when one person directs his or her gaze toward the face of another. Even though recordings were made with videotapes, they were not utilized in a manner that would allow proper evaluation of eye gaze. Two cameras with a split screen or one camera and a mirror can be used to concurrently photograph two people and the accuracy can then be enhanced by recording from slow motion or from individual frames (Kleinke, 1986). Those who look more are seen as attentive, while those who gaze little are viewed as passive and inattentive (Kleinke, 1986). People gaze more if they anticipate a positive reaction from another. Foddy (1978) found that individuals also look more when cooperating than when competing against one another. Mehrabian (1968a) found that males have

significantly more eye contact with liked addressees than with disliked addressees, females did not. Mehrabian and Friar (1969) indicated that in a sitting position, male communicators had less eye contact with disliked addressees than with liked addressees. Females had significantly less eye contact with disliked male addressees than with liked males, liked females or dislike females. Therefore, males show greater variability in their eye contact with their addressee relative to females and they more consistently exhibit greater degrees of eye contact with liked than disliked addressees. Gaze across cultures vary, but the phenomena are the same (Argyle, 1988). Greater degrees of eye contact with an addressee tend to be associated with a more direct orientation of the head, shoulders, and legs of a communicator toward his addressee (Mehrabian, 1969).

CONCLUSIONS

5.3. Future Research

5.3.1. Nonverbal Communication

The findings of this study suggested that, on the surface level, disciplinarily homogeneous teams disagree more and the disciplinarily heterogeneous teams agree more in terms of body language, while disciplinarily heterogeneous disagree more through verbal utterances of sighs and pauses. Although, the Group Behavior may not be the ideal instrument to be utilized in the future to measure team effectiveness of students, the scores did corroborate some of the results of the body language indicator analyses. With further exploration, body language indicators of agreement and disagreement

concerning the aspects pertaining to the team could be utilized to establish the convergence of team members onto similar mental models and to then determine which team has the stronger mental model. Such a method would not be used alone, but in conjunction with an examination of context and other methods (direct or indirect) of mental model elicitation and representation, such as the visual card sorting technique or observation of the task (Langan-Fox, Code & Langfield-Smith, 2000). Similarities between participants as well as accuracies to an expert model can be revealed and corroborated, resulting in further information concerning the team mental model. In addition to discipline, personality and gender were vocalized and observed as issues that may impact the effectiveness of a team.

5.3.2. Discourse & Conversation Analysis

Discourse analysis serves as an umbrella term for a number of approaches to analyzing the use of written, spoken and signed language. There are many types of discourse analyses, such as rhetoric, ethnography of communication, conversation analysis, and pragmatics. Conversation analysis (CA) could be used in further studies. It is concerned with how the involvement of different speakers is enmeshed together in conversations and the way different types of actions, such as blaming, excuses, and greetings are produced and managed (Potter & Wetherell, 1987). CA concentrates on the details of naturally occurring conversations represented in verbatim transcript. These naturally occurring conversations have become a distinctive feature of conversation analysis (Wooffitt, 2005). Normally, analysts study a number of instances of one

phenomenon and then make an attempt to clarify its systematic properties (Potter & Wetherell, 1987).

The discipline of CA was developed in the late 1960s and 1970s by Harvey Sacks and Emanuel Schegloff (Ten Have, 1999). Harvey Sacks was attempting to develop a new method of sociology in which analytic observations were grounded in detailed analysis of actual instances of human behavior. Therefore, he rejected any artificially produced data, such that would be generated in an experimental setting or an institution. The use of audio recordings allows the analyst the ability to transcribe what is said to the necessary level of detail and to repeat what is said at numerous times and occasions (Wooffitt, 2005).

Since verbal interaction is characterized with details by transcripts, intuition as an analytic guide has been abandoned. Introspection does not allow researchers to imagine how false starts to words and even the simple act of drawing a breath can have genuine consequences for the way in which interaction unfolds. An utterance may have a strong impact on an interaction based upon its location in a series of utterances (Wooffitt, 2005). Sack's focus, in addition to turn-taking, can be divided into three ideas – 1) the investigation of ordinary talk as the vehicle for interpersonal social actions: utterances are examined as activities people do to each other, 2) CA examines the highly patterned nature of these verbal activities in interaction- identifying and analyzing the properties of recurrent sequences of interaction, and 3) identifies the normative expectations which strengthen action sequences (Wooffitt, 2005).

5.3.3. Phases of Development in Groups

Further investigation with the body language indicators within the phases of development in small groups (Tuckman, 1965) would reveal much more concerning the hypothesized process from team differentiation by discipline to establishing the convergence of a team mental model. Future studies could determine which phases the teams are in and the duration of that phase, then examine the agreement and disagreement communication patterns over the total duration of the development phases to determine the strength of the team mental models. Due to the various lengths of duration in certain developmental phases, specifically the intragroup hostility phase, conflict resolution, so as to not allow conflict to the point of hindering productivity to engulf the team, could also be addressed in addition to the guidelines for team effectiveness. Negotiation and mediation are the most common forms of conflict resolution (Shin, 2005). Within interdisciplinary health care teams, approaches to conflict and interdependent decision-making, not only include negotiation, but also withdrawal, accommodation and collaboration (Drinka, 1994). Drinka (1994) found that the team's ability to deal with conflict constructively was linked with the developmental phase of the team. Conflicts do occur in each phase, yet are viewed differently. Hirokawa (1983) found that even though there are several different sequences of phases that are associated with "successful" and "unsuccessful" group problem-solving, "successful" teams begin their discussion by analyzing the problem before searching for a solution to it, while

“unsuccessful” teams tend to first search for a feasible solution without prior analysis of the problem.

5.3.4. Gender

Research has verified that gender does have an influence on group interaction (Carli, 1989). Mabry found that women display a greater amount of agreement and other constructive social behaviors, such as alleviating group tension, whereas men engage in a greater amount of disagreements (1985). Lockheed and Hall suggest an explanation for this difference is due to that fact that as a group, men have higher status than women (1976). High group status members (men) are assumed to be more competent, receive more opportunities to make task contributions to the group discussion and receive more support for their contributions (Berger, Cohen & Zelditch, 1972). It has been suggested that women try to gain acceptance from other group member by engaging in high amounts of positive social behavior, which may communicate to others that the female is not challenging their status, but merely trying to help the group achieve its goals (Meeker & Weitzel-O’Neill, 1977). Agreement should convey an altruistic desire to help the group and thereby, increase a group member’s ability to influence others; Such positive social behaviors may be most successful when the influence agent is of low status, such as a woman attempting to influence a man (Meeker & Weitzel-O’Neill, 1977). Further studies could form the teams with further gender diversity from both field of engineering and industrial design, as well as various personality types to determine the impact on student teams.

5.3.5. Team Effectiveness & Mental Models

Organizations have been using collaborative teams to produce products. Teams are thought to work well under certain conditions and are formed based on notion that 'two heads are better than one'. It creates a dilemma when team members are not equipped to function as an entity (Mohrman, Cohen, & Mohrman, 1995). Convergence of many team members onto similar mental models can be brought about through many avenues, one such being training. The establishment of team convergence through verbal/nonverbal communication cues could reveal additional information pertaining to the team members having similar and accurate mental models, as well as the areas that the team should improve upon to be more effective.

Training is thought to deliver accurate and efficient mental models for team development (Langan-Fox, Anglim, & Wilson, 2004). According to a study by Marks, Sabella, Burke and Zaccaro (2002), cross-training assisted the progress of team-interaction models. Mental models, or shared representations of knowledge, allow teammates to work under equivalent assumptions and possess similar prospects regarding teammates' roles and responsibilities (Marks et al., 2002). The objective of cross-training is to "enhance the knowledge of interpersonal activities by introducing team members to the roles and responsibilities of their teammates" (Marks et al., 2002, p. 4). By members understanding the behaviors and actions of others around them, cross-training is thought to contribute to team coordination, communication and regulation. Blickensderfer et al. (1998) identified and specified three types of cross-training

that differ in the depth and method in which roles of the team members' are taught to others on the team. Positional clarification involves verbally presenting team members with information about their teammates' responsibilities through lecture and discussion: positional modeling involves verbal discussion and observation of teammates' performing their tasks, and positional rotation provides information about teammates' roles by utilizing a hands-on approach in which each member performs each teammates' tasks to grasp a better understanding. This type of training teaches teammates about each others' roles in hopes of improving coordination and increasing team performance (Blickensderfer, Cannon-Bowers, & Salas, 1998). Table 7 displays the attributes of effective teams discussed in this section. Note that the list is not comprehensive.

Table 7. Compilation of Attributes of Effective Teams (Information from: Marks, Sabella, Burke & Zaccaro, 2002, Blickensderfer et al., 1998, Edwards, Day, Arthur, & Bell, 2006)

Attributes of Effective Teams
Cross-Training
* positional clarification
* positional modeling
* positional rotation
Existence of a team mental model
* similarity
* accuracy
* communication & coordination

A recent study by Edwards, Day, Arthur, & Bell (2006) supports the evolving view that team mental models are an important determining factor in the growth of complex skills and consequent team performance. Their study confirmed that similarity and accuracy of team mental models were strongly related and that accuracy proves as a stronger indicator of team performance

than similarity. In 1994, Acton, Johnson, and Goldsmith contended that an increase in accuracy is a result of individuals' development of expertise to the level comparable to an expert mental model. As expertise is attained by the team members and they begin to converge on a 'true' mental model, alikeness and precision of the team mental model are thought to increase as well. Team members can have similar mental models, but they may not be accurate; however, team members that have accurate mental models will most likely share similar mental models (Edwards et al., 2006). The results of Edwards et al.'s (2006) study confirmed Acton et al.'s findings (1994) that with more training, teams acquired more skill and converged on one mental model, accuracy again has proved to be a stronger predictor than similarity in shared mental models. Team mental ability was proven to be correlated with accuracy of team mental models. In this study, the focus was only isolated on taskwork mental models, not taskwork and teamwork mental models together; therefore, only in this case is accuracy of mental models known to be a better predictor of team performance than their similarity (Edwards et al., 2006).

Research has suggested that the application of team mental models (TMM) will potentially allow communication and coordination to become more efficient by promoting the use of a common language among team members (Langan-Fox, 2001) and by providing greater collective efficacy and sharing in mental models. Team mental models may also make mutual team member learning more prompt and improve task allocation and decision control by making team members aware of their teammates' strengths and weaknesses. Study of

TMMs has the potential to elucidate the processes involved in achieving high levels of performance among teams, as well as improving coordination, communication and team performance (Rouse, Cannon-Bowers, & Salas, 1992) and to assist in the efficient use of time and preparation by allowing team members to better envisage what will be required and how team interactions should continue (Klimoski & Mohammed, 1994).

Cohen and Bailey (1997) studied teams in organizational settings and focused on teams in which effectiveness outcomes were captured on all levels, individuals to organizations. Four types of teams were identified: work teams, parallel teams, project teams, and management teams. Cohen and Bailey (1997) categorized effectiveness into three major elements: 1) performance effectiveness evaluated in terms of the quantity and quality of the outputs such as efficiency, productivity, response time, and innovation; 2) member attitudes, such as measuring employee satisfaction and commitment; and 3) behavioral outcomes including absenteeism and turnover. The Team Effectiveness Framework used for analyzing effectiveness depicts effectiveness as a function of environmental factors, design factors, group processes, and group psychosocial traits (Figure 14).

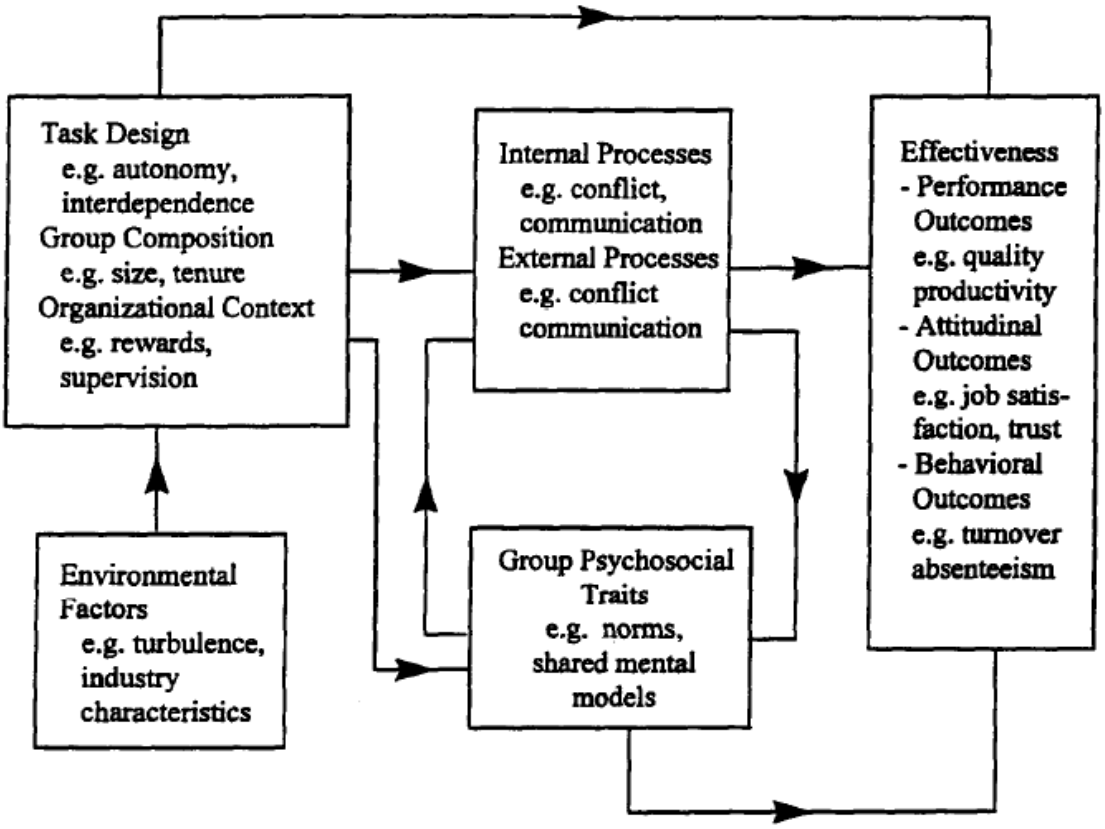

Figure 14. A Heuristic Model of Group Effectiveness. Variables listed under each category are meant as examples; they do not constitute an exhaustive listing. (Copyright Permissions Approved by Sage Publications)

This particular framework illustrates design factors, which have an indirect influence on outcomes via group processes and psychosocial traits. Group processes become embedded in psychosocial traits such as group norms, shared mental models or emotional states (Cohen & Bailey, 1997). Resulting from the studies of the work and parallel teams, the internal process of collaboration had a positive effect on the cohesion of a team, which is considered a group psychosocial trait. Based on thirteen studies of project teams, cooperation, communication and task processes also positively impacted team effectiveness (Cohen & Bailey, 1997). Cohen and Bailey (1997) presented seven

major lessons learned from their studies: 1) the type of team is a determinant of team effectiveness, 2) attitudinal benefits and performance from self-directed work teams are superior to those from parallel teams, 3) group cohesiveness is positively related to performance, 4) autonomy is associated with higher performance for work teams, but not for project teams, 5) factors most associated with success vary based on who is rating the team's performance, 6) diversity in demographic variables is related to performance outcomes in various ways and 7) cognitive and emotional dimensions are likely to have different effects on outcomes.

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APPENDIX A: DEMOGRAPHICS & KNOWLEDGE ASSESSMENT

DEMOGRAPHICS & KNOWLEDGE ASSESSMENT

Instructions: The purpose of this questionnaire is for you to provide some basic background information about yourself and your experience with team collaboration, if any. Please complete the following demographics questionnaire.

Name: _____ Age: ____

Gender: Male ____ Female ____ Year in School: _____

Major: _____

If you have worked with other students in this class before on another project, please list their names.

_____
_____
_____
_____
_____

Answer the following questions based upon the scale ranging from strongly disagree to strongly agree.

1. I have previously been involved in academic teamwork.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

----|----------|----------|----------|----------|----

2. I have worked on a project team with people who are not in my major.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

----|----------|----------|----------|----------|----

3. I understand what is meant by the term “team effectiveness.”

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

4. I feel a team should spend 5 or more hours per week working together in order to be productive.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

5. I don’t think teamwork is very important.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

6. I have had formal training in teamwork (ex. through classroom instruction).

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

7. I am most comfortable working on a school project by myself.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

8. I would rather work on a school project with other students on a team.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

9. Discipline has the strongest impact on the ways people communicate.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

10. Team effectiveness is influenced by the personality of the team members.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

11. Ethnic/Cultural differences hinder a project team's effectiveness.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

12. The gender of a team's members has no effect on the effectiveness of the team.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

APPENDIX B: INTERVIEW PROTOCOL

Interview Protocol

Introduction: Thanks for taking the time to talk with me today. I know you're a busy college student and I appreciate your time. I'll take notes as we talk, but is it okay with you if I tape this interview to help me make sure that I get all of your responses correct? As you know, the tape is entirely confidential and only the Virginia Tech research team will have any access to it.

1. Please describe an experience when you worked with someone who had a very different approach from yours. Include:
   a. _____ the nature of the differences
   b. _____ disciplines of the people involved
   c. _____ difficulties encountered
   d. _____ benefits experiences
   e. _____ methods of overcoming differences/reaching consensus

2. Please describe a time when you worked on a team that did not communicate effectively. Include:
   a. _____ the nature of the conflict
   b. _____ source of the conflict
   c. _____ method of resolution
   d. _____ effectiveness of method
   e. _____ "better" approach if the method used was not effective

3. What do you consider the strengths of the team process so far?

4. What do you consider the team's biggest challenges?

5. What percentage of the time do you feel your team worked on "teamwork" or activities concerning interaction between the team members?

6. What percentage of the time do you feel your team worked on "taskwork" or tasks concerning the assignment given by your instructor?

APPENDIX C: GUIDE TO CODING VIDEOTAPED MEETINGS

Instructions: The following are nonverbal indicators of agreement and disagreement that you should look for in the videotaped team meetings. Feel free to watch and replay the videotapes as many times as you'd like. If you have any questions, pleas feel free to ask the researcher.

Agreement	Frequency	Disagreement	Frequency
Body orientation towards speaker		Body orientation away from speaker	
Nodding head up and down		Shaking head left and right	
Erect posture (not slouching)		Arms folded across the chest	

Decision Guidelines:

* You **MUST** agree on the **frequency** of **each** indicator in **each** video.
* Examine frequencies of the above indicators of those team members **NOT** speaking at the time.
* For discrepancies between frequencies:
  - verbal conversation should be listened to again and body language should be examined in context of what is being said.
  - examine indicator in context with the other body language the person is displaying
* If the listener(s) are doing something other than paying attention to the speaker (ex. laptop, cell phone, etc), code as a negative body language indicator

Definitions:

* Indicators above will only be coded if a movement is made by the listener(s) when someone is speaking.
* If more than one person is speaking at a time, the "speaker" will be observed as center of the group
* In teams of three or four, the speaker is denoted as the person speaking for 5 seconds or more
* With the team of four, if two pairs of people are speaking with each other, indicators will be counted separately and as ½ of an indicator

APPENDIX D: TEAM EVALUATION BY INSTRUCTOR

Team Evaluation

Team # _____
Members: _____
_____
_____
_____
_____

Instructions: Please rate the team that participated in my study based upon the following criteria, using the scale “strongly disagree” to “strongly agree.”

1. The members of the team have high motivation.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

----|----------|----------|----------|----------|----

2. The team members are communicating effectively.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

----|----------|----------|----------|----------|----

3. The team is meeting its deadlines for assignments.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

----|----------|----------|----------|----------|----

4. Intra-team conflict is handled appropriately. (Intra-team conflict meaning issues and problems that arise between the members of the team are dealt with in a professional manner.)

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

----|----------|----------|----------|----------|----

5. Each member is a team player.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

6. The team is willing to cooperate with the professor.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

7. The team participates in the in-class activities.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

8. Each team member is involved in class and team discussions.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

9. This deliverables from this team are acceptable at this level of academia.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

10. The deliverables from this team exceeded my expectations for this assignment.

1	2	3	4	5
strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree

APPENDIX E: IRB APPROVAL LETTER

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Institutional Review Board

Dr. David M. Moore
IRB (Human Subjects) Chair
Assistant Vice President for Research Compliance
1880 Pratt Drive, Suite 2006(0497), Blacksburg, VA 24061
Office: 540/231-4991; FAX: 540/231-0959
email: moored@vt.edu

DATE: February 2, 2006

MEMORANDUM

TO: Elizabeth McNair Engineering Education
Maura Jenkins Borrego EE
Marie C. Paretti Materials Engineering
Janis Terpenny Dept. of Engineering Education

FROM: David Moore

SUBJECT: **IRB Expedited Approval:** "Facilitating Effective Communication in Interdisciplinary Design Teams" IRB # 06-045

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective February 2, 2006.

Virginia Tech has an approved Federal Wide Assurance (FWA00000572, exp. 7/20/07) on file with OHRP, and its IRB Registration Number is IRB00000667.

APPENDIX F: INFORMED CONSENT

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY GRADO DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING

Informed Consent for Participants of Investigative Projects

Title of Project: Disciplinarily Hetero- and Homogeneous Design Team Convergence: Communication Patterns and Perceptions of Teamwork

Principal Investigator: Shawnette K. Adams, Graduate Student, ISE

Faculty Advisor: Dr. Maura J. Borrego, Assistant Professor, Dept. of Eng. Edu.
Dr. Marie Paretti, Assistant Professor, Dept. of Eng. Edu.
Dr. Lisa McNair, Assistant Professor, Dept. of Eng. Edu
Dr. Janis Terpenny, Associate Professor, Dept. of Eng. Edu.
Akshi Kakar, Graduate Student, Dept. of ISE

THE PURPOSE OF THIS RESEARCH

The purpose of this research is to investigate the communication patterns of interdisciplinary student design teams at the university level, resulting in the formation of guidelines that will assist such students in improving their effectiveness by allowing the convergence of the team members onto the same mental model(s).

PROCEDURES

The procedures for the experiment are as follows. First, the entire class will be asked to read and sign the informed consent form for the experiment. Once the form is completed, you will be asked to complete a demographic questionnaire and a knowledge assessment of group effectiveness. The questionnaire will include demographic information such as the participant's age, gender, year in school and academic major. Once the demographic & knowledge assessment questionnaire, the researcher will construct two teams of three to five students in the class based upon the results. Four team meetings will be videotaped. Prior to the videotaped meetings, the students on the 2 observed teams will completed a Group Behavior Inventory. Following the completion of the four videotaped observations of your team, you will be required to complete a one-on-one interview (which will be tape recorded), as well as another Group Behavior Inventory. Your instructor will evaluate your team based upon specified criteria. This evaluation will NOT impact your grade in the course. The entire class will also be asked to complete the Group Behavior at the conclusion of the fourth

observation. You will be asked to read the instructions about the inventory and answer as honestly as possible.

The length of the videotaped sessions of your team will be at your team's discretion. There are no risks to you other than those introduced by using conducting teamwork, verbally answering questions and manually filling out a questionnaire. You may also terminate your participation at any time, for any reason.

RISKS

There are no risks to you while participating in this research study other than those introduced by using conducting teamwork, verbally answering questions and manually filling out a questionnaire.

BENEFITS OF THIS RESEARCH

Your participation in this research will be used to help improve interdisciplinary team effectiveness at the university level. Your participation will also contribute to the guidelines and recommendations that will assist in the teaching of how to work on an interdisciplinary team.

EXTENT OF CONFIDENTIALITY/ANONYMITY

The information gained in this research project will be kept strictly confidential. At no time will the researcher release the results of the study to anyone other than individuals working on the project without your written consent.

You will be identified only by a participant ID code. Data will be stored securely and will be made available only in the context of research publications and discussion. No reference will be made in oral or written reports that could link you to the data nor will you ever be identified as a participant in the project.

COMPENSATION

At the conclusion of the research, your team will receive a $60 gift certificate to a local Blacksburg restaurant.

FREEDOM TO WITHDRAW

You are free to withdraw from this study at anytime without penalty.

APPROVAL OF THIS RESEARCH

This research project has been approved, as required, by the Institutional Review Board for projects involving human participants at Virginia Polytechnic Institute and State University, and the Department of Engineering Education.

PARTICIPANTS RESPONSIBILITY

I voluntarily agree to participate in this study and know of no reason in which I would not be able to participate. As a participant in this study, I have the following responsibility: Answer each question as honestly as possible.

QUESTIONS

If you have questions, or do not understand information on this form, please feel free to ask Shawnette (skadams@vt.edu) now.

PARTICIPANTS' PERMISSION (GENERAL)
I have read and understand the Informed Consent and conditions of this project. I have had all questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty.

_____
Signature of Participant

_____
Date

CONTACT
If you have questions at any time about the project or the procedures, you may contact the principal investigators, Dr. Maura J. Borrego at 231-9536 or mborrego@vt.edu (332 Randolph) or Shawnette K. Adams at 232-1644 or email: skadams@vt.edu.

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant have been violated during the course of this project, you may contact Dr. David M. Moore, Interim Chair of the Institutional Review Board Research Division at 231-4991 or moored@vt.edu.

PARTICIPANT'S PERMISSION TO USE BODY LANGUAGE AND VOICE FROM VIDEOTAPED SESSIONS

I have read and understand the manner in which videotapes will be used for in this study. I understand that my video and voice will be presented as relevant to understanding how people communicate (agree and disagree) and reach similar mental models. I grant permission to researchers to present this information as necessary in the manner described on this form.

Signature

_____

Date

_____

I **DO NOT** grant permission to researchers to present videotaped information as necessary in the manner described on this form. I **DO NOT** want any recordings of video or voices of me to be used.

Signature

_____

Date

_____

CONTACT

If you have questions at any time about the project or the procedures, you may contact the principal investigator, Maura Borrego at 231-9536 or mborrego@vt.edu (332 Randolph).

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant have been violated during the course of this project, you may contact Dr. David Moore, Chair of the Institutional Review Board Research Division at 231-4991.

PARTICIPANT'S PERMISSION TO USE VOICE FROM VOICE RECORDED SESSIONS

I have read and understand the manner in which the voice recorded tapes will be used for in this study. I understand that my voice will be presented as relevant to understanding my interactions with teamwork, both with people inside and outside of my major. I grant permission to researchers to present this information as necessary in the manner described on this form.

Signature

_____

Date

_____

I **DO NOT** grant permission to researchers to present voice recorded information as necessary in the manner described on this form. I **DO NOT** want any recordings of my voices to be used.

Signature

_____

Date

_____

CONTACT

If you have questions at any time about the project or the procedures, you may contact the principal investigator, Maura Borrego at 231-9536 or mborrego@vt.edu (332 Randolph).

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant have been violated during the course of this project, you may contact Dr. David Moore, Chair of the Institutional Review Board Research Division at 231-4991.

PARTICIPANT'S PERMISSION

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent to participate in this project, with the understanding that I may discontinue participation at any time if I choose to do so.

Signature: _____

Printed Name: _____

Date: _____

If you have any questions about this research or its conduct, you may contact:

Principal Investigator: Shawnette K. Adams
Phone: (540) 232-1644
Graduate Student, Department of Industrial and Systems Engineering
Email: skadams@vt.edu

Faculty Advisor: Dr. Maura J. Borrego
Phone: (540) 231- 9536
Assistant Professor, Dept. of Engineering Education
Email: mborrego@vt.edu

If you feel you have not been treated accordingly to the descriptions in this form, or your rights as a participant have been violated during the course of this project, you may contact Dr. David Moore, Chair of the Institutional Review Board Research Division at (540) 231-4991.