INCORPORATING COLLABORATIVE LEARNING METHODS IN
CONSTRUCTION EDUCATION

by

Mikkea Noele Carter

A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Science in
Construction and Facilities Management

Charlotte

2017

Approved by:

_____
Dr. Bruce Gehrig

_____
Dr. Jake Smithwick

_____
Dr. Glenda Mayo

_____
Dr. Nicholas Tymvios

ABSTRACT

MIKKEA CARTER. Incorporating Collaborative Learning Methods in Construction
Education. (Under the direction of DR. BRUCE GEHRIG)

Architecture, engineering and construction industries are advancing in
collaborative methods for completing projects. Consequently, institutions of education
are investigating methods of teaching students how to effectively function in teams in
order to prepare students for industry. Majority of the proposed methods are resource
intensive and require extensive planning before students are introduced to the teamwork
training. This thesis study is an exploratory investigation into applying a current training
method as a one-time intervention. The goal of the research is to see if this method of
training will impact student's attitudes and behaviors about teamwork. A two phase,
survey based research design collected data from Engineering Technology and
Construction Management students at the University of North Carolina at Charlotte. The
resulting data highlighted a significant change in attitudes between phases for 18 survey
items. This change, coupled with professor and student feedback, demonstrates how the
the training raised awareness of what constitutes effective teamwork. 44% of the
significant responses where associated with communication although communication
questions accounted for 33% of total survey items. This research recommends that future
study designs for teamwork trainings with limited resources focus on communication in
order to make the most impact in the shortest period of time and establish a foundation
for later skill development.

ACKNOWLEDGMENTS

Thanks be to God for the continues blessings, wisdom and perseverance. I would like to extend the sincerest gratitude to my thesis committee chair, Dr. Bruce Gehrig. He helped to cultivate a small idea into a research study and thesis. I would like to thank my thesis committee that joined us on the journey, Dr. Jake Smithwick, Dr. Glenda Mayo and Dr. Nicholas Tymvios. The continued support and encouragement of the committee was an integral part in completing the research study and thesis. I would also like to thank my professors and the staff in the Engineering Technology and Construction Management department.

I am grateful for those who have come before me to pave the path I now take. Their sacrifice and fortitude made it possible for me reach my goals. I would also like to thank my family and friends for their unwavering support. Most importantly, I would like to thank my mom, Robyn Taylor-Smith, for being my biggest cheerleader. You uplifted me in my down moments and celebrated with me in the high moments.

A special thanks to my research assistant office mate, Pauline Karanja. We started this journey together and have completed it together. Through all the assignments, presentations and late nights we have preserved together. We made it!

Lastly, I am thankful to the countless individuals I have met along the way. You all are too numerous to name in this small space, but you are my coworkers, my fellow classmates, my doctors, friends of friends and strangers I have met in the last two years. I appreciate the time you gave to listen to me talk about my work and the words of advice offered to me. I will be certain to pass forward the words of encouragement that were passed to me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

As architecture, engineering and construction (AEC) industries moved toward more collaborative approaches for delivering projects, educational practices began to reflect this shift (Becerik-Gerber and Kensek, 2010). Educators seek to foster an environment conducive to collaborative learning while also preparing students for industry practice (Becerik-Gerber and Kensek, 2010). However, in industries long focused on individual success, shifting to a team environment evolves slowly. An obstacle of educators is overcoming internal difficulties, such as negative attitudes, associated with teamwork to implement more collaborative approaches of practice and learning (Forgues and Becerik-Gerber, 2013).

A common method to overcoming these obstacles is the incorporation of collaborative learning environments. This can be done in the form of collaborative classrooms, workshops, studios and regular lectures where students complete group work. However, this method fails to 1) develop a systematic method of teaching collaboration and 2) teach students the skills necessary for effective collaboration. Present collaborative learning for students focuses on the end result of completing a group project. It is based in teaching technical skills. Conversely, examining the process and skills conducive to collaboration may help in the development of more effective and focused collaborative methods.

This thesis is an exploratory research study to investigate the practical education

problem of the current time and resource intensive nature of teamwork training for students. The purpose of this research is to identify areas of focus for teaching teamwork skills based on a training framework that can 1) be taught concurrently with class curriculum and 2) is less time and resource consuming than previously proposed classes, workshops, and studios. The research objective was to investigate the introduction of an abridged teamwork training program to identify the teamwork skills most impacted by a training intervention. These identified skills can then be recommended for more focused attention in the future designs of more streamlined, in class training programs.

CHAPTER 2: LITERATURE REVIEW

2.1. Background of Construction Industry

Construction developed as a competitive industry. Companies competed to receive the best projects, resulting recognition and profit. Consequently, the focus of work relationships and developed bidding practices prevented companies from exploring collaborative processes. Focus remained on maximizing profit and edging out the competition. However, a gradual shift towards more collaborative approaches emerged in the industry with the advancement of means, methods and technology. Companies began to realize the value of implementing collaborative methods in the workplace.

2.1.1. Project Delivery

Development of new delivery methods changed the way projects are procured and delivered. Design-Build, Construction Management at Risk, and Integrated Project Delivery are changing how companies view the construction process. These alternative methods provided improved results such as shifting of risks, maximizing profits, and reducing delays. The industry began to see the tangible benefits of these new collaborative approaches and such approaches have begun to expand.

2.1.1.1. Design-Build

Design-build (DB) project delivery is an increasingly accepted alternative to design-bid-build (DBB). With DB, owners are able to have one contract for both the designer and contractor. The one entity is known as the single point of responsibility

(Kenig, 2011). Since the designer and contractor are the design-build entity, design and construction happen under one team. Consequently, much of the risk is shifted from the owner to the design-build entity (Kenig, 2011). All designs, changes, and construction are handled by this one entity.

For collaboration purposes, DB offers a greater potential for collaboration as designers and contractors are working together from the beginning. The alliance, as described by Design-Build Institute of America (2014), "fosters collaboration and teamwork". Since the designer and contractor are working as one entity, any changes and problems are a shared responsibility. Furthermore, the success of DB can be attributed to innovative management approaches (Design-Build Institute of America, 2014). The contractual arrangement between owner and the design-build entity allows for more integration of value management and partnering between all involved parties to find the best solutions. Overall, DB provides an easier pathway to collaboration because of shared risk/reward and the opportunity of collaboration in the process that is not present in DBB.

2.1.1.2. Construction Management at Risk

Construction Management at Risk (CMR) is another alternative to design-bid-build. This method has a similar contractual arrangement to DBB, with the owner having separate contracts for both the designer and contractor. However, the contractor may also act as a construction manager or construction manager agency (Kenig, 2011). In contrast to DBB, the owner brings in the construction manager earlier in the project, usually during preliminary design, as opposed to after the design is finalized (Kenig, 2011).

The potential of collaboration in CMR, similar to DB, relies on the early integration of the construction manager (CM). Adding the CM in during preliminary

design helps to create dialogue between the designer and the contractor (Bilbo et al., 2015). Many issues can potentially be solved in relation to constructability and costs. Hence, the potential for collaboration in CMR may lead to positive outcomes for the success of the project (Bilbo et al., 2015).

2.1.1.3. Integrated Project Delivery

Integrated Project Delivery is the project delivery method centered in collaboration. The American Institutes of Architects (AIA) defines IPD as the, "Approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction" (The American Institute of Architects, 2007).

While many contractual arrangements exist, ideally all involved parties, including the owner, designer, and contractor, are working under one shared contract (Kenig, 2011). Bringing together each discipline at the beginning of a project is key to benefiting from shared knowledge, experience, potential methods of innovation, and the establishment of a shared goal. The nature of IPD creates at atmosphere of both shared risks and shared rewards (The American Institute of Architects, 2007). To maximize rewards and minimize risks, all parties work collaboratively, expanding on individual contributions, to "design, build, and deliver a project" as one.

IPD is the highest form of collaboration for construction project delivery methods. Each discipline is an active member in realizing a concept, designing the project, and building the project (The American Institute of Architects, 2007). AIA describes the team

nature of IPD as based on the following nine principles of collaboration (The American

Institute of Architects, 2007):

1. Mutual Respect and Trust

2. Mutual Benefit and Reward

3. Collaborative Innovation and Decision Making

4. Early Involvement of Key Participants

5. Early Goal Definition

6. Intensified Planning

7. Open Communication

8. Appropriate Technology

9. Organization and Leadership

Mutual respect involves all parties understanding, respecting, and committing to the

team process of IPD (The American Institute of Architects, 2007). The interest is shifted

from individual desires to team desires. Mutual benefits and rewards recognize the

incentive to achieve as a team (The American Institute of Architects, 2007). These

incentives can include shared profits and losses. Focus should again be on what is best for

the group as a whole, not one individual. Collaborative innovation and decision making

allows input from all parties (The American Institute of Architects, 2007). Each idea is

accessed on its potential to benefit team goals and decisions are made collectively. Early

involvement of key participants combines the knowledge and expertise of parties in

collaborative processes at the beginning stages of the project (The American Institute of

Architects, 2007). This allows for decisions, which may greatly affect the project, to be

made early before cost overruns incur. Early goal definition defines the overall project

goals to be, "developed early, agreed upon and respected by all participants" (The

American Institute of Architects, 2007). Therefore, everyone is aware of what outcome

the team is working towards. Intensified planning by the team helps to coordinate the

project to increase efficiency and streamline effort (The American Institute of Architects,

2007). Open communication allows consistent and honest communication between team

members. It always contributes to conflict resolution and mediation. Appropriate

technology use helps to define standards of data use and exchange between parties on the

project (The American Institute of Architects, 2007). Without the exchange of

information, collaboration would be difficult to achieve. Lastly, organization and

leadership helps to guide work through clearly defined roles while maintaining open

communication (The American Institute of Architects, 2007).

2.2. Education Theory

Various methods exist to explain learning and teaching. Educational theories

categorize these methods based on the relationship between the individual and the

learning process. In educational theory teaching can happen in multiple environments

with different methods. The resulting patterns and outcomes help to reveal insights of

how learning happens based on teaching.

2.2.1. Behaviorist

In education there are two prominent approaches to teaching, behaviorist and

constructivist. Behaviorists focus on the outcome of the learning process (Hean et al.,

2009). The subsequent student behavior is based on the experience. This experience is a

culmination of lessons learned through trial and error (Hean et al., 2009). Competence of

the learning individual is measured based on the attitude and knowledge expressed at the

end of a lesson (Hean et al., 2009). A behaviorist method to teaching is the base for most

modern curriculum. Competence is viewed on how well a student scores on an

assessment or how well an employee reacts to a circumstance. As noted by Hean et al.

(2009), a behaviorist based approach potentially fails to help students reflect fully on

their actions. This prevents the students from gaining a greater understanding of non-

successful endeavors.

2.2.2. Constructivist

Contrastingly, constructivists focus on the process of learning. Learning is viewed

as more than an assessed outcome (Hean et al., 2009). Rather, it is developed through a

series of experiences. Jean Piaget's (1973) cognitive stages of development has been

applied in constructivist teaching methods to support learning stage development (Hean

et al., 2009). Similarly, as children progress cognitively in stages, learning can progress

in stages with each stage building upon the skills of the previous. In conjunction with

development learning, the social implications of education theory have been applied

(Hean et al., 2009). As learning happens in developed stages, it is "mediated by the

environment" (Hean et al., 2009) That is to say that social interactions greatly impact

experience and thus learning. Therefore, the social environment of learning may be

tailored to have the greatest impact on learning.

2.2.3. Zone of Proximal Development

Lev Vygotsky further explored how social environment influences learning. He

studied the relationship between learning and development by focusing on children. The

children were studied to see how they learned skills through encounters prior to being

properly taught the skill (Vygotsky, 1978). His work revealed a relationship between

learning and development identified as the zone proximal development (ZPD). Vygotsky

(1973) explains ZPD as,

> "…the distance between the actual development level as determined by
>
> independent problem solving and the level of potential development as
>
> determined through problem solving under adult guidance or in collaboration with
>
> more capable peers."

Essentially, the ZPD is learning through experience of others. Although a student may

not have the final answer, the student has basic skills to find the answer (Vygotsky,

1978). Through interaction with peers and teachers that have knowledge of how to find

the answer, the student himself/herself can better develop the skills to solve the problem.

Vygotsky (1978) adds that children are more capable of excelling in collective activities

or under guidance of an adult.

Applying this theory in a higher education setting, the children are students and

the adult the teacher (or other knowledgeable professional). Patrick et al. (2009) applies

this to collaborative learning. Each student has a unique skill set that allows him/her to

solve familiar problems. This skill set can also be used to solve problems outside a set

discipline (Patrick et al., 2009). By combining these students in a zone of proximal

development, students are able to learn from each other's strengths (or a professional as a

guide) to further develop their own skills collectively.

2.2.4. Collaborative Learning

Collaborative learning is a method of teaching that involves students learning

together, usually in small groups. As the world evolves, educators are tasked with

revamping learning environments to better prepare students. In addition, there is a,

"common belief that collaborative learning is better than learning alone (Nokes-Malachi, 2015). López-Yáñez et al. (2015) further adds that, "educators are pushed to find, develop, and implement new appropriate pedagogical methods". In doing so, the classroom environment must also transform. Collaborative learning is a method that helps to create an active learning environment, thus supporting these new methods (López-Yáñez et al., 2015).

Implementing collaborative learning presents challenges. First, teachers have to incorporate methods to actively engage students. A researched and documented objection by students to collaborative learning (Solnosky et al., 2014) is lack of satisfaction with the group. Particularly, students were least satisfied when they could not choose group members and were forced to work with students they did not like. Considering that the, "effectiveness of collaborative learning largely depends on the quality of student interaction" (Kaendler et al., 2015), finding ways to overcome student bias is vital. Conversely, the benefits of successful collaborative learning may be greater than incurred challenges. Benefits include, "pooled knowledge, explanation, cross-cueing, error-correction, reduced memory load, and observational learning" (Nokes-Malachi, 2015). Students can develop both soft skills and technical skill through collaborative learning.

Kaendler et al. (2015) research in collaborative learning yielded the Implementing Collaborative Learning in the Classroom (ICLC) framework. This framework divides collaborative learning into three distinct phases based on the work of Artzt and Armour-Thomas. The ICLC method teaches the phases through problem solving. Phase 1, pre-active, involves teacher planning (Kaendler et al., 2015). In this phase learning objectives are established that will guide the teachers through the next two phases. Phase 2, inter-

active, is the active learning portion (Kaendler et al., 2015). The teacher monitors, supports, and consolidates the student group with assignments that engage the students in collaborative learning. Lastly, Phase 3, post-active, involves the teacher reflecting on the outcomes of Phase 2 (Kaendler et al., 2015). The teacher should be able to learn from the weaknesses and strengths to produce a better approach for the next collaborative learning engagement. Overall, this framework provides a methodological approach to implementing collaborative learning in the classroom. It accounts for both the benefits and drawbacks of collaborative learning in an attempt to help the teacher better engage students.

2.3. Interprofessional Development

Interprofessional development expands on the concept of interdisplinarity. Whereas interdisplinarity focuses on knowledge development of multiple disciplines as one, interprofessionalism focuses on developing "cohesive practice among different professionals from the same organization or from different organizations and the factors influencing it" (D'Amour and Oandasan, 2005). Clark (2006) describes how the professional knowledge exchange between members of an Interprofessional team helps everyone in the group gain more knowledge. The members, "learn with, from, and about'' each other, as well as master the skills needed to work as team members" (Clark, 2006). As members are contributing their knowledge they are also learning in the social environment. Skills crucial to the success of a team can be learned through this type of social learning. These skills include leadership, communication, and conflict management (Clark, 2006). In all, the development of the interprofessional team develops both an individual's skill toolkit and interprofessional toolkit.

2.3.1. Interprofessional Development in Education

Interprofessional development in practice has evolved depending on the discipline. Although most used in health professions, variations of the methods are applicable to other fields of study. For educational purposes, interprofessional development helps to recreate potential industry practices in the curriculum. Also, it has the potential to further highlight collaborative practices by allowing instructors to adjust the curriculum based on a desired outcome. The following are two case study examples of interprofessional development adapted to higher education.

2.3.1.1. Linkoping University Faculty of Health Sciences, Sweden

Linkoping University Faculty of Health Sciences created a development program to immerse its medical students in a real world learning environment. Students from medicine, nursing, occupational therapy, and physiotherapy were chosen to work as part of a interprofessional training ward (IPTW) (Falk et al., 2013). This ward functioned as an active medical wing, with patients and a supervising staff. The goal of the IPTW was to enhance collaboration between the four disciplines through the use of practice theory (Falk et al., 2013). Choosing the practice theory allowed educators to shift focus, "from cognitive aspects of experience and attitudes to the social and material aspects of practice itself" (Falk et al., 2013). IPTW thus helped students to better understand their own profession in conjunction with developing a greater understanding of the other professions.

IPTW operated on the basis that each student performed their own tasks, associated with their discipline, and community tasks that each member must complete (Falk et al., 2013). The creators of the IPTW targeted three themes of learning. First,

students enacted their professional responsibilities (Falk et al., 2013). Each student completed tasks assigned, much as they anticipated was expected of the discipline. Second, a theme of conflict management during care work was created (Falk et al., 2013). This theme stressed the work that everyone must complete in the role of patient care. It could include assisting patients with dressing, eating, and assistance in taking medication, etc. Students were forced to work beyond their discipline to accomplish common goals of patient care. The author describes this process as the, "clash between the practical understandings of the professional responsibility, characteristic of a specific profession and the general understanding of the tasks and roles at the IPTW" (Falk et al., 2013). Third, educators concentrated on creating a proximity of students to one another (Falk et al., 2013). The goal of this proximity was to create opportunities for negotiations and understanding of professional responsibilities (Falk et al., 2013). With each student having to share patient care and still complete their own work, the need for collaboration emerged. Together students were able to learn to share responsibilities to ensure the patient received necessary care while the students simultaneously completed work for their respective disciplines.

In all, the program has proved to be effective in engaging students. In a follow-up questionnaire, the students reported how the format forced them to grow as future practitioners. It was noted that the, "unexpected responsibilities that disrupt practical and general understanding of professionals' responsibilities" (Falk et al., 2013) helped students to gain greater insights of collaborative work. The interprofessional nature of the development forced student to collaborate to achieve a positive end result.

2.3.1.2. Roger Williams University, Rhode Island

Two professors at Roger Williams University studied methods of interprofessional development within the classroom (Charles and Thomas, 2009). While not formally named interprofessional development, the methods and desired outcomes reflect similar meaning.

Research focused on using a problem-based education to reflect the growing trend of collaboration in the Architecture, Engineering, and Construction (AEC) industry (Charles and Thomas, 2009). The belief that students should have at least a "minimum understanding" (Charles and Thomas, 2009) of the other fields was a driving force for methodology development. Four approaches were analyzed to incorporating building simulation software into the curriculum. Each approached was based on either an architecture studio, architecture workshop, or regular course with enrollment from students in all AEC disciplines (Charles and Thomas, 2009). The following is the analysis of the four approaches.

2.3.1.2.1. Outside Expert Integrated into Studio

The first approach centered on the introduction of an outside expert into an architecture studio (Charles and Thomas, 2009). This expert was to be a resource and a consultant to the students learning the new software. The expert was to help supplement knowledge learned in the classroom while also providing the students with ono-on-one interaction (Charles and Thomas, 2009). Replicating a real-world consulting scenario between architect and engineering was a major appeal of this approach. It helped to illustrate the "collaborative nature of design" (Charles and Thomas, 2009) while also teaching students new skills. The expert and instructor involved students in a series of

lectures, group critiques, and small workshops (Charles and Thomas, 2009). Overall, the arrangement was effective in helping students understand the consulting relationship. However, they learned less about the use of the tool due to remaining in the early stages of design.

2.3.1.2.2. Studio Instructor as Consultant

The second approach focused on the instructor acting as a consultant rather than the teacher (Charles and Thomas, 2009). This puts students in a position of more directed self-learning. The teacher as consultant provided simulations for the class within their design groups (Charles and Thomas, 2009). The students only focus on design, not running the simulation software. Again, the focus was to recreate the consulting relationships between engineers and architects (Charles and Thomas, 2009). A downfall of this approach is that there is not a centralized method of instruction and students only learn the basics of running the simulation. However, the overall course proved to be effective in helping student development of their design (Charles and Thomas, 2009). Part of this success may be due to students focusing more on their design and less on new software.

2.3.1.2.3. Student Volunteer as Consultant

The third approach involved selecting a student of the class to become an "expert" for the students to seek help (Charles and Thomas, 2009). This student volunteer received a short, intensive training session outside of class on how to operate the building simulation software. It was expected of the student to not only act as a consultant for his/her peers, but also to maintain their own coursework in the class (Charles and Thomas, 2009). The arrangement provided much needed support to the professor in

helping students develop their design and run the software. However, it greatly hindered the work of the student volunteers. Furthermore, the student volunteer was not able to provide the same level of detailed feedback as an outside expert or professor due to the lack of formal training (Charles and Thomas, 2009).

2.3.1.2.4. Student Volunteer after workshop

The fourth approach was a hybrid of student volunteering and formal training (Charles and Thomas, 2009). A three week, four hours a day for five days, workshop was held to train volunteers on the building simulation software. Once the students received a thorough background of the process of the simulation, their skills were tested in a real life problem solving scenario (Charles and Thomas, 2009). For this project, students were divided in groups with each group having engineering students partnered with architecture students. One student from each group volunteered to become the expert consultant (Charles and Thomas, 2009). Similar to the studio based volunteer, this student provided support to their classmates in running simulation software and teaching methods. The workshop success expanded to a general course comprising students in all AEC fields (Charles and Thomas, 2009). Students from the workshop volunteered to be consulting experts. The formal training of these students provided greater success for teacher, students, and volunteers. The combination of the formal training and problem based project was seen as, "opening the door to collaboration between the two groups of students" (Charles and Thomas, 2009).

2.3.1.3. Conclusion

While these two applications of interprofessional development differ in disciplines, they both adopt similar methods of a collaborative curriculum. The lessons

learned from these case studies can be applied to future research in creating a methodology of practicing collaboration in education. One important finding of both case studies is the guidance of a professional. Both groups benefited from supervision and input of industry professionals in helping guide their decision making. Secondly, creating an environment that forced students out of their comfort yielded the best overall outcome of opinions toward collaboration. Students learned to work together to solve problems. Thus, the importance of collaboration between the disciplines became more evident. Lastly, the most effective structure of collaborative learning occurred when students worked with a real life scenario. Developing these skills in real time with real problems helped students develop collaborative skills together that were instantly applied. The results of their decisions were immediately observed. The combination of an outside professional providing students consultation within a real-world learning scenario proved to help students better understand the project and their roles within the project.

2.4. BIM in AEC Education

BIM has been employed as a tool in helping students learn to work in multidisciplinary teams (AutoDesk, 2011). Furthermore, BIM is described as a collaborative process (Wang and Leite, 2014), rather than just a drawing tool (Sacks and Pikas, 2013). Teaching BIM as a collaboration tool was not readily achievable with traditional teaching methods (Wang and Leite, 2014). Consequently, new methods have been explored to help students understand concepts and the value of BIM as a skill set (Sacks and Barak, 2010) in the workplace.

Wang and Leite (2014) proposed a process-oriented teaching method to help students learn BIM in this manner. In process-oriented learning, the importance of

learning lies in the process, not the just the tool (Wang and Leite, 2014). Learning experiences help develop critical thinking skills as students learn the process of BIM and its application to various aspects of industry (Wang and Leite, 2014). While the content is still important, students develop knowledge of how to apply content. Wang and Liete (2014) state this approach helps students, "understand BIM as a new construction management process as well as impacts on project success". Since a student's first hand exposure to BIM is likely through classroom experience, creating a program that teaches BIM as a collaborative tool can potentially help students develop a more positive attitude about collaboration.

However, challenges hinder integrating collaboration into an education curriculum. While support may be present for endorsing the idea, actual involvement from faculty and professionals can be difficult to secure. For universities, coordinating between different departments is difficult due to faculty schedule and curriculum requirements (Sacks and Pikas, 2013). Studies of collaborative BIM projects in universities share the same take away of the need of faculty involvement (Becerik-Gerber and Kensek, 2010). Program leaders have noted the importance of faculty involvement in helping keep students on track with the curriculum.

In addition, input from industry professionals help enhance student learning and reinforce goals (AutoDesk, 2011). Simulating real world projects in a classroom environment help students to better understand concepts, especially when taught by professionals who worked on the projects (Forgues and Becerik-Gerber, 2013) This type of engagement extends the curriculum beyond the academic bubble that separates learning from application (Sacks and Pikas, 2013). Training in school can serve as a

strong basis for continued training in the workforce (Dossick et al., 2014). Students can readily see their learned skills in an applicable setting and how it affects project outcomes.

However, limitations of BIM adaptation can create barriers to learning (Tian and Xue, 2014). Certain applications, such as high detailed modeling, can be difficult to achieve in classroom settings (Tian and Xue, 2014). Finding ways to analyze and utilize the wealth of data information produced in BIM in a classroom setting is difficult, creating barriers in sharing the information among different roles (Tian and Xue, 2014). Overcoming these difficulties is necessary to effectively engage students in a collaborative learning environment.

In education there is also a lack of agreement of the needed skills to produce an effective, collaborative BIM program (Sacks and Pikas, 2013). Deciding what is necessary for students to learn is critical to developing a curriculum that prepares students for practice. However, there is consensus across educators, professionals, and researchers that the most effective method of learning happens continuously throughout the degree program (Dossick et al., 2014; Wang and Leite ,2014; Sacks and Pikas 2013; Sacks and Barak, 2010; Bercerik-Gerber and Kensek, 2010; AutoDesk 2011). Introducing BIM early in the curriculum allowed students to develop the necessary base skill that allows for introduction of more complex methods later in the degree program (Becerik-Gerber and Kensek, 2010).

2.5. Teamwork Training Protocols

Four teamwork training programs were reviewed to establish the types of training programs previously researched and available.

2.5.1. Engineering Education Team Training Intervention

One engineering program applying teamwork training in its curriculum is the College of Engineering at the University of Tennessee. The college created a new a minor entitled *Engineering Communication and Performance* (Seat et al., 2001). This minor was created in partnership with a freshman level engineering Engage program and the College of Education's Counseling, Deafness, and Human Service Department. The goal of the minor was to provide a structured curriculum to help engineering students improve teamwork skills (Seat et al., 2001). Five courses, listed in Table 1 are included in the minor for a total of 15 credit hours.

Table 1: Engineering Communication and Performance Minor Course Requirements

Course	Description
CECP 206- Facilitation of Technical Teams (CECP- Counselor Education and Counseling Psychology	Facilitation and group dynamics of technical task teams with mini-practicum
CECP 306- Facilitation of Technical Performance	Facilitation of individuals for performance improvement of both technical and communication skills with mini-practicum
HS 406- Capstone Practicum	Supervised social service practicum
Two Courses selected from the following: Psych 360- Social Psychology Psych/Mgmt 440- Organizational Psychology HRD 471- Principles of Supervision Speech Comm 420 – Communication and Conflict Speech Comm 440- Organizational Communication	Theoretical basis for performance skills, cultural perspective, and leadership

The diversity of classes addresses the diversity of performance skills that are lacking according to industry review by Seat et al. (2001). Without these skills, it is noted that industry professionals do not believe students are reaching their full technical potential. Adding courses that address social aspects of teamwork in addition to

performance skills is proposed to help mitigate this inadequacy. A driving force and goal of the creators of this academic minor is to prepare students who can transfer learned skills outside of the engineering profession (Seat et al., 2001).

Assessment of the the effectiveness is measured with pre and post testing. However, it was noted by Seat et al. (2001) that this method has not provided an accurate measure. Contributors believe pre tests are influenced by a lack of team familiarity with each other and the project. Similarly, the facilitation tests may be reflecting cognitive responses instead of the tested behavior response. To supplement these tests, contributors are developing a longitudinal study to measure behavior changes in relation to teamwork training (Seat et al., 2001). It will be a one-time peer evaluation tool administered mid-year. Results of the evaluation will compare evaluations from students participating in the minor to students not participating in the minor. The hypothesized outcome is that minor participants will have higher peer evaluation results (Seat et al. 2001).

Many previously described difficulties for incorporating teamwork learning in an education setting were observed at the University of Tennessee. One frequently noted barrier is acquiring the resources necessary in terms of staff and teaching material was difficult (Seat et al., 2001). The new program for undergraduate students requires interdisciplinary instructions. College of Education professionals were teaching engineering students in an environment unlike their own. The curriculum had to be tailored to engineering students and the experiences expected in an engineering industry. However, committed faculty and a high interest rate from students helped researchers and educators develop a successful program (Seat et al., 2001). Since the program inception, student enrollment has remained steady and employers have expressed increased interest

in students completing the program. Student facilitation leaders from the freshman Engage teams continue to seek opportunities and educators have adopted the facilitation model in their classrooms (Seat et al., 2001).

Overall, the contributors to this minor believe their success of implementation can serve as a framework for other universities (Seat et al., 2001). Its success is based on the desire of educators to expand student knowledge, industry input, and skill sets readily available in an education setting. The requirement of establishing an interdisplinary link between education, social science, psychology and engineering may be filled by interested faculty and graduate students (Seat et al., 2001). The outlined framework can be an opportunity for universities with these resources to incorporate similar programs.

2.5.2. Construction Industry Institute (CII) RT-105 and Compass Tool

The goal of the original CII Project Team Communication Research Team in 1996 was to investigate the relationship of communication between project managers, engineers and construction employees during construction projects (Compass, 2011). These findings, published in RT-105, were incorporated into a tool for improving team communication based on an assessment tool training program. The result of this research was Compass: Communications Project Assessment Tool. An update to the tool was introduced in 2011(Compass, 2011). It was aimed at measuring the effectiveness of communication between responsible parties on a construction site. It evaluates how the roles and input of the project manager, construction manager, and project engineer contribute to the measured and perceived success of the project as a whole (Compass: Communications Project Assessment Tool XLSM, 2011). The tool was able to highlight areas of strength and weakness to allow the users to understand the communication needs

of the team based on six identified critical communication issues shown in Table 2.

Table 2: Critical Communication Issues

Category	Definition
Accuracy	the accuracy of information received as indicated by the frequency of conflicting instructions, poor communication, and a lack of coordination
Timeliness	the timeliness of information received, including design and schedule changes
Completeness	the amount of relevant information received
Understanding	an understanding of information expectations with supervisors and other groups
Barriers	the presence of interpersonal, accessibility-related, logistical, or other types of barriers that interfere with communications with supervisors or other groups
Procedures	the existence, use, and effectiveness of formally defined procedures outlining scope, methods, or other project concerns

2.5.3. CATME SMARTER Teamwork

The CATME SMARTER Teamwork program began as a research study to develop a peer evaluation assessment tool in 2003. Through National Science Foundation grant award 0243254 entitled, "Designing a Peer Evaluation Instrument that is Simple, reliable, and Valid," the original researchers were able to establish a new, computerized assessment protocol. New researchers were recruited to add expertise in the areas of classroom teaching and teamwork. The result of their efforts was the first CATME assessment instrument (CATME, 2016). It contained Likert style questions in two variations. The first was an 87 item assessment and the second a condensed 33 item instrument. The CATME assessment tool focused on five categories of individual behavior in the team: contributing to the team's work, interacting with teammates, keeping the team on track, expecting quality and having relevant knowledge, skills and abilities (Loughry et al., 2007). The success of the research into teamwork assessment

continued with the development of an integrated CATME Peer Evaluation system. The program helps instructors to gather, incorporate, and disseminate feedback to the students (Loughry et al., 2007, Ohland et al., 2012 and CATME, 2016). This online system also combined the individual and peer assessments of previous researchers with the Team-Maker system. The original Team Maker system was the work of Richard Layton. His goal of the the system was to design user input variables to create teams based on an algorithm (Layton et al., 2010). The National Science Foundation supplemented the CATME grant and Richard Layton revised the Team-Maker with CATME researchers Matt Ohland and Hal Pomeranz (CATME, 2016). The result was a system that, "could form teams fast and more consistently than an experienced faculty member" (CATME, 2016).

The researchers of the successful CATME Peer Evaluation remained committed to expanding the knowledge base of the CATME system. In 2008, a National Science Foundation grant, award #0817403, for "SMARTER Teamwork: System Management, Assessment, Research, Training, Education, and Remediation for Teamwork" (CATME, 2016) This grant furthered the the development of CATE with the introduction of CATME Rater Calibration to help students better understand the rating process. Additionally, the CATME website was updated and a new CATME Meeting Support was introduced to aid in the facilitation of team meetings. One area still in development is the teamwork training modules (Loughry et al., 2014). The goal is to create web-based training modules to train students in teamwork. The CATME Peer Evaluation would be used in conjunction with the training modules to measure student progress (Loughry et al., 2014). As of 2013, the training modules are still in development.

2.5.4. TeamSTEPPS and PACT-Novice Observer

The foundation for the TeamSTEPPS began in the late 1990s with research of the Dynamics Research Corporation (King et al., 2008). Their research focused on studying emergency department team training. The knowledge gained from this and other studies influenced the work of a new set of researchers in the early 2000s (King et al., 2008). These researchers goal was to apply the insights and literature of the past decade into a professional program for education healthcare professionals. Their work further refined the key principles of teamwork that would become the foundation of the current TeamSTEPPS program. The TeamSTEPPS program, created by the Agency for Healthcare Research and Quality and the Department of Defense's Patient Safety program, is a program tailored to teaching healthcare students and professionals how to function as effective teams (King et al., 2008). The current program is a multifaceted approach to team training and assessment. It includes training aids for instructors, a curriculum, simulation activities and assessments. Included exercises require students to work as a team to achieve the end goal of quality patient care (King et al., 2008). In addition to teaching teamwork, the program highlights areas of improvement for teams and provides instructors with the tools to improve performance. TeamSTEPPS is based on five key principles, shown in Table 3, that aid in improving team performance for the healthcare industry (King et al., 2008).

Table 3: TeamSTEPPS Key Principles

Key Principle	Definition
Team Structure	Identification of the components of a multi-team system that must work together effectively to ensure patient safety

Table 3 continued: TeamSTEPPS Key Principles

Communication	Structured process by which information is clearly and accurately exchanged among team members
Leadership	Ability to maximize the activities of team members by ensuring that team actions are understood, changes in information are shared, and team members have the necessary resources
Situation Monitoring	Process of actively scanning and assessing situational elements to gain information or understanding, or to maintain awareness to support team functioning
Mutual Support	Ability to anticipate and support team members' needs through accurate knowledge about their responsibilities and workload

The Performance Assessment of Communication and Teamwork (PACT) is a derivative of TeamSTEPPS. Its development was funded by the Macy and Hearst Foundations (Chiu et al., 2013). The PACT-Novice observer tool is an assessment tool designed to help measure the effectiveness of received training for individuals who do not have extensive experience with TeamSTEPPS or simulation training. The assessment questions derive from Brock et al. (2011a) and Brock et al. (2011b) Pre and Post Assessment questions respectively, however, the PACT-Novice tool is still in the process of validation (Chiu et al., 2013). For the purpose of this thesis, validated questions from the Pre/Post Assessment that are used in conjunction with PACT-Novice will be used. These questions maintain the keys principles of TeamSTEPPS.

2.5.5. TEACH Teamwork

The American Psychological Association's TEACH Teamwork training framework is also a derivate of the TeamSTEPPS program. Its goal is to apply a science based approach to teaching teamwork in a school setting. However, the teaching is aimed at the faculty instead of the students (Benishek et al., 2016). The program follows the core teamwork principles outline by Salas, Sims and Burke (2005). These five principles are known as the Big 5 of teamwork. TEACH Teamwork's training modules emphasize

these principles as the skills necessary to creating more effective teams. Additionally, the

creators of TEACH Teamwork incorporate instruction methods proposed by Merriam

(2008) to increase the effectiveness of the training modules. These methods include

didactic information, self-reflection questions, video-based demonstrations and applied

activities that allow for group engagement. Supplementation materials were also

developed including instructor scripts and support notes.

The modules are designed to each focus on one aspect of teamwork skill building.

Table 4 outlines the goal of each module (Benishek et al., 2016).

Table 4: Overview of Teach Teamwork Modules

Module	Learning Objectives	Key Concepts, Tools, and Strategies
Introduction to teams and teamwork	1. Understand why teamwork is important in schools 2. Appreciate why learning about teamwork is relevant to you 3. Understand the advantages of attending Teach Teamwork	Key concepts: † Teams † Groups † Teamwork
Communication	Understand the importance of communication 2. Identify barriers to effective communication 3. Compose messages that are clear, brief, timely, and complete 4. Communicate critical information through best practices and strategies	Key concept: † Foundation of teamwork Tools and strategies: † Paraphrasing † Perception checking † Clarifying questions † Closing-the-loop † SBAR (Situation, Background, Assessment, Recommendation)

Table 4 continued: Overview of Teach Teamwork Modules

Situation monitoring	1. Understand the importance situation monitoring 2. Understand the importance of cross monitoring 3. Identify barriers to both situation and cross monitoring 4. Use the STEP to anticipate and predict team needs	Key concept: † Situation awareness Tool: † STEP (Self, Team members, Environment, Progress toward goals)
Mutual support	1. Understand the importance of mutual support 2. Know the components of mutual support 3. Provide support constructively 4. Use the Two-Challenge Rule to advocate for yourself and your teammates 5. Understand the appropriateness and use of the DESC(Describe, Explain, Support, Collaborate) template Tools and Strategies: 6. Manage conflict effectively	Key concepts: † Task assistance † Social support † Feedback † Conflict management Tools and Strategies: † Two-challenge rule † DESC script
Leadership	1. Understand the importance of leadership 2. Recognize that anyone can be a leader 3. Distinguish between effective and ineffective leadership behaviors 4. Use leadership triathlon strategies: STEP, SWIM, BIKE, RACE	Key concept: † Shared leadership Tools: † STEP † SWIM (Start With Intent and Meaning) † BIKE (Bring In Knowledge and Equipment) † RACE (Respect viewpoints, Address questions and concerns, Consider

The training modules have been tested and published for public use. The entire

program and supplemental materials are available, for free, online. This aligns with the

goals of the researchers to have the training available to the end-user in a manner that is

more easily integrated for the needs of the school (Benishek et al., 2016). Unlike other

teamwork training programs, this program was not sponsored by a major grant.

Therefore, follow up of implementation of the training tools is not as widely documented.

However, the same rigor of literature review, research, and testing has been applied by

educators, psychologist, and professionals contributing to the project (Benishek et al.,

2016).

2.6. Literature Review Summary

The literature review revealed three major aspects of teamwork training. Firstly,

programs are focused on the process of team training in addition to the outcome. This

aligned with the Constructivist perspective of learning theory. Secondly, teamwork

training methodologies can be adapted from other disciplines. Industries that depend

heavily on teamwork for successful outcomes, such as the medical industry, can provide

valuable insights on how to train teams effectively. Lastly, a similar focus of skills can be

found across disciplines. These skills reflect those outlined by Salas et al. (2008) in the

form of communication, leadership, situation monitoring, mutual support and conflict

resolution.

CHAPTER 3: RESEARCH NEED AND OBJECTIVES

3.1. Research Need

In all, the literature reveals the wealth of collaborative approaches used in education. Many of these approaches are based on real world examples. Furthermore, the research reveals the most effective collaborative experiences for students reflected in industry scenarios. Across disciplines, establishing greater incorporation of collaborative practices is supported as a concept.

Seat el al. (2001) observed that it important for engineering students to increase their competency in performance skills to effectively use their technical skills. It also noted that performance skills for teamwork are a learned skilled. Across the literature, students who improve these skills increase their marketability of industry desired skills. However, many teamwork training interventions are resource intensive. The teamwork training requires extensive input of skill and time from contributors. Creating new classes, programs and workshops may not be an option for all AEC educational settings. Therefore, creation of a less resource consuming method of teamwork training, derived from the major interventions, would enable more educators to adopt teamwork training for their classrooms.

3.2. Research Questions and Objectives

This exploratory study will investigate the skills most impacted by a teamwork training intervention to inform future research development of less consuming training

methods. It seeks to address the following research questions:

1. Can a one-time teamwork training intervention impact student's attitudes and

    behaviors about teamwork?

2. What are the skills most impacted by a one-time teamwork training intervention?

For the purpose of this research, the terms collaboration and teamwork will be used

interchangeably. Research outcomes will be attained with the following objectives:

1. Identify skills of focus

2. Identify and implement training method

3. Identify assessment method

4. Evaluate changes in attitudes and behaviors towards teamwork

5. Identify skills of importance for future research

CHAPTER 4: RESEARCH METHODOLOGY

4.1. Identification of Skills of Focus (Objective 1)

The research study will focus on skills most commonly used among reviewed

teamwork training frameworks. These skills reflect the Big 5 outlined by Salas et al.

(2008). For the purpose of this research, the TEACH Teamwork application of these

skills will be used because of their adaptation to a school environment. These skills are

defined in the TEACH Teamwork Modules as the following (Benishek et al., 2016):

Communication: the creation of dialogue between two or more individuals for shared
perspective, information exchange, and talent integration

Situation Monitoring: the scanning of the environment to seek out important information
including monitoring teammates and progress towards goals

Conflict Resolution: applying support techniques to resolve tension and disagreements
that delay the achievement of team goals and productivity

Mutual Support: the back-up behavior given to one of more team members as needed for
the benefit of an individual or the greater good of the team

Leadership: carrying out necessary behaviors in order to help the team accomplish their
goals

4.2. Identification of Training Method (Objective 2)

Five teamwork training frameworks from the literature review, shown in Table 5,

were considered for this research study. The training frameworks were each considered

on the basis of three conditions.

Table 5: Training Protocol Comparison

Training Protocol	Accessible Training Tool?	Accessible Assessment Tool?	Training can be integrated into regular class time?
Performance Skills and Communication Minor			X
CII Compass		X	
CATME SMARTER Teamwork		X	
TeamSTEPPS and PACT-Novice	X	X	
TEACH Teamwork	X		X

4.2.1. Accessibility of Training Tool

The first condition was the accessibility of the program. Considering the end goal of an accessible training program that can be adopted by educators, the method of research should also be accessible. TeamSTEPPS and TEACH Teamwork were the only training frameworks accessible from the internet and that did not require a requested account. CATME SMARTER Teamwork and CII Compass do not have a training protocol.

4.2.2. Accessibility of Assessment Tool

The second condition was the accessibility of the training assessment. CII Compass, CATME SMARTER Teamwork and TeamSTEPPS PACT-Novice all have assessments that can be downloaded from the internet. TEACH Teamwork is the only training framework that does not include an assessment as part of the program.

4.2.3. Training Integration to Class

The third condition was the ability of the training to be integrated into a regular class time. The Performance Skills and Communication Minor focused on teaching the Big 5 skills in the context of class. However, its integration is beyond the scope of this

thesis. TEACH Teamwork had the most adaptable training to a class setting in the form of PowerPoint presentations. TeamSTEPPS requires extensive training of the instructor and simulation activities to complete teamwork training. The required resources and time thus makes it ineffective for this research study.

4.2.4. Method Selection

The selected training method based on the outlined conditions was TEACH Teamwork. The PowerPoint format of the training, in addition to a provided script fro each module, allows for easy integration into the classroom. Online availability of the training modules gives instructors easy access TEACH Teamwork. All three available assessment methods were selected. The major skills addressed by the assessments are also addressed in the TEACH Teamwork modules. Therefore, the assessments would be capable of measuring the impact of skills addressed by TEACH Teamwork.

4.3. Identification of Assessment Method (Objective 3)

The assessment methods of the three training frameworks using assessment were all survey based and measured skills related to the Big 5. Therefore, questions from all three assessments were use for this study. Tables 6,7 and 8 show the selected questions to be used as part of the study. An additional question, "Overall, how effective was communication on this project?" was added to reflect the overall goal of the CII RT-105. It was not part of the formal assessment.

All survey responses were collected by an anonymous link, thus mitigating the risk of students being matched to their answers. Each phase of the research study consists of a Pre-Survey, During-Survey and Post-Survey. This research study contains a total of 144 assessment questions, shown in Tables 6,7 and 8.

Table 6: PACT-Novice Assessment Questions

PACT- Novice	
Question	**Survey**
How familiar are you with WORKING as part of a team?	Pre
How familiar are you with TRAINING as part of a team?	Pre
Learning with other students helps me become a more effective member of a team.	Pre
I enjoy learning in team based activities.	Pre
I perform well in team based activities.	Pre
I can work effectively in teams.	Pre
I can contribute valuable insight to teams.	Pre
It is important for leaders to share information with team members.	Pre
Effective leaders view honest mistakes as meaningful learning opportunities.	Pre
It is a leader's responsibility to model appropriate team behavior.	Pre
Team leaders should ensure that team members help each other out when necessary.	Pre
I can facilitate communication between team members.	Pre
Teams that do not communicate effectively, significantly increase their risk of committing errors.	Pre
Poor communication is the most common cause of reported errors.	Pre
It is difficult to train individuals how to be better communicators.	Pre
I prefer to work with team members who ask questions.	Pre
I can effectively coordinate tasks and activities of a team.	Pre
Effective team members can anticipate the needs of other team members.	Pre
Offering to help a fellow team member with his/her individual work tasks is an effective tool for improving team performance.	Pre
To be effective, team members should understand the work of their fellow team members.	Pre
I am able to resolve conflicts between individuals effectively.	Pre
Adverse events may be reduced by maintaining an information exchange between group members.	Pre
Identifies goals, assigns roles and responsibilities, holds members accountable. (I and They statements)	During
Utilizes resources, delegates tasks and balances workload. (I and They statements)	During
Empowers members to speak freely. (I and They statements)	During
Fosters communication. (I and They statements)	During
Resolves conflict. (I and They statements)	During
Works collaboratively. (I and They statements)	During

Table 6 continued: PACT-Novice Assessment Questions

Provides brief, clear, specific and timely information. (I and They statements)	During
Seeks and communicates information from all available sources. (I and They statements)	During
I prefer to work with team members who ask questions.	Post

Table 7: CATME SMARTER Teamwork Assessment Questions

CATME	
Question	**Survey**
Got team input on important matters before going ahead. (I and They statements)	Post
Used teammates' feedback to improve performance. (I and They statements)	Post
Had the skills and expertise to do excellent work. (I and They statements)	Post
Had the skills and abilities that were necessary to do a good job. (I and They statements)	Post
Had enough knowledge of teammates' jobs to be able to fill in if necessary. (I and They statements)	Post
Knew how to do the jobs of other team members. (I and They statements)	Post
Communicated effectively. (I and They statements)	Post
Facilitated effective communication in the team. (I and They statements)	Post
Exchanged information with teammates in a timely manner. (I and They statements)	Post
Provided constructive feedback to others on the team. (I and They statements)	Post
Helped the team to plan and organize its work. (I and They statements)	Post
Provided encouragement to other team members. (I and They statements)	Post
Offered to help teammates when it was appropriate. (I and They statements)	Post
Expressed enthusiasm about working as a team. (I and They statements)	Post
Let other team members help when it was necessary. (I and They statements)	Post
Motivated others on the team to do their best. (I and They statements)	Post
Expected the team to succeed. (I and They statements)	Post
Believed that the team could produce high-quality work. (I and They statements)	Post
Believed that the team should achieve high standards. (I and They statements)	Post
Cared that the team produced high-quality work. (I and They statements)	Post
Did a fair share of the team's work. (I and They statements)	Post
Fulfilled responsibilities to the team. (I and They statements)	Post

Table 7 continued: CATME SMARTER Teamwork Assessment Questions

Completed work in a timely manner. (I and They statements)	Post
Came to team meetings prepared. (I and They statements)	Post
Did work that was complete and accurate. (I and They statements)	Post
Made important contributions to the team's final product. (I and They statements)	Post
Stayed aware of fellow team members' progress. (I and They statements)	Post
Assessed whether the team was making progress as expected. (I and They statements)	Post
Stayed aware of external factors that influenced team performance. (I and They statements)	Post
Made sure that everyone on the team understood important information. (I and They statements)	Post
Kept trying when faced with difficult situations. (I and They statements)	Post
Heard what teammates had to say about issues that affected the team. (I and They statements)	Post
Accepted feedback about strengths and weaknesses from teammates. (I and They statements)	Post

Table 8: CII Compass Assessment Questions

CII	
Question	**Survey**
How well do you understand what information your INSTRUCTOR expects from you?	During
How well do you understand what information OTHER GROUPMEMBERS on this project expect from you?	During
How often do you receive conflicting instructions from more than one person?	During
How often does poor communication or lack of coordination occur in your project?	During
How often are you kept current with project changes?	During
How often do you receive less information than you need?	During

The selected survey platform for this research study was Qualtrics. All survey responses are collected by an anonymous link, thus mitigating the risk of students being matched to their answers. Each phase of the research study consists of three surveys. Survey questions are grouped by the themes and most reference the TEACH Teamwork

training modules. The pre-survey assesses student's attitudes about group work before the completion of a group project. The during-survey assesses students' attitudes and perceived performance of the team, based on the five defined skills, while the project is being completed. The post-survey assesses students' attitudes and perceived performance of the team, based on the five defined skills, after the group project is completed. Students are not required to take the surveys as part of the class curriculum. Any student can opt of a question or the entire survey at any point in time.

4.4. Research Study Design

This research study was modelled after the pre/post format used in reviewed teamwork training frameworks. Phase 1 was completed before the teamwork training intervention. Phase 2 was completed after the teamwork training intervention. This research study was approved by the Institutional Review Board for Research under IRB Number 16-0985.

4.4.1. Inclusion Criteria and Recruitment

Students enrolled in the undergraduate Construction Management and Engineering Technology courses at UNC Charlotte were eligible to participate in this research. The inclusion criteria for class curriculum selection included the following:

1. Class curriculum related to construction field

2. Must have at least two group projects during the duration of the research study

3. In-class time available for TEACH Teamwork training modules

Three classes met the inclusion criteria: CMET 3123 Cost Estimating, CMET 4272 Capstone and ETCE 2221 Construction Mean and Methods. Students recruited from these classes were a mixture of male and female, sophomores, juniors and seniors.

Participation in the research study was optional and not a requirement of the class. In class recruitment was completed at the beginning of the semester for each class. This included an overview of the research study, risks and informed consent.

4.4.2. Survey Structure

Each phase of the research study consisted of three surveys: pre-survey, during-survey and post-survey. The pre-survey assessment was completed before the commencement of a group project. The during-survey assessment was completed while the project was being completed. The post-survey assesses was completed after the group project was completed. Students were not required to take the surveys as part of the class curriculum. Any student could opt of a question or the entire survey at any point in time.

4.5. Phase 1

At the beginning of the semester, the teachers assigned students to groups within their designated classes based on teacher preference. Before the first group project was assigned, students completed the Phase One Pre-Survey. After the teacher assigned the first group project, students completed the Phase One During-Survey. Once the group project was completed, students completed the Phase One Post-Survey. These Phase One surveys, three in total, were completed before the introduction of the TEACH Teamwork training modules.

4.6. Training Intervention

The TEACH Teamwork Training Modules were recorded into video lectures. The lectures followed the instructor script included from TEACH Teamwork (2016). Each module consisted of 1-3 videos. The training videos were shown during one normal class meeting time. The video playlist and original PowerPoint presentation (in addition to the

instructor script) were available to students for reference online after the training class.

4.7. Phase Two

After students completed the TEACH Teamwork training, the process of Phase

Two was completed. The survey questions were repeated from Phase One for all three

surveys. Before the second group project was assigned, students completed the Phase

Two Pre-Survey. After the teacher assigned the second group project, students completed

the Phase Two During-Survey. Once the second group project was completed, students

completed the Phase Two Post-Survey. These Phase Two surveys, three in total, are

completed after the introduction of the TEACH Teamwork training modules. The results

of the surveys from Phase One were compared to the results of Phase Two.

4.8. Data Type and Analysis (Objective 4)

The anonymous response survey platform produced unpaired data. Students

answers could not be matched to their responses. Therefore, unpaired analysis of the

differences in the data between Phase 1 and Phase 2 was performed using the Mann-

Whitney U test for independent samples. The Mann-Whitney U test is a non-parametric

test used for data with similar, non-normal distributions (Daniel, 1990). The Mann-

Whitney U test compares the shift of the distributions by comparing the medians between

the two groups. Four assumptions were met to ensure the data fit requirements for use of

the Mann-Whitney U test (Daniel, 1990):

1. The dependent variable, the survey questions, was measured on an ordinal scale in

   the form of Likert data.

2. The independent data, Phase 1 and Phase 2, were categorical and independent

   groups.

3. Phase 1 and Phase 2 were unpaired observations because of the anonymity of the surveys.

4. The distribution was not normal because of the ordinal nature of the data.

Secondly, outside, independent variables such as project type, teacher instructor or group partners could have contributed to a change in student responses. A control group was not used to established if these independent variables could impact results. However, these conditions of the data were acceptable because this was an exploratory study. The goal of the research was to provide a basis for further research for further design development (Common Guidelines for Education Research and Development, 2013), not to establish firm conclusions.

To find missing values within the completed report, a missing value analysis was conducted using a multiple implementation method of expectation maximization (EM) in SPSS. Schafer and Olsen (1998) state that EM is an efficient computation method for estimating missing values. The process involves SPSS analyzing the data around the missing data in order to determine preliminary parameters to estimate the missing values. Once parameters have been determined, the process is repeated to determine new parameters with the new estimated values until a maximum-likelihood was achieved (Schafer and Olsen, 1998). The predicted values were added to the survey data to complete further analysis.

The Mann-Whitney U test was performed for all 114 questions to compare the Phase 1 results to the Phase 2 results. The confidence level was set at 90%, $\alpha=0.1$. A 90% confidence level allows the significant changes to be noted without disregarding potential impacts that fall out of the standard 95%, $\alpha=0.5$. The questions scoring a significant value

≤ 0.1 were selected for additional analysis. The additional analysis included descriptive

statistics and comparison of means.

CHAPTER 5: RESULTS AND ANALYSIS

5.1. Phase 1

A total 87 students were eligible to complete the Phase 1 surveys. An average of 72 responses were collected for all three surveys of Phase 1. This yielded an 83% response rate. The average academic standing for students were 9% sophomore, 35% junior and 56% senior. A majority of the students completing the survey and demographic data were Male. The average credit hours taken this semester for students completing these surveys was 15 credit hours. An average of 80% of students reported having professional experience related to their field of study. An average of 57% students were currently working in the profession related to their field of study. The majority of students responding to demographic questions were not involved in extra curricular activities.

5.2. Phase 2

A total 87 students were eligible to complete the Phase 2 surveys. An average of 30 responses were collected for all three surveys of Phase 2. This yielded a 34% response rate. The smaller response rate in Phase 2 could not be contributed to a specific cause. Phase 1 could not be paired to Phase 2, by students or class, because the surveys were anonymous. Also, possible outside influences, such as midterm evaluations, may have affected the response rate. However, the influence of outside influences cannot be established in the absence of a control group. The average academic standing for students

were 19% junior and 81% senior. A majority of the students completing the survey and demographic data were Male. The average credit hours taken this semester for students completing these surveys was 15 credit hours. An average of 83% of students reported having professional experience related to their field and study. An average of 50% students were currently working in the profession related to their field of study. The majority of students responding to demographic questions were not involved in extra curricular activities. 5.2 Mann-Whitney U Test

Statistical analysis was conducted using IBM Statistical Package for Social Sciences, version 23. A confidence level of 90% was used to determine questions of statistical significance. The question with significant value of 0.108 was included because it was very close to 0.10 cutoff. All 144 items were analyzed using the Mann-Whitney U non-parametric test for independent samples. A total of 18 items, displayed in Table 9, were considered statistically significant. The results suggest these areas were impacted by the one-time training intervention.

Table 9: Mann-Whitney U Significant Questions

Questions	Mann Whitney U	Asymp. Sig.
Pre-Survey		
It is difficult to TRAIN individuals how to be better communicators.	792.000	0.030
Teams that DO NOT communicate effectively significantly INCREASE THEIR RISK of committing errors.	869.500	0.081
I am able to RESOLVE conflicts between individuals effectively.	867.000	0.089
Team leaders should ENSURE that team members HELP EACH OTHER out when necessary.	882.000	0.108

Table 9 continued: Mann-Whitney U Significant Questions

During- Survey		
How often do you receive LESS INFORMATION than you need?	652.000	0.009
How often does POOR COMMUNICATION or LACK OF COORDINATION occur in your project?	681.000	0.018
They IDENTIFY goals, ASSIGN roles and responsibilities, HOLD members ACCOUNTABLE.	746.500	0.051
How often do you receive CONFLICTING INFORMATION from more than one person?	735.000	0.056
Post-Survey		
I BELIEVED that the team should achieve high standards.	882.000	0.026
They let other TEAM MEMBERS HELP when it was necessary.	871.000	0.026
They kept TRYING when faced with difficult situations.	894.500	0.036
I provided CONSTRUCTIVE FEEDBACK to others on the team.	895.000	0.048
They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.	928.500	0.080
They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.	934.000	0.085
I FULFILLED RESPONSIBILITIES to the team.	942.000	0.088
They EXCHANGED INFORMATION with teammates in a TIMELY manner.	935.000	0.088
I EXCHANGED INFORMATION with teammates in a TIMELY manner.	941.000	0.096
I CARED that the team produced high-quality work.	961.000	0.100

5.3. Pre-Survey Results

Descriptive analysis of individual questions showed the frequency of answer choice for Phase 1 compared to Phase 2. The general distribution of answers remained similar despite a difference of response rate for Phase 1 compared to Phase 2. Figures 1-4 illustrate the distribution of answer frequencies for each significant question.
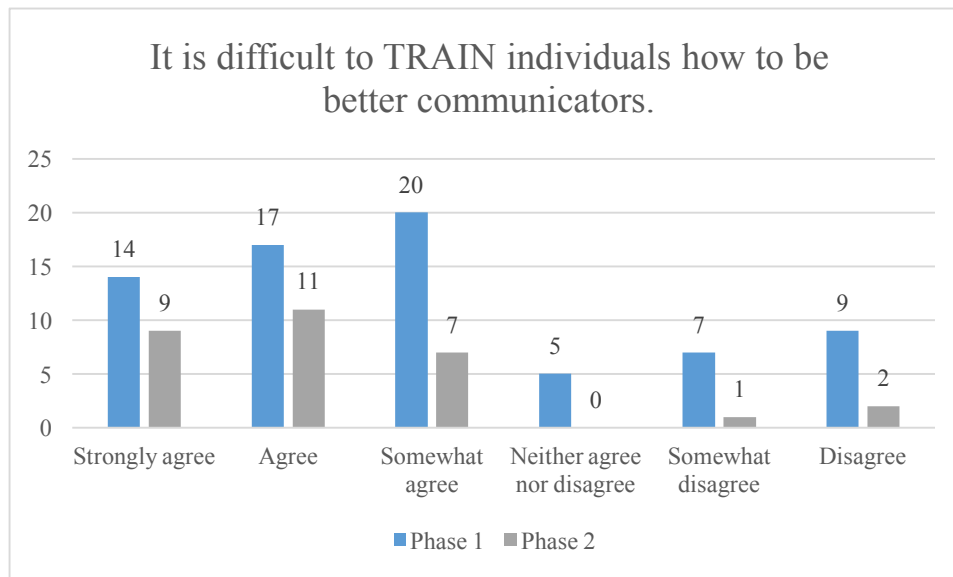
Figure 1: It is difficult to TRAIN individuals how to be better communicators.
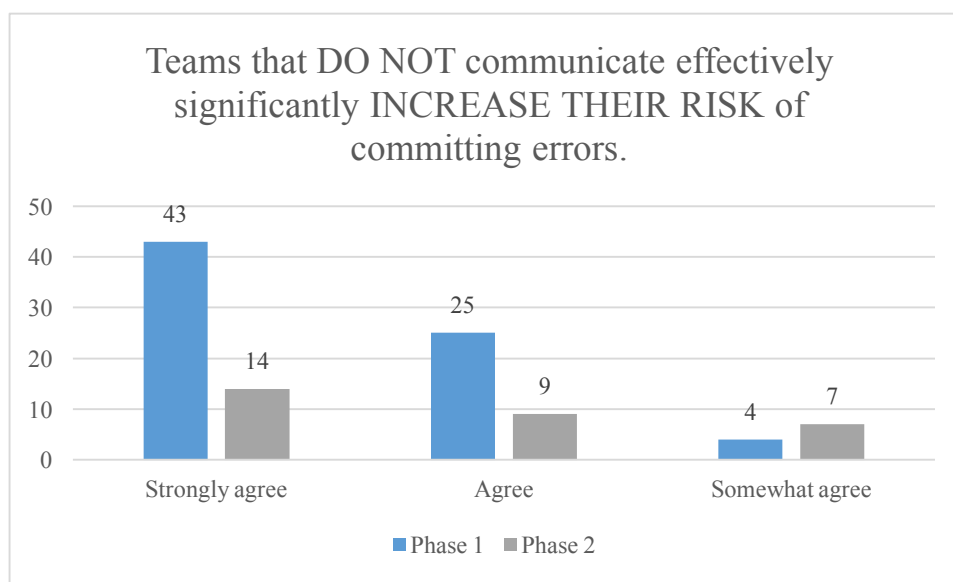
Figure 2: Teams that DO NOT communicate effectively significantly INCREASE THEIR RISK of committing errors.
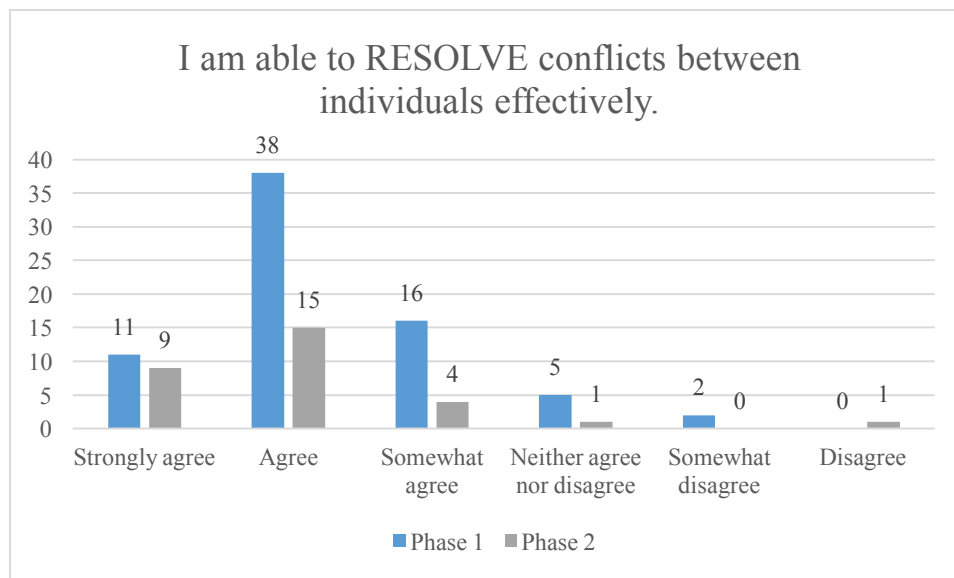
Figure 3: I am able to RESOLVE conflicts between individuals effectively.
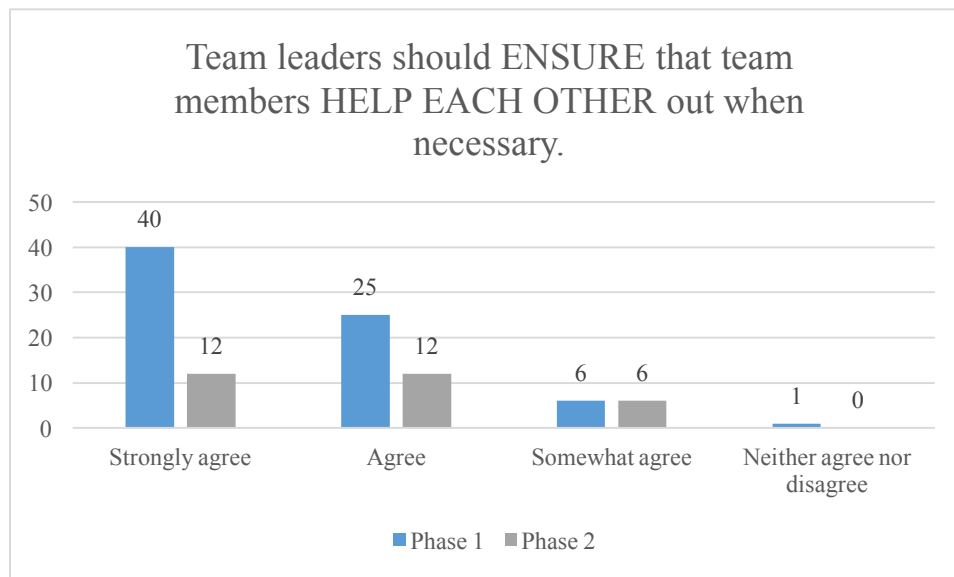
Figure 4: Team leaders should ENSURE that team members HELP EACH OTHER out when necessary.

5.4. During- Survey Results

Descriptive analysis of individual questions showed the frequency of answer choice for Phase 1 compared to Phase 2. The general distribution of answers remained similar despite a difference of response rate for Phase 1 compared to Phase 2. Figures 5-8 illustrate the distribution of answer frequencies for each significant question.
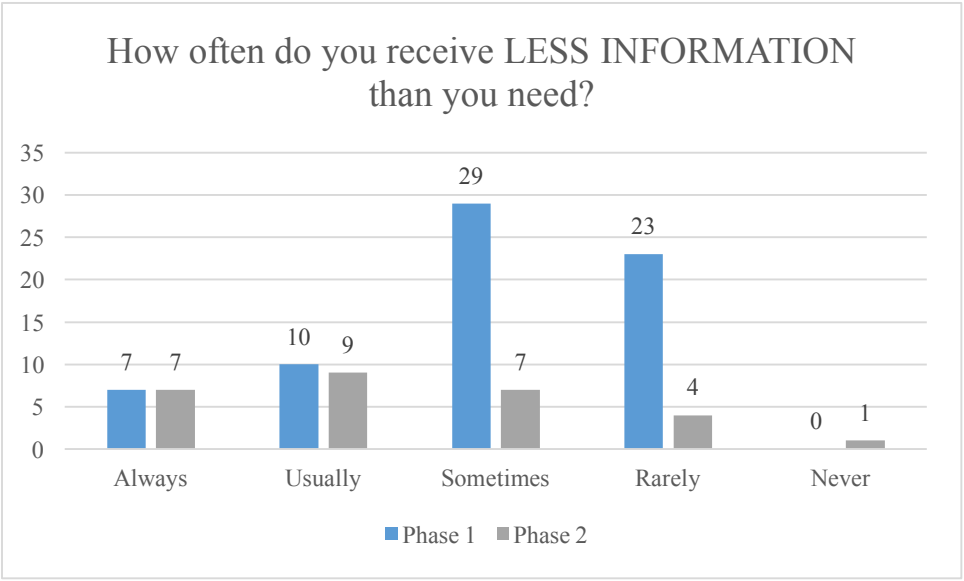
Figure 5: How often do you receive LESS INFORMATION than you need?
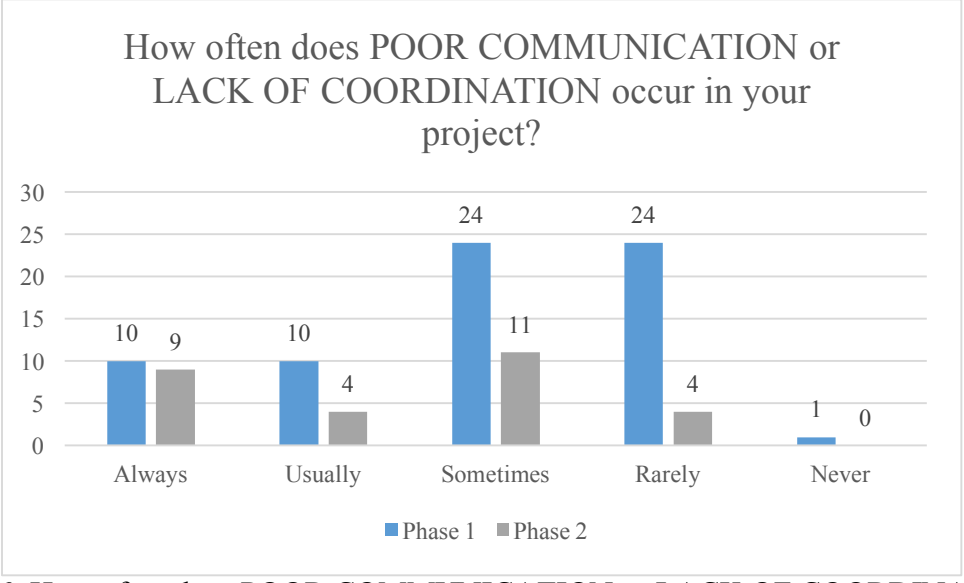
Figure 6: How often does POOR COMMUNICATION or LACK OF COORDINATION occur in your project?
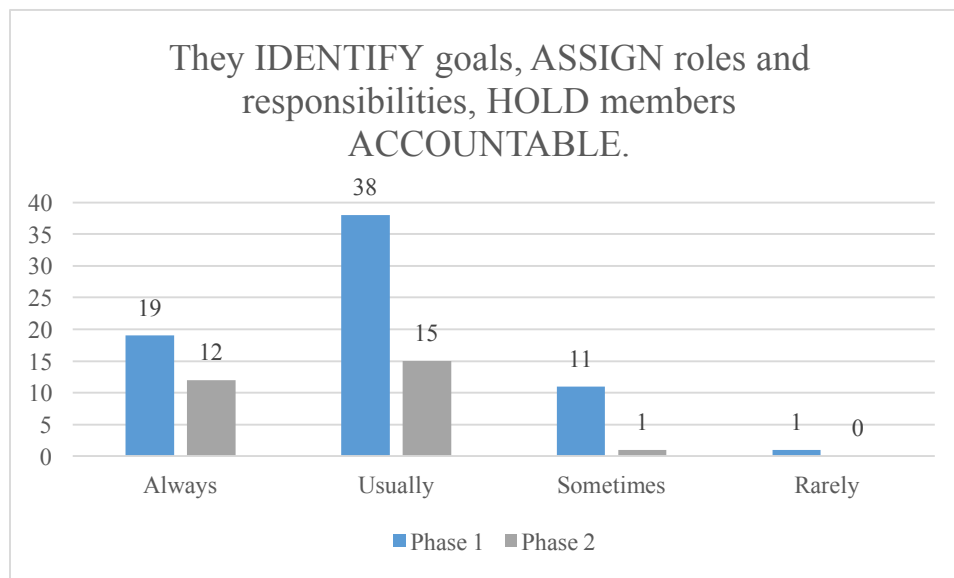
Figure 7: They IDENTIFY goals, ASSIGN roles and responsibilities, HOLD members ACCOUNTABLE.
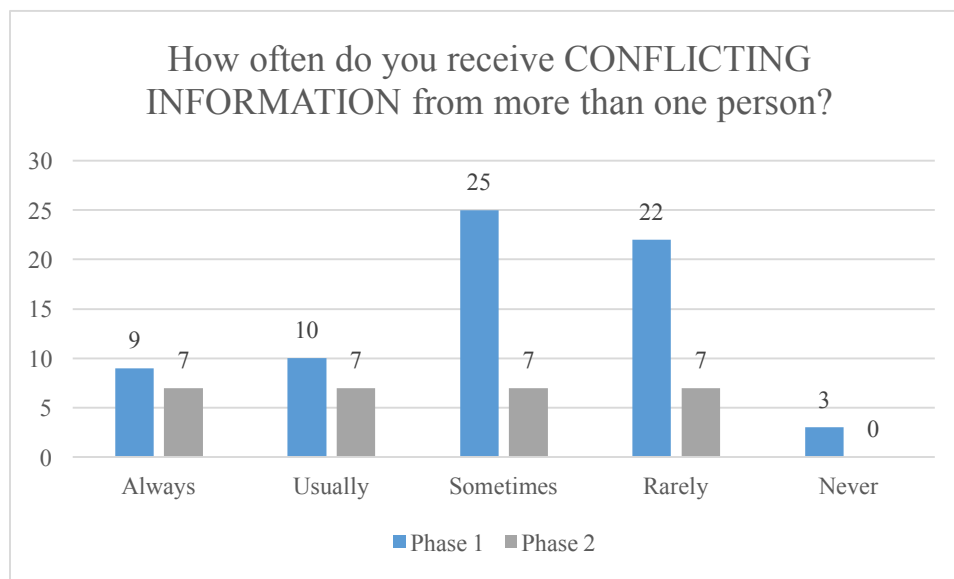
Figure 8: How often do you receive CONFLICTING INFORMATION from more than one person?

5.5. Post-Survey Results

Descriptive analysis of individual questions showed the frequency of answer choice for Phase 1 compared to Phase 2. The general distribution of answers remained similar despite a difference of response rate for Phase 1 compared to Phase 2. Figures 9-18 illustrate the distribution of answer frequencies for each significant question.
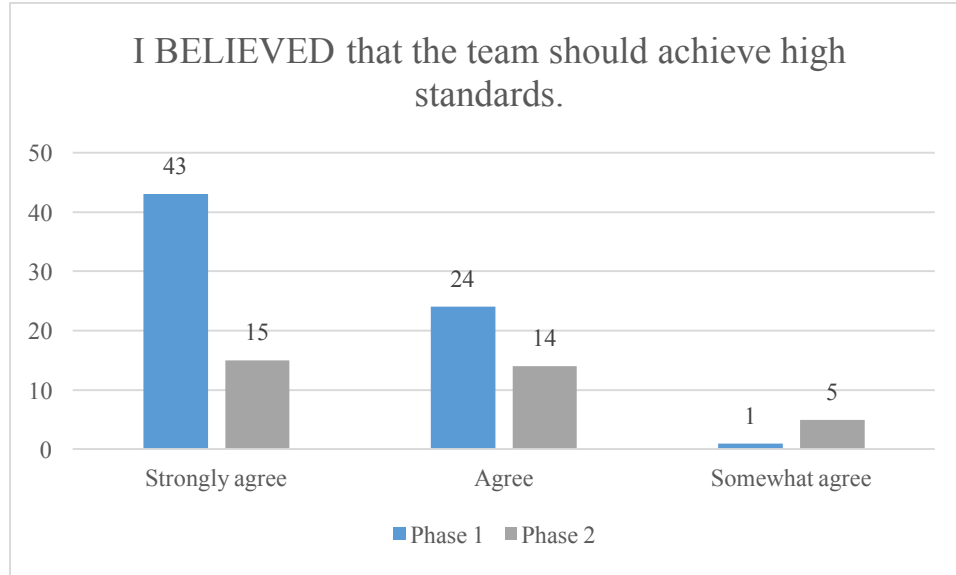
Figure 9: I BELIEVED that the team should achieve high standards.
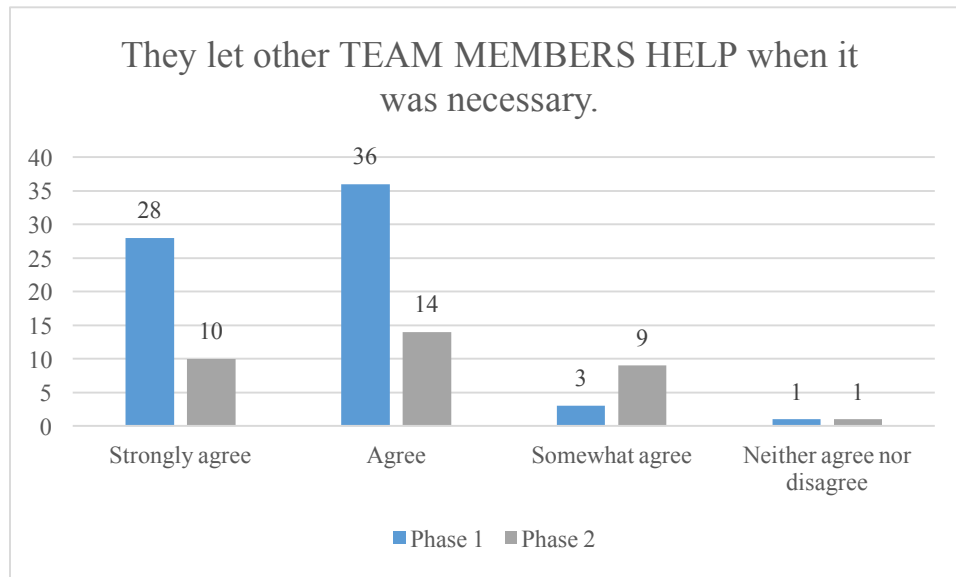
Figure 10: They let other TEAM MEMBERS HELP when it was necessary.
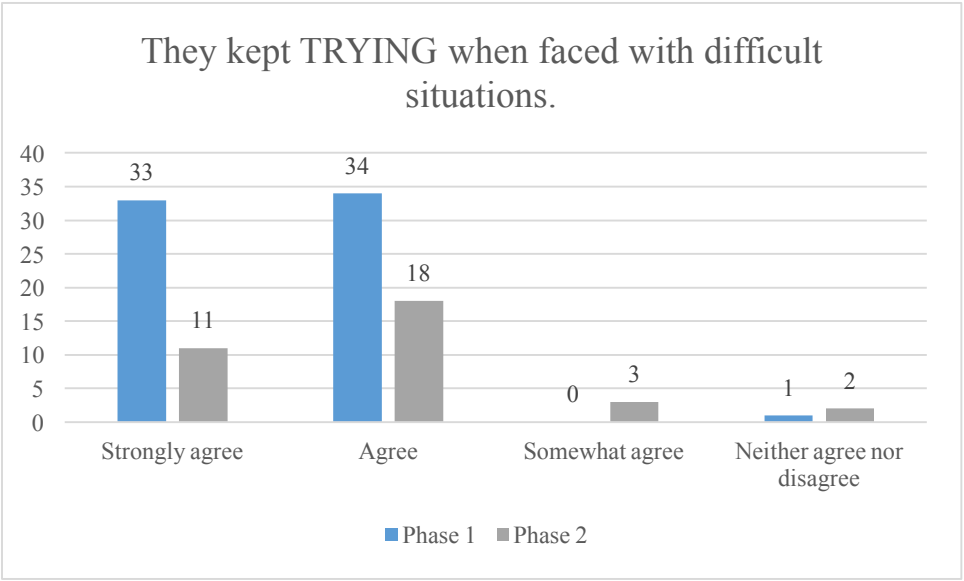
Figure 11: They kept TRYING when faced with difficult situations.
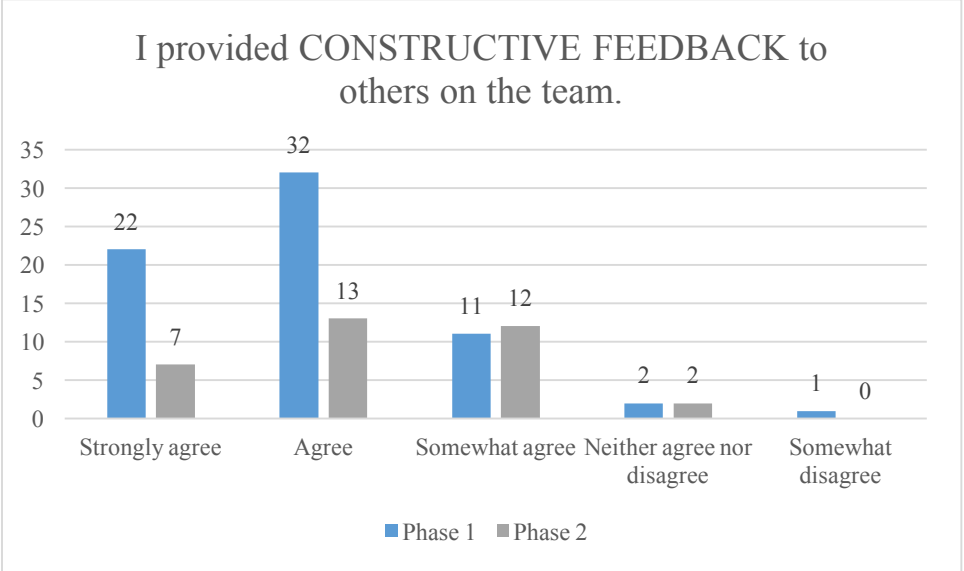
Figure 12: I provided CONSTRUCTIVE FEEDBACK to others on the team.

They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.
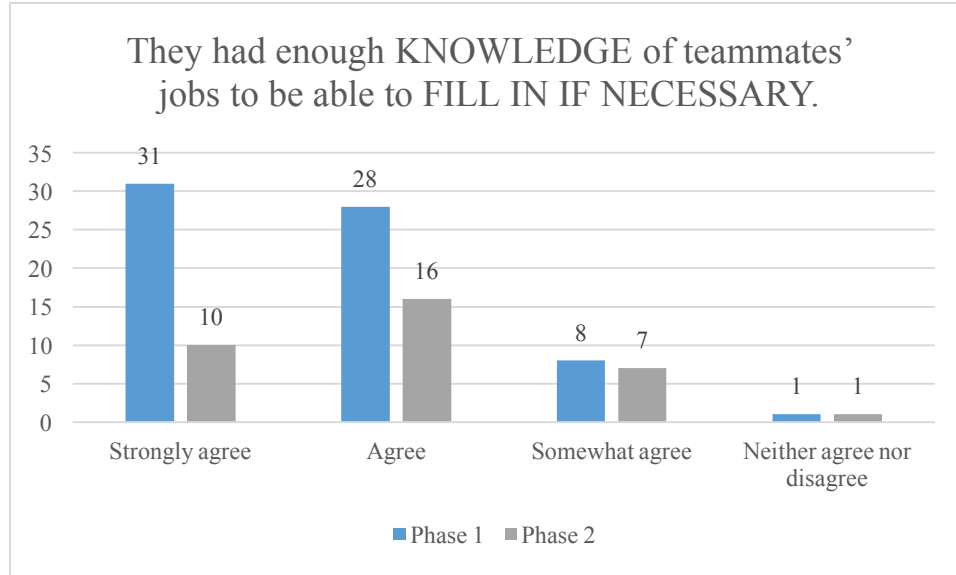
Figure 13: They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.

They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.
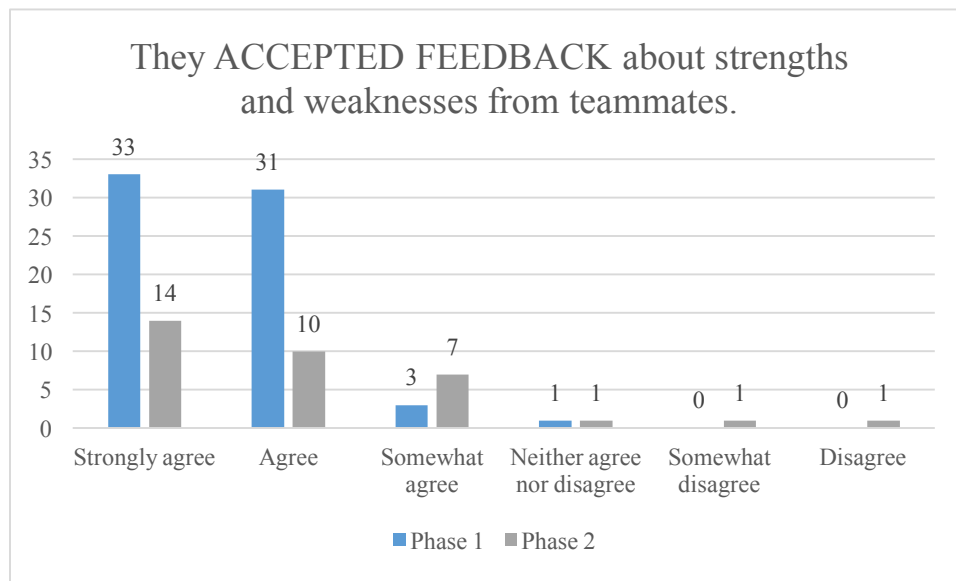
Figure 14: They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.
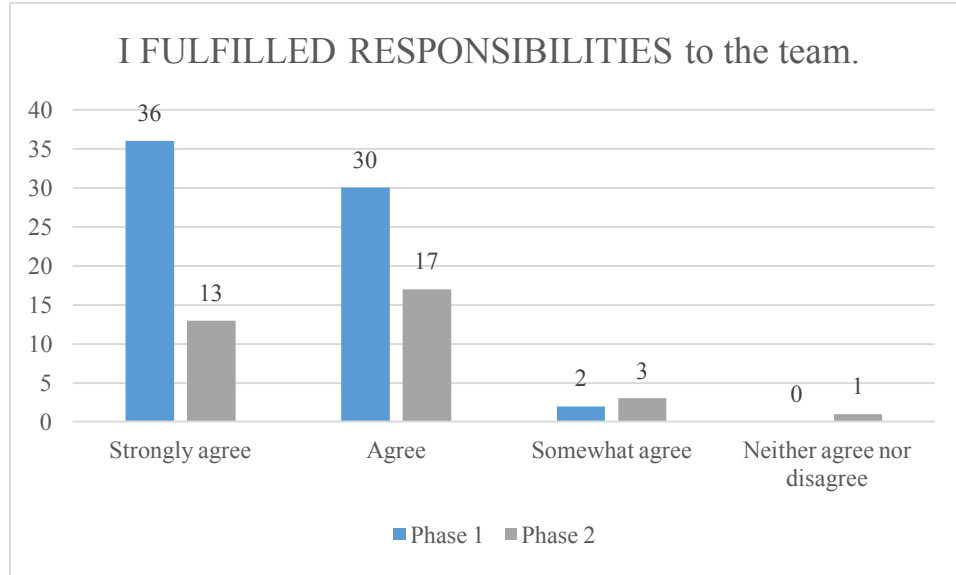
Figure 15: I FULFILLED RESPONSIBILITIES to the team.
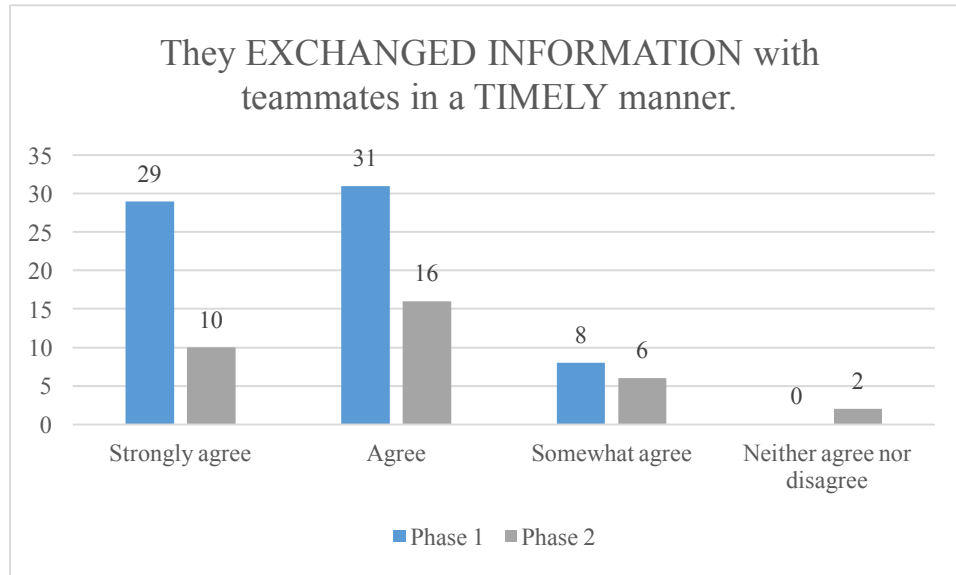
Figure 16: They EXCHANGED INFORMATION with teammates in a TIMELY manner.
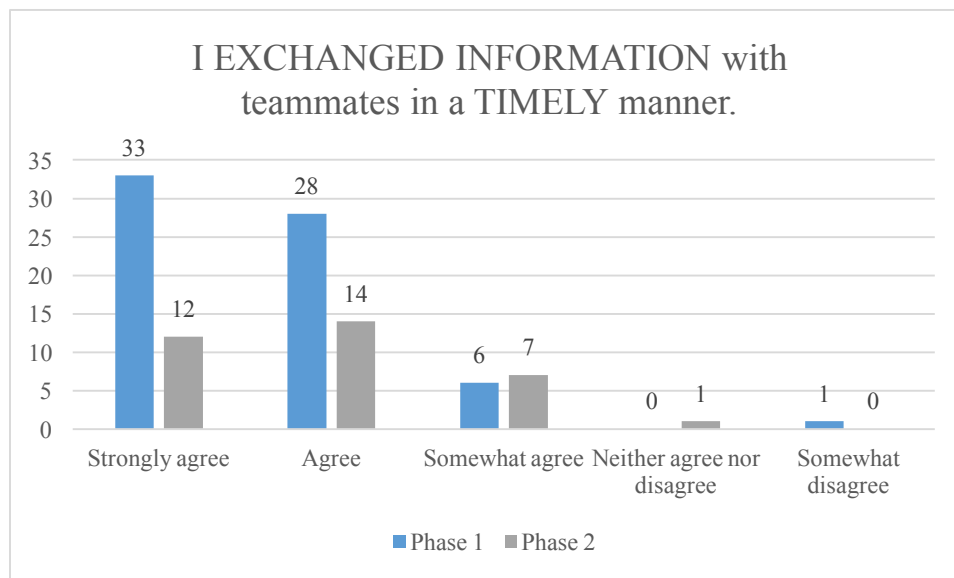
Figure 17: I EXCHANGED INFORMATION with teammates in a TIMELY manner.
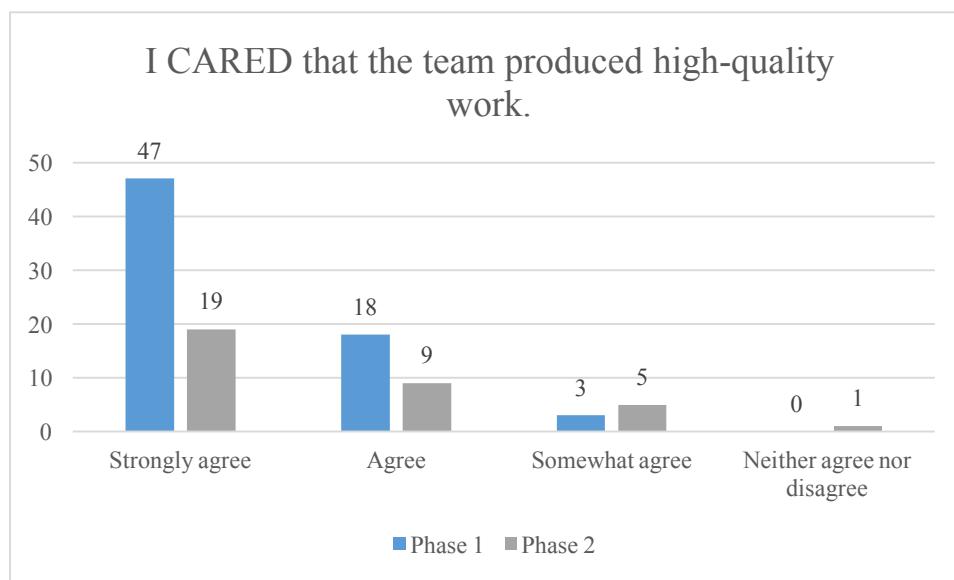
Figure 18: I CARED that the team produced high-quality work.

5.6. Comparison of Means Results

A comparison of means analysis was performed to compare change in mean from Phase 1 to Phase 2 for each question. The results were illustrated graphically with an x-axis scale reflecting the Likert scale of the question group. Thus, the change in means of the question can be described in terms of a positive or negative along the Likert scale. Table 10 illustrates the change of means for the significant pre-survey questions. These

questions were analyzed on 1-7 Likert scale, Strongly Agree-Strongly Disagree. Question

1 and Question 3 observed negative changes in attitudes and behaviors with Phase 2

means increasing from Phase 1. Questions 2 and 3 observed positive changes in attitudes

and behaviors with Phase 2 means decreasing from Phase 1.

Table 10: Pre-Survey Means

	Question	Means	
		Phase 1	Phase 2
1	Team leaders should ensure that team members help each other out when necessary.	1.56	1.8
2	I am able to resolve conflicts between individuals effectively.	2.29	2.03
3	Teams that do not communicate effectively, significantly increase their risk of committing errors.	1.46	1.77
4	It is difficult to train individuals how to be better communicators.	3.01	2.3
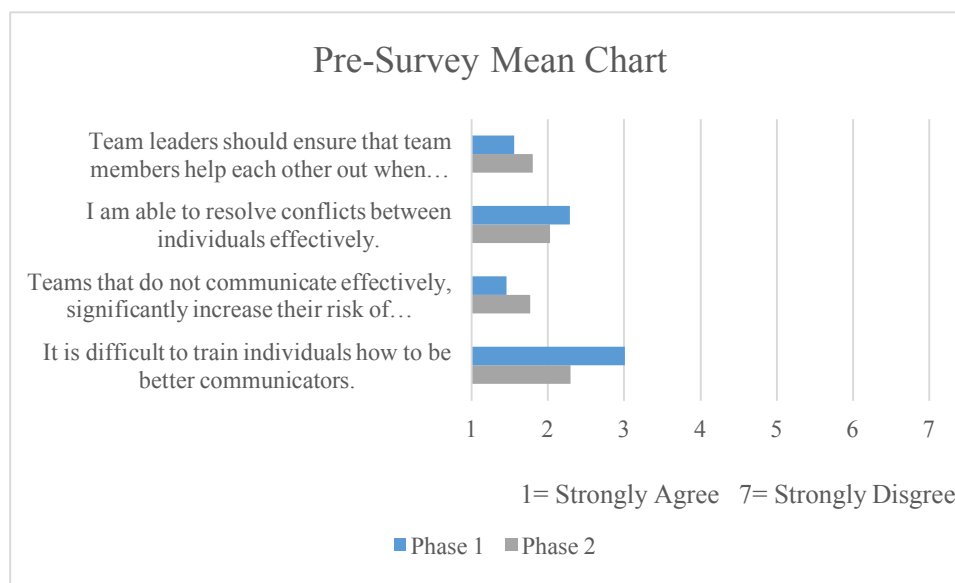
Figure 19: Pre-Survey Mean Chart

Table 11, illustrates the change of means for the significant during-survey

questions. These questions were analyzed on 1-5 Likert scale, Always-Never. Question 1

and Questions 3-4 are negative questions and thus answers were inversed to reflect the

same 1-5, Always-Never scale. The decrease in means from Phase 1 to Phase 2 thus

indicates a negative change in attitudes and behaviors. Conversely, Question 2 observed a

positive change in attitude and behavior with a decrease in mean from Phase 1 to Phase 2.

Table 11: During-Survey Means

	Question	Means	
		Phase 1	Phase 2
5	How often do you receive CONFLICTING INFORMATION from more than one person?	3	2.5
6	They IDENTIFY goals, ASSIGN roles and responsibilities, HOLD members ACCOUNTABLE	1.91	1.61
7	How often does POOR COMMUNICATION or LACK OF COORDINATION occur in your project?	2.94	2.36
8	How often do you receive LESS INFORMATION than you need?	2.99	2.39
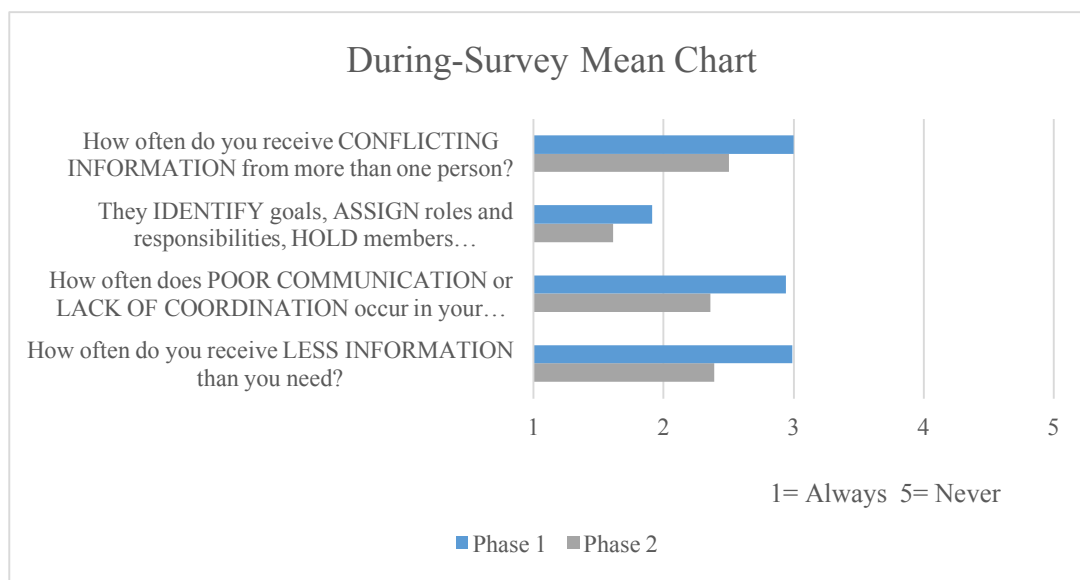
Figure 20: During-Survey Mean Chart

Table 12, illustrates the change of means for the significant post-survey questions.

These questions were analyzed on 1-7 Likert scale, Strongly Agree-Strongly Disagree.

All questions observed a negative change in behavior from Phase 1 to Phase 2.

Table 12: Post-Survey Means

Question		Means	
		Phase 1	Phase 2
9	They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.	1.69	1.97
10	I provided CONSTRUCTIVE FEEDBACK to others on the team.	1.94	2.26
11	They kept TRYING when faced with difficult situations.	1.54	1.88
12	They let other TEAM MEMBERS HELP when it was necessary.	1.66	2.03
13	I BELIEVED that the team should achieve high standards.	1.38	1.71
14	I CARED that the team produced high-quality work.	1.35	1.65
15	I EXCHANGED INFORMATION with teammates in a TIMELY manner.	1.65	1.91
16	They EXCHANGED INFORMATION with teammates in a TIMELY manner.	1.69	2
17	I FULFILLED RESPONSIBILITIES to the team.	1.5	1.76
18	They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.	1.59	2.06
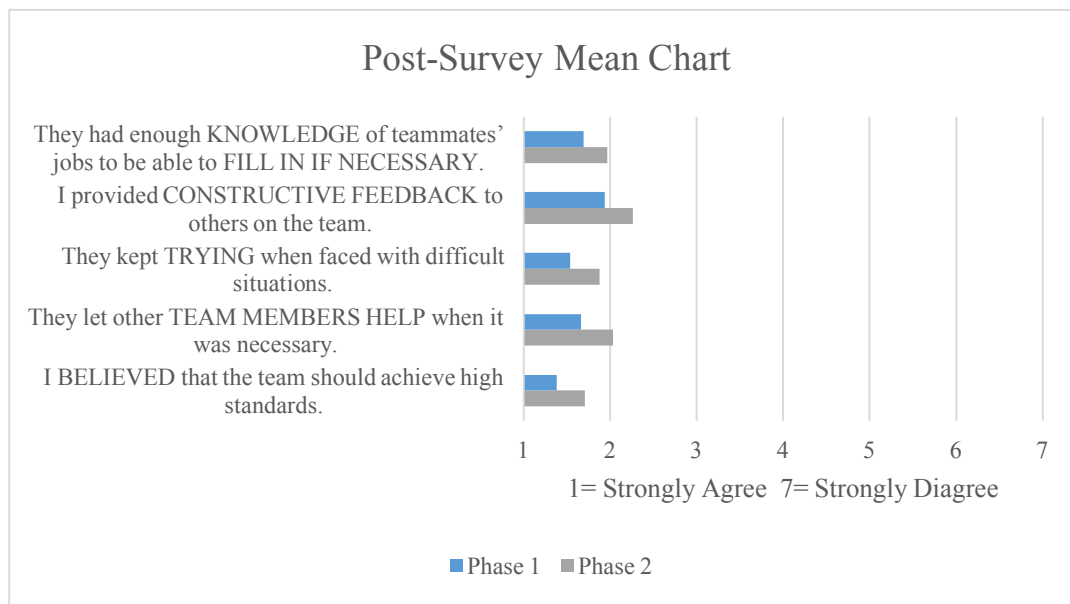
Figure 21: Post- Survey Mean Chart 9-13
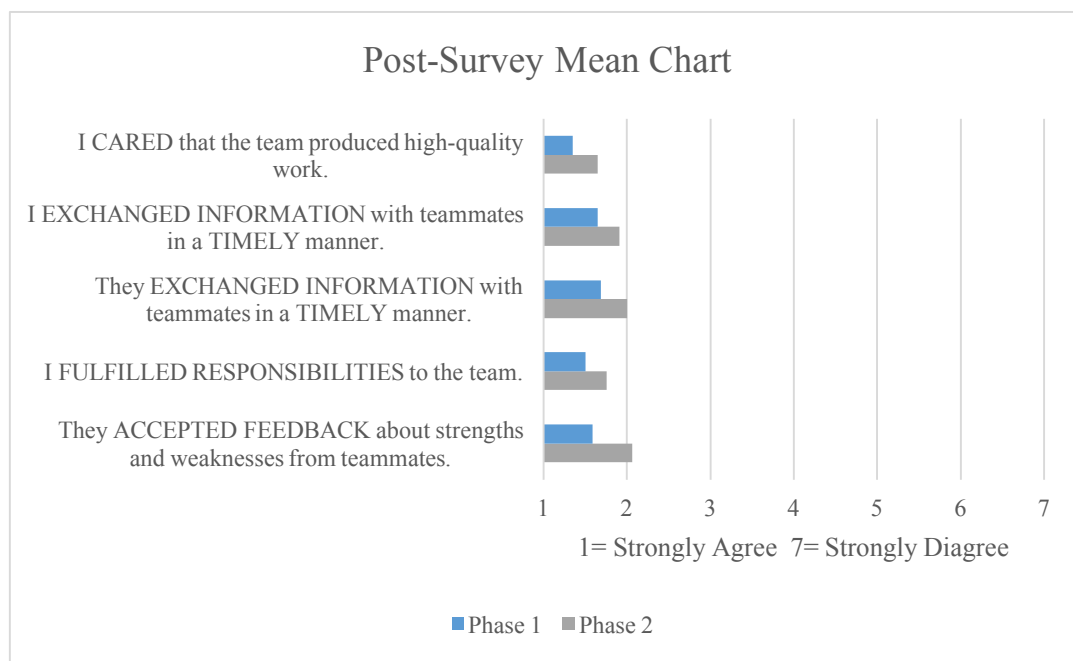
Figure 22: Post- Survey Mean Chart 14-18

5.7. Analysis Summary

Off the 114 items surveys in Phase 1 and Phase 2, 18 items were deemed statistically significant according to the Mann-Whitney U test. Comparison of means analysis revealed 15 of the 18 significant items showed a negative change in attitudes and behaviors from Phase 1 to Phase 2. This negative change in attitudes and behaviors does not conclusively indicate the training was not successful. The goal of the research study was to determine if a change could be observed and if so, what skill reflected the most change. Due to the nature of the data being unpaired and no control of outside influences, a concrete determination cannot be made that the TEACH Teamwork training is the sole contributor to this change. However, a correlation can be established between the TEACH Teamwork intervention and the significant changes between Phase 1 and Phase 2.

Secondly, the identified significant questions can be grouped in themes according to the Big 5 outline skills. As illustrated in Table 13, Communication skills had the most

occurrence of significant questions accounting for 44% of the 18 questions.

Table 13: Questions Ranked by Big 5 Skills

| Question	Big 5 Skill
How often do you receive LESS INFORMATION than you need?	Communication
How often does POOR COMMUNICATION or LACK OF COORDINATION occur in your project?	Communication
It is difficult to train individuals how to be better communicators.	Communication
I provided CONSTRUCTIVE FEEDBACK to others on the team.	Communication
How often do you receive CONFLICTING INFORMATION from more than one person?	Communication
Teams that do not communicate effectively, significantly increase their risk of committing errors.	Communication
They EXCHANGED INFORMATION with teammates in a TIMELY manner.	Communication
I EXCHANGED INFORMATION with teammates in a TIMELY manner.	Communication
They kept TRYING when faced with difficult situations.	Conflict Resolution
They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.	Conflict Resolution
I am able to resolve conflicts between individuals effectively.	Conflict Resolution
They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.	Leadership
Team leaders should ensure that team members help each other out when necessary.	Leadership
I BELIEVED that the team should achieve high standards.	Mutual Support
I FULFILLED RESPONSIBILITIES to the team.	Mutual Support
I CARED that the team produced high-quality work.	Mutual Support
They let other TEAM MEMBERS HELP when it was necessary.	Situation Monitoring
They IDENTIFY goals, ASSIGN roles and responsibilities, HOLD members ACCOUNTABLE	Situation Monitoring

The distribution of questions by skill type shown in Table 14, illustrates that although communication did not comprise the majority of total questions, it dominates the total of significant questions.

Table 14: Distribution of Questions by Skill Type

Big 5 Skill	Number of Total Questions	Number of Significant Questions	Percent of Total Questions	Percent of Significant Questions
Communication	25	8	22%	44%
Conflict Resolution	10	3	9%	17%
Leadership	16	2	14%	11%
Mutual Support	25	3	22%	17%
Situation Monitoring	38	2	33%	11%
Total	**114**	**18**	**100%**	**100%**

Conversely, situation monitoring, which account for the largest amount of total questions at 33%, only comprised 11% of the significant questions. Mutual support, which had the same number if total questions as communication, only comprised 17% of the significant questions. It can be concluded the communication skill's 44% occurrence of significant questions was not the result of an uneven distribution of questions towards communication.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1. Conclusions

Based on descriptive and statistical analysis of the Phase 1 and Phase 2 surveys, the following conclusions have been determined in relation to the research questions:

1. *Can a one-time teamwork training intervention impact student's attitudes and behaviors about teamwork?* It is possible for a one-time teamwork training intervention to impact student's attitudes and behaviors about teamwork based on the results of Phase 1compared to Phase 2. As noted, the differences are based in a correlation and not a causation due to the type of data collected. Also, it can be inferred that the teamwork training informed students on what attitudes and behaviors should be present in an effective team. Therefore, the change between Phase 1 and Phase may be attributed to increased awareness.

2. *What are the skills most impacted by a one-time teamwork training intervention?* All skills noted significant changes. Communication was the skill most frequently observed in statistically significant questions. This is significant because communication is an integral aspect of applying the other four skills. Communication is required to resolve conflicts, provide leaderships to others, provide support and deliver updates about situations affecting the team. Addressing communication as the focus of a teamwork training provides a foundation to build upon for the other four skills.

As previously stated, the interest of the research is to analyze the process that leads to an impact, not exclusively the results. Interpretation of the change in attitudes and behaviors may be attributed to an increase awareness of how teams can function effectively. Both professors and students noted that the training modules increased their awareness of what constitutes teamwork. The TEACH Teamwork training provided an example of successful and effective teamwork. Thus, students could compare their performance and the performance of their peers to the example set forth in the teamwork training. A negative or positive shift in the means of the significant questions may reflect that students had a better understanding of how to analyze attitudes and behaviors in the context of their group project. This understanding formed during the process of the teamwork training.

Feedback from both professors and students provided suggestions for improvements in the studies. Both professors and students suggested incorporating the training modules into more than one class period. This would help to prevent information fatigue and give more opportunity to discuss the information covered in the modules. Students noted that incorporation of more activities would help to reinforce the skills outlined in the training modules and keep them more engaged with the training.

6.2. Recommendations and Future Applications

Further research is recommended to investigate the effectiveness of communication instruction in a classroom training intervention. In testing a framework that can be integrated quickly into a class setting and with little resources, communication has been shown to be the most impacted skill in a short amount of time. Situation monitoring was the second skill most impacted by a classroom training intervention and

is recommended for further research. Additional incorporation of paired assessments, in addition to a control group, would allow more rigorous testing of the effective of the training tool. Concrete conclusions could be established about the strength of impact of the training intervention.

The scope of this research study was limited to a one-time training intervention given in video lecture format. Additional research in the use of facilitation methods, in conjunction with the training intervention, would potentially help to reinforce the effectiveness of the training tool as noted by professors and students. Teaching the modules in parts, instead of one continuous lesson, may also help students to better

This research study demonstrated how a teamwork training intervention, small in scope, impacted major teamwork skills. It raised awareness of how teams can effectively function based on a set of acquirable skills. This is a beginning step to addresses the major obstacle of overcoming negative attitudes stated by Forgues and Becerik-Gerber (2013). Small scope interventions, such as this research study, may better prepare students for more in-depth teamwork training because it established the foundation of what teamwork is, why it is important and how it can impact not only the project outcomes but also the group members. Therefore, early introduction of small scope interventions, such as the beginning semesters of higher education, would provide time to further develop skills. Students' understanding could be tested with more complex group projects reflecting common situation encountered in industries. The small scope interventions could then act as a refresher or reference for students.

Although these results and recommendations are not exclusive to construction or the AEC industry, they provide feedback directly beneficial to the development of the

future professionals of the AEC industry. As the shift continues to collaborative

approaches to business and project delivery, students' skillsets should continue to

develop to address these changes.

REFERENCES

Becerik-Gerber, B., and Kensek, K. (2010). "Building Information Modeling in Architecture, Engineering, and Construction: Emerging Research Directions and Trends." *Journal of Professional Issues in Engineering Education and Practice*, 136(3), 139–147.

Becerik-Gerber, B., and Forgues, D. (2013). "Integrated Project Delivery and Building Information Modeling: Redefining the Relationship between Education and Practice." *The International Journal of Design Education*, 6(2), 47–56.

Benishek, L. E., Gregory, M. E., Hodges, K., Newell, M., Hughes, A. M., Marlow, S., Lacerenza, C., Rosenfield, S., and Salas, E. (2016). "Bringing the Science of Team Training to School-Based Teams." *Theory Into Practice*, 55(2), 112–119.

Bilbo, D., Bigelow, B., Escamilla, E., & Lockwood, C. (2015). "Comparison of Construction Manager at Risk and Integrated Project Delivery Performance on Healthcare Projects: A Comparative Case Study." *International Journal of Construction Education and Research*, 11(1),40-53.

Brock, D., Abu-Rish, E., Vorvick, L., Wilson, S., Liner, D., Schaad, D. & Blondon, K. (2011a). "Pre-Assessment: Interprofessional Team Simulation Training." <http://collaborate.uw.edu/sites/default/files/files/Post_Assessment.pdf (Nov. 2016).

Brock, D., Abu-Rish, E., Vorvick, L., Wilson, S., Liner, D., Schaad, D. & Blondon, K. (2011b). "Post-Assessment: Interprofessional Team Simulation Training." <http://collaborate.uw.edu/sites/default/files/files/InterprofessionalTeamSimulationTraining_PreAssessment.pdf> (Nov. 2016).

"CATME: SMARTER Teamwork." (2016). *CATME*, <http://info.catme.org/> (Nov. 2016).

Charles, P., and Thomas, C. (2009). "Four approaches to teaching with building performance simulation tools in undergraduate architecture and engineering education." *Journal of Building Performance Simulation*, 2(2), 95–114.

Chiu, C.-J., D. B., and E. A.-R. (2016). "Performance Assessment of Communication and Teamwork (PACT) Tool Set." *Center for Health Sciences Interprofessional Education, Research and Practice*, <http://collaborate.uw.edu/tools-and-curricula/tools-for-evaluation/performance-assessment-of-communication-and-teamwork-pact-t> (Nov. 2016).

Clark, P. G. (2006). "What would a theory of interprofessional education look like? Some suggestions for developing a theoretical framework for teamwork training." *Journal of Interprofessional Care*, 20(6), 577–589.

Common Guidelines for Education Research and Development (Rep.). (2013). *Institute of Education Services and National Science Foundation*.

D'amour, D., and Oandasan, I. (2005). "Interprofessionality as the field of interprofessional practice and interprofessional education: An emerging concept." *Journal of Interprofessional Care*, 19(1), 8–20.

Daniel, W. W. (1990). *Applied nonparametric statistics* (2nd ed). Boston, MA: Cengage Learning.

Design Build Institute of America. (2014) "What is Design-Build: A Design-Build Done Right Primer". *Design Build Institute of America.*

Dossick, C. N., L. N., and F. S. (2014). "Building Information Modeling in Graduate Construction Engineering and Management Education." *International Conference on Computing in Civil and Building Engineering*, Orlando, 2176–2183.

Dossick, C., Neff, G., and Homayouni, H. (2009). "The Realities of Building Information Modeling for Collaboration in the AEC Industry." *Construction Research Congress*, Seattle, 396–405.

Falk, A. L., Hult, H., Hammar, M., Hopwood, N., and Dahlgren, M. A. (2013). "One site fits all? A student ward as a learning practice for interprofessional development." *Journal of Interprofessional Care*, 27(6), 476–481.

Fong, P. S. (2010). "Building Teams That Learn: Study of Learning Effects in Engineering Student Teams." *Journal of Professional Issues in Engineering Education and Practice*, 136(3), 121–127.

Hean, S., Craddock, D., and O'Halloran, C. (2009). "Learning theories and interprofessional education: a user's guide." *Learning in Health and Social Care*, 8(4), 250–262.

"IPD in Education: Best Practices Whitepaper." (2011). *Autodesk University Workshop*, Autodesk, <http://auworkshop.autodesk.com/library/ipd-education-best-practices-whitepaper> (Nov. 7, 2015).

IR 105-2 Compass: Communications Project Assessment Tool, Version 2.1 [XLSM]. (2011, December 1). Austin: Construction Industry Institute.

Kaendler, C., Wiedmann, M., Rummel, N., and Spada, H. (2015). "Teacher Competencies for the Implementation of Collaborative Learning in the Classroom: a Framework and Research Review." *Educational Psychology Review*, 27(3), 505–536.

Kenig, M.E. (2011) *Project Delivery System for Construction*. Associated General Contractors of America, Arlington.

King, H. B., Battles, J., and Baker, D. (2008). "TeamSTEPPS™: Team Strategies and Tools to Enhance Performance and Patient Safety." *Advances in Patient Safety: New Directions and Alternative Approaches (Vol. 3: Performance and Tools).*, U.S. National Library of Medicine, <https://www.ncbi.nlm.nih.gov/books/NBK43686/> (Apr. 14, 2017).

Loughry, M. L., Ohland, M. W., and Moore, D. D. (2007). "Development of a Theory-Based Assessment of Team Member Effectiveness." *Educational and Psychological Measurement*, 67(3), 505–524.

López-Yáñez, I. C. A., Yáñez-Márquez, C., Camacho-Nieto, O., Aldape-Pérez, M., and Argüelles-Cruz, A.-J. (2015). "Collaborative learning in postgraduate level courses." *Computers in Human Behavior*, 51, 938–944.

Nokes-Malach, T. J., Richey, J. E., and Gadgil, S. (2015). "When Is It Better to Learn Together? Insights from Research on Collaborative Learning." *Educational Psychology Review*, 27(4), 645–656.

Ohland, M. W., Loughry, M. L., Woehr, D. J., Bullard, L. G., Felder, R. M., Finelli, C. J., Layton, R. A., Pomeranz, H. R., and Schmucker, D. G. (2012). "The Comprehensive Assessment of Team Member Effectiveness: Development of a Behaviorally Anchored Rating Scale for Self- and Peer Evaluation." *Academy of Management Learning & Education*, 11(4), 609–630.

Piaget, J. (1973). *To Understand Is to Invent*, Grossman, New York

Sacks, R., and Barak, R. (2010). "Teaching Building Information Modeling as an Integral Part of Freshman Year Civil Engineering Education." *Journal of Professional Issues in Engineering Education and Practice*, 136(1), 30–38.

Sacks, R., and Pikas, E. (2013). "Building Information Modeling Education for Construction Engineering and Management. I: Industry Requirements, State of the Art, and Gap Analysis." *Journal of Construction Engineering and Management*, 139(11), 04013016–1-04013016–12.

Salas, E., Sims, D., and Burke, C. S. (2005). "Is there a "Big Five" in Teamwork?" *Small Group Research*, 36(5), 555–599.

Schafer, J. L., and Olsen, M. K. (1998). "Multiple Imputation for Multivariate Missing-Data Problems: A Data Analyst's Perspective." *Multivariate Behavioral Research*, 33(4), 545–571.

Seat, E., Parsons, J. R., and Poppen, W. A. (2001). "Enabling Engineering Performance Skills: A Program to Teach Communication, Leadership, and Teamwork*." *Journal of Engineering Education*, 90(1), 7–12.

Solnosky, R., Parfitt, M. K., and Holland, R. J. (2014). "IPD and BIM–Focused Capstone

Course Based on AEC Industry Needs and Involvement." *Journal of Professional Issues in Engineering Education and Practice*, 140(4).

"TEACH Teamwork: An evidence-based, self-guided program on how to work effectively in teams." (2016). American Psychological Association, <http://www.apa.org/education/k12/teach-teamwork.aspx?tab=5> (Sep. 12, 2016).

The American Institute of Architects (2007). "Integrated Project Delivery: A Guide". *The American Institute of Architects*.

Tian, Q., and Xue, X. (2014). "Information Barriers in BIM Collaborative Application on Site." *Smart Construction and Management in the Context of New Technology*, 246–255.

Vygotsky, L. (1978) *Mind in Society*. Harvard University Press, Cambridge.

Wang, L., and Leite, F. (2014). "Process-Oriented Approach of Teaching Building Information Modeling in Construction Management." *Journal of Professional Issues in Engineering Education and Practice*, 140(4), 04014004–1-04014004–9.

APPENDIX A: QUALTRICS SURVEYS

Incorporating Collaborative Teaching Methods Pre-Survey

Please rate how FAMILIAR you are with working in teams.

	Extremely familiar	Very familiar	Moderately familiar	Slightly familiar	Not familiar at all
How familiar are you with WORKING as part of a team?	○	○	○	○	○
How familiar are you with TRAINING as part of a team?	○	○	○	○	○

Please rate your OVERALL ATTITUDE about working in teams.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I ENJOY LEARNING in team based activities.	○	○	○	○	○	○	○
I PERFORM WELL in team based activities.	○	○	○	○	○	○	○
I can WORK EFFECTIVELY in teams.	○	○	○	○	○	○	○
I can CONTRIBUTE valuable insight to teams.	○	○	○	○	○	○	○
Learning with other students helps me become a MORE EFFECTIVE member of a team.	○	○	○	○	○	○	○

"Leadership is carrying out necessary behaviors in order to help the team accomplish their goals."   For the purpose of this survey, a leader is defined as any group member that may step up to guide the group. The leader maybe an individual that has the greatest amount of knowledge or experience in a particular aspect of the project. The leader may change during the course of a project, maybe more than one person, or maybe a chosen person.   Please rate your EXPERIENCE AND ATTITUDE ABOUT LEADERSHIP in teams.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
It is important for leaders to SHARE INFORMATION with team members.	❍	❍	❍	❍	❍	❍	❍
Effective leaders view HONEST MISTAKES as meaningful LEARNING OPPORTUNITIES.	❍	❍	❍	❍	❍	❍	❍
It is a leader's RESPONSIBILITY to model APPROPRIATE team behavior.	❍	❍	❍	❍	❍	❍	❍
Team leaders should ENSURE that team members HELP EACH OTHER out when necessary.	❍	❍	❍	❍	❍	❍	❍

"Communication is the creation of dialogue between two or more individuals for shared perspective, information exchange, and talent integration." Please rate your EXPERIENCE AND ATTITUDE ABOUT COMMUNICATION in teams.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I can FACILITATE communication between team members.	❍	❍	❍	❍	❍	❍	❍
Teams that DO NOT communicate effectively significantly INCREASE THEIR RISK of committing errors.	❍	❍	❍	❍	❍	❍	❍
POOR COMMUNICATION is the MOST COMMON cause of reported errors.	❍	❍	❍	❍	❍	❍	❍
It is difficult to TRAIN individuals how to be better communicators.	❍	❍	❍	❍	❍	❍	❍
I PREFER to work with team members who ask questions.	❍	❍	❍	❍	❍	❍	❍

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your EXPERIENCE AND ATTITUDE ABOUT SITUATION MONITORING in teams.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I can EFFECTIVELY COORDINATE tasks and activities of a team.	❍	❍	❍	❍	❍	❍	❍
Effective team members can ANTICIPATE the needs of other team members.	❍	❍	❍	❍	❍	❍	❍
OFFERING to help a fellow team member with his/her individual work tasks is an EFFECTIVE TOOL for improving team performance.	❍	❍	❍	❍	❍	❍	❍
To be effective, team members should UNDERSTAND the work of their fellow team members.	❍	❍	❍	❍	❍	❍	❍

"Conflict resolution is applying support techniques to resolve tension and disagreements that delay the achievement of team goals and productivity." Please rate
your EXPERIENCE AND ATTITUDE ABOUT CONFLICT RESOLUTION in teams.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I am able to RESOLVE conflicts between individuals effectively.	○	○	○	○	○	○	○
Adverse events may be REDUCED by MAINTAINING an information exchange between group members.	○	○	○	○	○	○	○

The following questions are about your general background and experiences. AS A REMINDER, YOUR RESPONSES WILL BE HELD IN COMPLETE CONFIDENTIALITY.

How many months or years of professional experience do you have relating to your field of study?

Average number of hours working in profession related to field of study per week this semester:

What is your academic standing? (select one)
○ Freshmen
○ Sophomore
○ Junior
○ Senior
○ Graduate

Number of credit hours you're taking this semester:

What extracurricular activities are you involved with?
- ❑ AGC
- ❑ SLC
- ❑ Student Competition
- ❑ IFMA
- ❑ None
- ❑ Other _____

What is your generational affiliation?
- ○ Traditionalist (born prior to 1946)
- ○ Baby Boomer (born 1946 – 1964)
- ○ Generation X (born 1965 – 1978)
- ○ Generation Y (born 1979 – 1997)
- ○ Generation Z (born 1998 – present)

What is your gender?
- ○ Female
- ○ Male
- ○ Do not wish to specify

Incorporating Collaborative Teaching Methods During-Survey

Please rate how well you UNDERSTAND the information and expectations about the project while working in the team.

	Always	Usually	Sometimes	Rarely	Never
How well do you understand what information your INSTRUCTOR expects from you?	○	○	○	○	○
How well do you understand what information OTHER GROUP MEMBERS on this project expect from you?	○	○	○	○	○

Please rate YOUR PERFORMANCE in the team.

	Always	Usually	Sometimes	Rarely	Never
I IDENTIFY goals, ASSIGN roles and responsibilities, and HOLD members ACCOUNTABLE.	❍	❍	❍	❍	❍
I UTILIZE resources, DELEGATE tasks and BALANCE workload.	❍	❍	❍	❍	❍
I EMPOWER members to speak freely.	❍	❍	❍	❍	❍
I FOSTER communication.	❍	❍	❍	❍	❍
I RESOLVE conflicts.	❍	❍	❍	❍	❍
I work COLLABORATIVELY.	❍	❍	❍	❍	❍
I provide BRIEF, CLEAR, SPECIFIC and TIMELY information.	❍	❍	❍	❍	❍
I SEEK and COMMUNICATE information from all available sources.	❍	❍	❍	❍	❍

In the following questions you will assess your TEAM MEMBERS' performance in the team. If you have more than one teammember, give a collective assessment of the members (rate the teammembers as a whole).   Please rate YOUR
TEAM MEMBERS' PERFORMANCE in the team.

	Always	Usually	Sometimes	Rarely	Never
They IDENTIFY goals, ASSIGN roles and responsibilities, HOLD members ACCOUNTABLE.	❍	❍	❍	❍	❍
They UTILIZE resources, DELEGATE tasks and BALANCE workload.	❍	❍	❍	❍	❍
They EMPOWER members to speak freely.	❍	❍	❍	❍	❍
They FOSTER communication.	❍	❍	❍	❍	❍
They RESOLVES conflict.	❍	❍	❍	❍	❍
They work COLLABORATIVELY.	❍	❍	❍	❍	❍
They provides BRIEF, CLEAR, SPECIFIC and TIMELY information.	❍	❍	❍	❍	❍
They SEEK and COMMUNICATE information from all available sources.	❍	❍	❍	❍	❍

Please rate HOW OFTEN you experience the statements below when working in the team.

	Always	Usually	Sometimes	Rarely	Never
How often does COMMUNICATION occur.	○	○	○	○	○
How often does POOR COMMUNICATION or LACK OF COORDINATION occur in your project?	○	○	○	○	○
How often do you receive CONFLICTING INFORMATION from more than one person?	○	○	○	○	○
How often do you receive LESS INFORMATION than you need?	○	○	○	○	○
How often are you KEPT CURRENT with PROJECT CHANGES?	○	○	○	○	○

Please rate the EFFECTIVENESS of communication in the team.

	Extremely effective	Very effective	Moderately effective	Slightly effective	Not effective at all
Overall, how effective do you think COMMUNICATION is on this project?	○	○	○	○	○

The following questions are about your general background and experiences. AS A REMINDER, YOUR RESPONSES WILL BE HELD IN COMPLETE CONFIDENTIALITY.

How many months or years of professional experience do you have relating to your field of study?

Average number of hours working in profession related to field of study per week this semester:

What is your academic standing? (select one)
- ○ Freshmen
- ○ Sophomore
- ○ Junior
- ○ Senior
- ○ Graduate

Number of credit hours you're taking this semester:

What extracurricular activities are you involved with?
- ❑ AGC
- ❑ SLC
- ❑ Student Competition
- ❑ IFMA
- ❑ None
- ❑ Other _____

What is your generational affiliation?
- ○ Traditionalist (born prior to 1946)
- ○ Baby Boomer (born 1946 – 1964)
- ○ Generation X (born 1965 – 1978)
- ○ Generation Y (born 1979 – 1997)
- ○ Generation Z (born 1998 – present)

What is your gender?
- ○ Female
- ○ Male
- ○ Do not wish to specify

Incorporating Collaborative Teaching Methods Post-Survey

"Leadership is carrying out necessary behaviors in order to help the team accomplish their goals."   For the purpose of this survey, a leader is defined as any group member that may step up to guide the group. The leader maybe an individual that has the greatest amount of knowledge or experience in a particular aspect of the project. The leader may change during the course of a project, maybe more than one person, or maybe a chosen person.   Please rate your LEADERSHIP PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I got TEAM INPUT on important matters before going ahead.	❍	❍	❍	❍	❍	❍	❍
I used teammates' FEEDBACK to improve performance.	❍	❍	❍	❍	❍	❍	❍
I had the SKILLS and EXPERTISE to do excellent work.	❍	❍	❍	❍	❍	❍	❍
I had the SKILLS and ABILTIES that were necessary to do a good job.	❍	❍	❍	❍	❍	❍	❍
I had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.	❍	❍	❍	❍	❍	❍	❍
I knew HOW TO DO the jobs of other team members.	❍	❍	❍	❍	❍	❍	❍

"Communication is the creation of dialogue between two or more individuals for shared perspective, information exchange, and talent integration." Please rate your COMMUNICATION PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I communicated EFFECTIVELY.	○	○	○	○	○	○	○
I FACILITATED effective communication in the team.	○	○	○	○	○	○	○
I EXCHANGED INFORMATION with teammates in a TIMELY manner.	○	○	○	○	○	○	○
I provided CONSTRUCTIVE FEEDBACK to others on the team.	○	○	○	○	○	○	○
I PREFERED to work with team members who ask questions.	○	○	○	○	○	○	○
I helped the team to PLAN and ORGANIZE its work.	○	○	○	○	○	○	○

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I provided ENCOURAGEMENT to other team members	❍	❍	❍	❍	❍	❍	❍
I offered to HELP teammates when it was appropriate.	❍	❍	❍	❍	❍	❍	❍
I expressed ENTHUSIASM about working as a team.	❍	❍	❍	❍	❍	❍	❍
I let other TEAM MEMBERS HELP when it was necessary.	❍	❍	❍	❍	❍	❍	❍
I MOTIVATED others on the team to do their best.	❍	❍	❍	❍	❍	❍	❍

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I EXPECTED the team to succeed.	○	○	○	○	○	○	○
I BELIEVED that the team should achieve high standards.	○	○	○	○	○	○	○
I BELIEVED that the team could produce high-quality work.	○	○	○	○	○	○	○
I CARED that the team produced high-quality work.	○	○	○	○	○	○	○

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I did a FAIR SHARE of the team's work.	❍	❍	❍	❍	❍	❍	❍
I completed work in a TIMELY manner.	❍	❍	❍	❍	❍	❍	❍
I came to team meetings PREPARED.	❍	❍	❍	❍	❍	❍	❍
I FULFILLED RESPONSIBILITIES to the team.	❍	❍	❍	❍	❍	❍	❍
I did work that was COMPLETE and ACCURATE.	❍	❍	❍	❍	❍	❍	❍

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals."Please rate your SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I made important CONTRIBUTIONS to the team's final product.	○	○	○	○	○	○	○
I STAYED aware of fellow team members' progress.	○	○	○	○	○	○	○
I ASSESSED whether the team was making PROGESS as expected.	○	○	○	○	○	○	○
I stayed aware of EXTERNAL FACTORS that influenced team performance.	○	○	○	○	○	○	○
I made sure that EVERYONE on the team UNDERSTOOD important information.	○	○	○	○	○	○	○

"Conflict resolution is applying support techniques to resolve tension and disagreements that delay the achievement of team goals and productivity." Please rate your CONFLICT RESOLUTION PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I kept TRYING when faced with difficult situations.	○	○	○	○	○	○	○
I HEARD what teammates had to say about ISSUES that affected the team.	○	○	○	○	○	○	○
I ACCEPTED FEEDBACK about strengths and weaknesses from teammates.	○	○	○	○	○	○	○

In the following questions you will assess your TEAM MEMBERS' performance in the team. If you have more than one team member, give a collective assessment of the members (rate the team members as a whole).

"Leadership is carrying out necessary behaviors in order to help the team accomplish their goals."   For the purpose of this survey, a leader is defined as any group member that may step up to guide the group. The leader maybe an individual that has the greatest amount of knowledge or experience in a particular aspect of the project. The leader may change during the course of a project, maybe more than one person, or maybe a chosen person.   Please rate your TEAM MEMBERS' LEADERSHIP PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
They got TEAM INPUT on important matters before going ahead.	❍	❍	❍	❍	❍	❍	❍
They used teammates' FEEDBACK to improve performance.	❍	❍	❍	❍	❍	❍	❍
They had the SKILLS and EXPERTISE to do excellent work.	❍	❍	❍	❍	❍	❍	❍
They had the SKILLS and ABILTIES that were necessary to do a good job.	❍	❍	❍	❍	❍	❍	❍
They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.	❍	❍	❍	❍	❍	❍	❍
They knew HOW TO DO the jobs of other team members.	❍	❍	❍	❍	❍	❍	❍

"Communication is the creation of dialogue between two or more individuals for shared perspective, information exchange, and talent integration." Please rate your TEAM MEMBERS' COMMUNICATION PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
They communicated EFFECTIVELY.	○	○	○	○	○	○	○
They FACILITATED effective communication in the team.	○	○	○	○	○	○	○
They EXCHANGED INFORMATION with teammates in a TIMELY manner.	○	○	○	○	○	○	○
They provided CONSTRUCTIVE FEEDBACK to others on the team.	○	○	○	○	○	○	○
They PREFERED to work with team members who ask questions.	○	○	○	○	○	○	○
They helped the team to PLAN and ORGANIZE its work.	○	○	○	○	○	○	○

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your TEAM MEMBERS' SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
They provided ENCOURAGEMENT to other team members	○	○	○	○	○	○	○
They offered to HELP teammates when it was appropriate.	○	○	○	○	○	○	○
They expressed ENTHUSIASM about working as a team.	○	○	○	○	○	○	○
They let other TEAM MEMBERS HELP when it was necessary.	○	○	○	○	○	○	○
They MOTIVATED others on the team to do their best.	○	○	○	○	○	○	○

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your TEAM MEMBERS' SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
They EXPECTED the team to succeed.	❍	❍	❍	❍	❍	❍	❍
They BELIEVED that the team should achieve high standards.	❍	❍	❍	❍	❍	❍	❍
They BELIEVED that the team could produce high-quality work.	❍	❍	❍	❍	❍	❍	❍
They CARED that the team produced high-quality work.	❍	❍	❍	❍	❍	❍	❍

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your TEAM MEMBERS' SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
They did a FAIR SHARE of the team's work.	○	○	○	○	○	○	○
They completed work in a TIMELY manner.	○	○	○	○	○	○	○
They came to team meetings PREPARED.	○	○	○	○	○	○	○
They FULFILLED RESPONSIBILITIES to the team.	○	○	○	○	○	○	○
They did work that was COMPLETE and ACCURATE.	○	○	○	○	○	○	○

"Situation monitoring is the scanning of the environment to seek out important information including monitoring teammates and progress towards goals." Please rate your TEAM MEMBERS' SITUATION MONITORING PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
They made important CONTRIBUTIONS to the team's final product.	❍	❍	❍	❍	❍	❍	❍
They STAYED aware of fellow team members' progress.	❍	❍	❍	❍	❍	❍	❍
They ASSESSED whether the team was making PROGESS as expected.	❍	❍	❍	❍	❍	❍	❍
They stayed aware of EXTERNAL FACTORS that influenced team performance.	❍	❍	❍	❍	❍	❍	❍
They made sure that EVERYONE on the team UNDERSTOOD important information.	❍	❍	❍	❍	❍	❍	❍

"Conflict resolution is applying support techniques to resolve tension and disagreements that delay the achievement of team goals and productivity." Please rate your TEAM MEMBERS' CONFLICT RESOLUTION PERFORMANCE in the team.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
They kept TRYING when faced with difficult situations.	○	○	○	○	○	○	○
They HEARD what teammates had to say about ISSUES that affected the team.	○	○	○	○	○	○	○
They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.	○	○	○	○	○	○	○

The following questions are about your general background and experiences. AS A REMINDER, YOUR RESPONSES WILL BE HELD IN COMPLETE CONFIDENTIALITY.

How many months or years of professional experience do you have relating to your field of study?

Average number of hours working in profession related to field of study per week this semester:

What is your academic standing? (select one)
- ○ Freshmen
- ○ Sophomore
- ○ Junior
- ○ Senior
- ○ Graduate

Number of credit hours you're taking this semester:

What extracurricular activities are you involved with?
- ❑ AGC
- ❑ SLC
- ❑ Student Competition
- ❑ IFMA
- ❑ None
- ❑ Other _____

What is your generational affiliation?
- ◯ Traditionalist (born prior to 1946)
- ◯ Baby Boomer (born 1946 – 1964)
- ◯ Generation X (born 1965 – 1978)
- ◯ Generation Y (born 1979 – 1997)
- ◯ Generation Z (born 1998 – present)

What is your gender?
- ◯ Female
- ◯ Male
- ◯ Do not wish to specify

APPENDIX B: SKILL CATEGORIES OF ALL SURVEY ITEMS

Big 5 Skill	Question
Communication	How often do you receive LESS INFORMATION than you need?
Communication	How often does POOR COMMUNICATION or LACK OF COORDINATION occur in your project?
Communication	It is difficult to train individuals how to be better communicators.
Communication	I provided CONSTRUCTIVE FEEDBACK to others on the team.
Communication	How often do you receive CONFLICTING INFORMATION from more than one person?
Communication	Teams that do not communicate effectively, significantly increase their risk of committing errors.
Communication	They EXCHANGED INFORMATION with teammates in a TIMELY manner.
Communication	I EXCHANGED INFORMATION with teammates in a TIMELY manner.
Communication	I FACILITATED effective communication in the team.
Communication	They provided CONSTRUCTIVE FEEDBACK to others on the team.
Communication	They communicated EFFECTIVELY.
Communication	How well do you understand what information OTHER GROUP MEMBERS on this project expect from you?
Communication	I helped the team to PLAN and ORGANIZE its work.
Communication	Poor communication is the most common cause of reported errors.
Communication	They PREFERED to work with team members who ask questions.
Communication	How often are you KEPT CURRENT with PROJECT CHANGES?
Communication	I prefered to work with team members who ask questions.
Communication	I PREFERED to work with team members who ask questions.
Communication	Overall, how effective do you think communication is on this project?
Communication	How well do you understand what information your INSTRUCTOR expects from you?
Communication	I can facilitate communication between team members.
Communication	They FACILITATED effective communication in the team.
Communication	How often does COMMUNICATION occur.
Communication	I communicated EFFECTIVELY.
Communication	They helped the team to PLAN and ORGANIZE its work.
Conflict Resolution	They kept TRYING when faced with difficult situations.
Conflict Resolution	They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.

Conflict Resolution	I am able to resolve conflicts between individuals effectively.
Conflict Resolution	They HEARD what teammates had to say about ISSUES that affected the team.
Conflict Resolution	I HEARD what teammates had to say about ISSUES that affected the team.
Conflict Resolution	I RESOLVE conflicts.
Conflict Resolution	Adverse events may be reduced by maintaining an information exchange between group members.
Conflict Resolution	I ACCEPTED FEEDBACK about strengths and weaknesses from teammates.
Conflict Resolution	I kept TRYING when faced with difficult situations
Conflict Resolution	They RESOLVES conflict
Leadership	They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.
Leadership	Team leaders should ensure that team members help each other out when necessary.
Leadership	Effective leaders view honest mistakes as meaningful learning opportunities.
Leadership	They used teammates' FEEDBACK to improve performance.
Leadership	I had the SKILLS and ABILITIES that were necessary to do a good job
Leadership	It is important for leaders to share information with team members.
Leadership	They had the SKILLS and ABILITIES that were necessary to do a good job.
Leadership	They had the SKILLS and EXPERTISE to do excellent work.
Leadership	It is a leader's responsibility to model appropriate team behavior.
Leadership	They knew HOW TO DO the jobs of other team members
Leadership	I had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.
Leadership	I used teammates' FEEDBACK to improve performance.
Leadership	I had the SKILLS and EXPERTISE to do excellent work.
Leadership	They got TEAM INPUT on important matters before going ahead.
Leadership	I knew HOW TO DO the jobs of other team members.
Leadership	I got TEAM INPUT on important matters before going ahead.
Mutual Support	I BELIEVED that the team should achieve high standards.
Mutual Support	I FULFILLED RESPONSIBILITIES to the team.
Mutual Support	I CARED that the team produced high-quality work.
Mutual Support	I offered to HELP teammates when it was appropriate.
Mutual Support	I expressed ENTHUSIASM about working as a team

Mutual Support	I EXPECTED the team to succeed.
Mutual Support	They MOTIVATED others on the team to do their best.
Mutual Support	I made important CONTRIBUTIONS to the team's final product.
Mutual Support	They FULFILLED RESPONSIBILITIES to the team.
Mutual Support	I MOTIVATED others on the team to do their best.
Mutual Support	They BELIEVED that the team could produce high-quality work.
Mutual Support	I BELIEVED that the team could produce high-quality work.
Mutual Support	They expressed ENTHUSIASM about working as a team.
Mutual Support	They offered to HELP teammates when it was appropriate.
Mutual Support	They BELIEVED that the team should achieve high standards.
Mutual Support	They provided ENCOURAGEMENT to other team members.
Mutual Support	I EMPOWER members to speak freely
Mutual Support	They made important CONTRIBUTIONS to the team's final product.
Mutual Support	Learning with other students helps me become a more effective member of a team.
Mutual Support	They EXPECTED the team to succeed.
Mutual Support	I provided ENCOURAGEMENT to other team members.
Mutual Support	They work COLLABORATIVELY.
Mutual Support	Offering to help a fellow team member with his/her individual work tasks is an effective tool for improving team performance.
Mutual Support	They EMPOWER members to speak freely
Mutual Support	They CARED that the team produced high-quality work.
Situation Monitoring	They let other TEAM MEMBERS HELP when it was necessary.
Situation Monitoring	They IDENTIFY goals, ASSIGN roles and responsibilities, HOLD members ACCOUNTABLE
Situation Monitoring	I did work that was COMPLETE and ACCURATE.
Situation Monitoring	They completed work in a TIMELY manner.
Situation Monitoring	I STAYED aware of fellow team members' progress.
Situation Monitoring	I completed work in a TIMELY manner
Situation Monitoring	They UTILIZE resources, DELEGATE tasks and BALANCE workload.
Situation Monitoring	I let other TEAM MEMBERS HELP when it was necessary.
Situation Monitoring	They made sure that EVERYONE on the team UNDERSTOOD important information.
Situation	I IDENTIFY goals, ASSIGN roles and responsibilities, and HOLD

Monitoring	members ACCOUNTABLE
Situation Monitoring	I made sure that EVERYONE on the team UNDERSTOOD important information.
Situation Monitoring	I stayed aware of EXTERNAL FACTORS that influenced team performance.
Situation Monitoring	They stayed aware of EXTERNAL FACTORS that influenced team performance.
Situation Monitoring	I can contribute valuable insight to teams.
Situation Monitoring	They FOSTER communication.
Situation Monitoring	I did a FAIR SHARE of the team's work.
Situation Monitoring	I work COLLABORATIVELY.
Situation Monitoring	I FOSTER communication
Situation Monitoring	I can effectively coordinate tasks and activities of a team.
Situation Monitoring	I came to team meetings PREPARED
Situation Monitoring	I SEEK and COMMUNICATE information from all available sources.
Situation Monitoring	I enjoy learning in team based activities.
Situation Monitoring	I UTILIZE resources, DELEGATE tasks and BALANCE workload
Situation Monitoring	They did work that was COMPLETE and ACCURATE.
Situation Monitoring	They SEEK and COMMUNICATE information from all available sources.
Situation Monitoring	They provide BRIEF, CLEAR, SPECIFIC and TIMELY information.
Situation Monitoring	How familiar are you with WORKING as part of a team?
Situation Monitoring	How familiar are you with TRAINING as part of a team?
Situation Monitoring	I perform well in team based activities.
Situation Monitoring	I ASSESSED whether the team was making PROGESS as expected.
Situation Monitoring	They ASSESSED whether the team was making PROGESS as expected.
Situation Monitoring	They STAYED aware of fellow team members' progress.

Situation Monitoring	I can work effectively in teams.
Situation Monitoring	They did a FAIR SHARE of the team's work.
Situation Monitoring	To be effective, team members should understand the work of their fellow team members.
Situation Monitoring	They came to team meetings PREPARED.
Situation Monitoring	Effective team members can anticipate the needs of other team members.
Situation Monitoring	I provide BRIEF, CLEAR, SPECIFIC and TIMELY information.

APPENDIX C: SIGNIFICANCE VALUE TABLE ALL SURVEY ITEMS

Question	Asymp. Value
How often do you receive LESS INFORMATION than you need?	0.009
How often does POOR COMMUNICATION or LACK OF COORDINATION occur in your project?	0.018
It is difficult to train individuals how to be better communicators.	0.030
I provided CONSTRUCTIVE FEEDBACK to others on the team.	0.048
How often do you receive CONFLICTING INFORMATION from more than one person?	0.056
Teams that do not communicate effectively, significantly increase their risk of committing errors.	0.081
They EXCHANGED INFORMATION with teammates in a TIMELY manner.	0.088
I EXCHANGED INFORMATION with teammates in a TIMELY manner.	0.096
I FACILITATED effective communication in the team.	0.116
They provided CONSTRUCTIVE FEEDBACK to others on the team.	0.126
They communicated EFFECTIVELY.	0.325
How well do you understand what information OTHER GROUP MEMBERS on this project expect from you?	0.328
I helped the team to PLAN and ORGANIZE its work.	0.385
Poor communication is the most common cause of reported errors.	0.399
They PREFERED to work with team members who ask questions.	0.417
How often are you KEPT CURRENT with PROJECT CHANGES?	0.443
I prefered to work with team members who ask questions.	0.446
I PREFERED to work with team members who ask questions.	0.605
Overall, how effective do you think communication is on this project?	0.655
How well do you understand what information your INSTRUCTOR expects from you?	0.716
I can facilitate communication between team members.	0.904
They FACILITATED effective communication in the team.	0.92
How often does COMMUNICATION occur.	0.961
I communicated EFFECTIVELY.	0.988
They helped the team to PLAN and ORGANIZE its work.	0.369
They kept TRYING when faced with difficult situations.	0.036
They ACCEPTED FEEDBACK about strengths and weaknesses from teammates.	0.085
I am able to resolve conflicts between individuals effectively.	0.089
They HEARD what teammates had to say about ISSUES that affected the	0.153

team.	
I HEARD what teammates had to say about ISSUES that affected the team.	0.227
I RESOLVE conflicts.	0.281
Adverse events may be reduced by maintaining an information exchange between group members.	0.487
I ACCEPTED FEEDBACK about strengths and weaknesses from teammates.	0.844
I kept TRYING when faced with difficult situations	0.900
They RESOLVES conflict	0.983
They had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.	0.080
Team leaders should ensure that team members help each other out when necessary.	0.108
Effective leaders view honest mistakes as meaningful learning opportunities.	0.347
They used teammates' FEEDBACK to improve performance.	0.390
I had the SKILLS and ABILITIES that were necessary to do a good job	0.422
It is important for leaders to share information with team members.	0.472
They had the SKILLS and ABILITIES that were necessary to do a good job.	0.550
They had the SKILLS and EXPERTISE to do excellent work.	0.65
It is a leader's responsibility to model appropriate team behavior.	0.662
They knew HOW TO DO the jobs of other team members	0.692
I had enough KNOWLEDGE of teammates' jobs to be able to FILL IN IF NECESSARY.	0.729
I used teammates' FEEDBACK to improve performance.	0.788
I had the SKILLS and EXPERTISE to do excellent work.	0.824
They got TEAM INPUT on important matters before going ahead.	0.841
I knew HOW TO DO the jobs of other team members.	0.955
I got TEAM INPUT on important matters before going ahead.	0.972
I BELIEVED that the team should achieve high standards.	0.026
I FULFILLED RESPONSIBILITIES to the team.	0.088
I CARED that the team produced high-quality work.	0.100
I offered to HELP teammates when it was appropriate.	0.124
I expressed ENTHUSIASM about working as a team	0.159
I EXPECTED the team to succeed.	0.312
They MOTIVATED others on the team to do their best.	0.338
I made important CONTRIBUTIONS to the team's final product.	0.361
They FULFILLED RESPONSIBILITIES to the team.	0.387
I MOTIVATED others on the team to do their best.	0.393
They BELIEVED that the team could produce high-quality work.	0.395

I BELIEVED that the team could produce high-quality work.	0.413
They expressed ENTHUSIASM about working as a team.	0.475
They offered to HELP teammates when it was appropriate.	0.590
They BELIEVED that the team should achieve high standards.	0.611
They provided ENCOURAGEMENT to other team members.	0.701
I EMPOWER members to speak freely	0.774
They made important CONTRIBUTIONS to the team's final product.	0.788
Learning with other students helps me become a more effective member of a team.	0.823
They EXPECTED the team to succeed.	0.847
I provided ENCOURAGEMENT to other team members.	0.879
They work COLLABORATIVELY.	0.899
Offering to help a fellow team member with his/her individual work tasks is an effective tool for improving team performance.	0.941
They EMPOWER members to speak freely	0.944
They CARED that the team produced high-quality work.	0.975
They let other TEAM MEMBERS HELP when it was necessary.	0.026
They IDENTIFY goals, ASSIGN roles and responsibilities, HOLD members ACCOUNTABLE	0.051
I did work that was COMPLETE and ACCURATE.	0.125
They completed work in a TIMELY manner.	0.141
I STAYED aware of fellow team members' progress.	0.158
I completed work in a TIMELY manner	0.17
They UTILIZE resources, DELEGATE tasks and BALANCE workload.	0.201
I let other TEAM MEMBERS HELP when it was necessary.	0.208
They made sure that EVERYONE on the team UNDERSTOOD important information.	0.234
I IDENTIFY goals, ASSIGN roles and responsibilities, and HOLD members ACCOUNTABLE	0.316
I made sure that EVERYONE on the team UNDERSTOOD important information.	0.335
I stayed aware of EXTERNAL FACTORS that influenced team performance.	0.339
They stayed aware of EXTERNAL FACTORS that influenced team performance.	0.351
I can contribute valuable insight to teams.	0.353
They FOSTER communication.	0.441
I did a FAIR SHARE of the team's work.	0.441
I work COLLABORATIVELY.	0.529
I FOSTER communication	0.598
I can effectively coordinate tasks and activities of a team.	0.617

I came to team meetings PREPARED	0.624
I SEEK and COMMUNICATE information from all available sources.	0.635
I enjoy learning in team based activities.	0.655
I UTILIZE resources, DELEGATE tasks and BALANCE workload	0.673
They did work that was COMPLETE and ACCURATE.	0.673
They SEEK and COMMUNICATE information from all available sources.	0.734
They provide BRIEF, CLEAR, SPECIFIC and TIMELY information.	0.736
How familiar are you with WORKING as part of a team?	0.737
How familiar are you with TRAINING as part of a team?	0.739
I perform well in team based activities.	0.750
I ASSESSED whether the team was making PROGESS as expected.	0.771
They ASSESSED whether the team was making PROGESS as expected.	0.774
They STAYED aware of fellow team members' progress.	0.822
I can work effectively in teams.	0.828
They did a FAIR SHARE of the team's work.	0.869
To be effective, team members should understand the work of their fellow team members.	0.924
They came to team meetings PREPARED.	0.926
Effective team members can anticipate the needs of other team members.	0.938
I provide BRIEF, CLEAR, SPECIFIC and TIMELY information.	0.993