INFLUENCE OF TEAM FORMATION ON TEAM MEMBER PERCEPTION OF SATISFACTION AND PARTICIPATION

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

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Title: Influence of Team Formation on Team Perception of Satisfaction and Participation
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Background: Purdue Polytechnic's Tech12000, *Design Thinking in Technology*, course incorporates many instances of team work. Over the last 8 years, there have been varied methods of how to create the teams for the projects.

Purpose: This study compares two methods of team formation, software generated and instructor/student-selected, to determine which, if any, method generates increased perception of team member satisfaction and increased team member contribution.

Methodology: The subjects for this study were students enrolled in a design course at a Purdue Polytechnic, divided into a comparison group with instructor/student-selected teams, and a treatment group with software-generated teams. These students were predominately first year students enrolled in their first semester of college.

Findings/conclusions: The researcher discovered that the computer software-generated teams produced teams that had slightly larger mean scores on satisfaction and contribution versus the instructor/student-selected teams, although not at a statistically significant level.

Implications: The findings of this study provide another tool for educators, with possible implications for industry, to generate teams in the classroom.

CHAPTER 1. INTRODUCTION

1.1 Introduction

Teams can be found in many areas of society including schools, sports teams, militaries, and communities. A brief look at teams over the course of history demonstrates that teams have been in existence since early times. Not only is it important to look at the history of teams, but because teams are comprised of members exhibiting a multitude of traits, identifying what traits are important to team formation assists in narrowing the choices of traits to include only relevant traits, while excluding those traits not relevant to team formation. Theoretical conceptions come and go, but history deals with what has actually occurred" (Deming, 2016). Examining what has occurred allows the researcher to learn from past failures and successes in order to create new and meaningful studies. The purpose of this study was to compare instructor/student-selected teams and CATME Team Maker generated teams in the Purdue Polytechnic's Tech12000 class, *Design Thinking in Technology*. Specifically, this research addressed the questions:

1. What is the impact of team formation on team member contribution, satisfaction and end of course grades?
2. Does team formation influence perceived consistency of team member contribution and satisfaction with in the team?

Instructors that had two sections of a required college level design course were asked to have one section comprised of instructor/student-selected teams, while the other section placed into teams using the software program, CATME Team Maker. A statistical t-test analysis was conducted between the instructor/student-selected teams and the CATME Team Maker teams data to determine which method, if any, had a greater perception of satisfaction and increased team member contribution.

1.2 Problem Statement

The existence of teams means that individuals are arranged into teams using some process of team formation. How a team is formed has taken many different approaches throughout history, such as, team captains picking the teams in the school yard, sports teams drafting players, students in the classroom being divided into teams for projects by counting numbers, where all the one's are teamed, all the two's are teamed, continuing this pattern until all students have been selected. There is a process in place for each of these examples by which the teams are formed, such as team captains choosing their friends or picking the best players. Where instructors select teams, students in the classroom are often teamed on ability, where students of like ability levels are placed together, or homogenously. The practice of homogeneous ability teaming is found most often in the secondary mathematics classrooms, but can also be found in high school science lessons (Wilkinson, Penny, & Allin, 2015). The obvious question arises, "is this the best method?" Some teams are formed heterogeneously, across ability levels. "Mixed ability classes benefited the less able pupils without reducing the attainment of the more able[sic]" (Hallam, 2002, p. 24).

In fact, according to Baer:

> For low achievers there was essentially no difference between those working in homogeneous and heterogeneous groups on either the midterm or final examinations. For both average and high achievers, however, homogeneous grouping was clearly preferable, leading to substantial (and statistically significant) differences on the final examination among both groups. Even on the midterm examination, which was given after students had worked with their assigned groups for only four weeks, homogeneously grouped high achievers significantly outperformed heterogeneously grouped high achievers, and among average achievers, the homogeneous group outperformed the heterogeneous group at a level approaching statistical significance ($p < .08$). (2003, p. 172-173)

There have been some attempts in the past at utilizing various software programs to help in the formation of teams. One of these attempts sought to make the learning experience better for students is the computer-software program *VIEW: An Assessment of Problem Solving Style* (Schroth, Crawford, Heifer, Dixon, & Hoyt, 2015). *VIEW* focuses on determining a student's problem-solving style which allows the instructor form team accordingly (Schroth, et. al.). As explained by Scroth, et. al.:

> A statistically significant greater number of members of the treatment group reported that the amount of attention their group gave to ideas or options that were novel worked well for them and [they] felt [more] comfortable than did members of the control group. This level of satisfaction is important, as it permits group members to engage in a pursuit of new ideas at a level each finds appropriate. (2015, para. 20)

This study utilized another program called CATME Team Maker to determine if using a computer based program increases team member satisfaction and team member contribution in teams. CATME, a program developed at Purdue through a NSF grant, was chosen for this study because it is currently used in the course as a method for team members to rate the performance of the team. The program was tested in ten Tech12000 *Design Thinking in Technology* classes, where five sections utilized CATME Team Maker software to generate teams, while five sections were instructed to generate teams through instructor/student selected teams. Data were to be collected and investigated at five time points in the study to determine if there is a difference between teams formed with the CATME Team Maker software or instructor/student selected teams.

1.3 Research Question

The overarching research questions driving this study were:

1. What is the impact of team formation on team member contribution, satisfaction and end of course grades?

2. Does team formation influence perceived consistency of team member contribution and satisfaction with in the team.

Five specific research questions guided this study:

Research question 1a: What is the impact of team formation on perceived team member contribution?

Research question 1b: What is the impact of team formation on team member satisfaction?

Research question 1c: What is the impact of team formation on end of course grades?

Research question 2a: Does team formation impact perceived consistency of team member contribution across team members?

Research question 2b: Does team formation impact consistency of team member satisfaction across team members?

1.4 Significance of the Problem

The significance of forming teams extends beyond the classroom. Academia has always utilized team projects in the classroom to teach students how to work with others, now the current industry landscape is requiring employees to perform in successful teams. Industry requires effective teamwork and the academic setting must prepare the next generation to be part of a successful team. Resolving the problem of successful team formation in the academic setting may allow prospective employees to enter the work force ready to be a contributing factor in a team setting. Optimizing team formation may help prevent an industry from losing valuable time in training employees on how to positively contribute to a team setting.

Various techniques for creating teams have been employed in Tech12000, *Design Thinking in Technology*, to complete a team project. Some of these techniques include letting the students choose their teams, instructor-selected teams using a small amount of student input, and arranging students by topic using post-it notes. Each of these techniques are common educational practices, but do they lead to a highly functional team, as indicated by increased perception in team satisfaction and individual contribution?

This study focuses on the comparison of two methods, instructor/student selected teams and teams formed using the software program, CATME Team Maker. The CATME Team Maker program generates teams using student self-reported data on several instructor-selected traits to create teams versus the instructor/students simply forming teams. The significance of this study was to compare instructor/student-selected teams and CATME Team Maker teams to determine which, if any, process produces the more successful team. Ideally, the results of this study will provide a platform for further research in team formation in academia and possibly industry.

1.5 Scope of Study

In this study, a comparison of two types of team formation was utilized. The sample size of this study was approximately 400 students enrolled in the Tech12000, *Design Thinking in Technology* course at a Purdue Polytechnic. The design class in an introductory class that is comprised of mainly first semester freshmen. Although many of the students may have been exposed to a design class at the high school level, for most, this is often the first exposure to applying the design process in depth to a real world situation. The course exposes the students to the design process in three phases, with each phase delving deeper, and deeper, into the design process. The capstone of the class is the final project, lasting for approximately the last eight weeks of the sixteen week course, in which the students are required to apply the design process to one of fourteen grand engineering challenges:

- Make solar energy affordable.
- Provide energy from fusion.
- Develop carbon sequestration methods.
- Manage the nitrogen cycle.
- Provide access to clean water.

- Restore and improve urban infrastructure.
- Advance health informatics.
- Engineer better medicines.
- Reverse-engineer the brain.
- Prevent nuclear terror.
- Secure cyberspace.
- Enhance virtual reality.
- Advance personalized learning.
- Engineer the tools for scientific discovery.

For the capstone project, the students will be divided into teams of four or five students to generate approximately 100 teams through either instructor/student-selected or CATME Team Maker software-generated teams.

1.6 Assumptions

The assumptions of this research study included:

- Students were not aware of this study and therefore would not perform differently as a result of being studied.
- Cooperating instructors implemented lessons as planned.
- Students had similar previous educational experiences.

1.7 Delimitations

- Only students enrolled in the design process class were used for this study.
- Only instructors that had more than one section of the design process class were used for this study.
- The time frame for this study was the Fall semester of 2018.
- This study was conducted in a course comprised mainly of underclassmen.
- This study was only being offered to Fall semester of 2018 students.

1.8 Limitations

The limitations of this research study included:

- The researcher could not control student interest for the class assignment.
- The researcher could not control if students do not follow assignment directions.
- The researcher could not control learning experiences before the study took place.
- The researcher could not control for or measure instructor bias in their presentation of the comparison, or treatment team instructions.
- The researcher could not control the number of sections offered by the university.
- The researcher could not control the number of students that sign up for each section.

1.9 Definitions

CATME - The Comprehensive Assessment of Team Member Effectiveness (CATME) is a web-based program designed for use in higher education to promote SMARTER Teamwork among teams (Braender & Naples, 2013).

CATME Bars – Section of the CATME software that allows participants to rate their team members, and themselves, on team satisfaction and participation.

CATME Team Maker – Section of the CATME software that allows user to create teams based off user selected characteristics. Participants self-report information on the user selected characteristics.

ESL – English as a Second Language.

Group – For the purpose of this study group will be used interchangeably with team.

Lean Manufacturing – A systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection (Weinrach, 2002, p. 96).

Six Sigma – Six Sigma is an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives (Schroeder, 2008).

Team – For the purpose of this study team refers to the teams created for the project in the Tech 12000, Design Thinking in Technology, class.

1.10 Summary

While the classroom has long embraced the concept and importance of teams, industry is now following suit. "In the past, companies assigned narrowly focused tasks to single individuals to manufacture a product" (Gutierrez, Astudillo Ballesteros-Perez, Mor-Melia, and Candia-Vejar, 2015, para. 4). In the present,

> "this strategy has been replaced by a scheme in which groups of people who are generally organized into work cells develop important components of the project using higher levels of social and skills interaction." (Gutierrez, Astudillo Ballesteros-Perez, Mor-Melia, and Candia-Vejar, 2015, para. 4).

There are many accepted methods of team formation that have been utilized throughout history. Exploration utilizing the Tech12000, *Design Thinking in Technology*, class examined two of these methods, CATME Team Maker software-generated teams and instructor/student selected teams.

CHAPTER 2. REVIEW OF LITERATURE

2.1 Introduction

There is an old adage that goes, “One person, one brain, one set of hands, capable of accomplishing many tasks.” Many tasks in life can be performed by one person. Writing a paper, flying a kite, using tools, are just a few examples of tasks a single person can perform. What about tasks that are more complex in nature that require several perspectives, or strengths, from different members? This is the power of forming teams. The concept of teams has been around since ancient times (Kozlowski & Ilgen, 2006). Teams throughout time have banded together for common purposes to exceed the performance of a single individual.

What has made some teams better than others throughout time? Has it been blind luck that has led to success, or is there a formula, a best practice that leads to the formation of a successful team? Most teams are constructed to be the best team out of a group of teams, but what if there are multiple teams all working towards a common goal, such as multiple factory assembly lines? Educators generally want all students to learn, and by creating balanced teams, can possibly ensure the same opportunity for all team members to learn. Industry requiring multiple assembly lines, requires lines that are balanced to maximize output. Having one line stronger than the next will not maximize output. Looking at a brief history of teams allows for understanding about different types of teams, and then looking at different traits allows for understanding what might make one team’s performance more successful than another team. Success, in the educational field, being measured by higher overall scores, higher perception of participation, and higher perception of team contribution.

2.2 Brief History of Teams

Many tasks in life are best confronted when human beings come together and form a team. An English quote from the 1300's from *Sir Bevis of Hampton* first introduced the proverb that more helpers make a task easier (The American Heritage dictionary of the English language, 2000). It has been demonstrated that "teams of people working together for a common purpose have been a centerpiece of human social organization ever since our ancient ancestors first banded together to hunt game, raise families, and defend their communities" (Kozlowski & Ilgen, 2006, abstract). While many civilizations no longer rely on hunting parties to supply food, it is arguable that departments at academic institutions, or corporations, might be the direct extension of the hunting parties of previous generations. Hillary Clinton entitled her 1996 book "It Takes a Village: And Other Lessons Children Teach Us", from a derivative of an old proverb "it takes a village to raise a child" (Goldberg, 2016). Although not what would traditionally be considered a team, a community that bands together to raise the next generation is definitely performing as a team. Much like sports teams today wear uniforms to show their team affiliation, countries use flags, Scottish clans use different textile patterns (Ray, 1998), militaries use uniforms (Yagou, 2011) to show "team" affiliation. The need for teams has long been a pervasive, and integral part of society, team learning, or collaborative learning, has even found its way into the classroom of our schools (Shimazoe & Aldrich, 2010).

2.3 Demand of Employers for Teamwork Skills

"Juran' s teachings focused on the "soft" side of quality - addressing how people work together and making them more able[sic] to share information effectively, removing the organizational barriers and constraints (known as functional silos). Team building became an integral part of making quality happen" (Allen, 2011, para. 9). As industry adopts the idea of using teams to improve product quality, creating highly productive teams is essential (Automotive Quality Improvement Teams, 2013). Joseph Juran's early "work in quality management led to the development of the widely practiced business methodologies referred to as Six Sigma and lean manufacturing" (Bunkley, para. 2, 2008). Given the integral part team building plays in industry producing a quality product, the importance of team building cannot be emphasized enough. Applying the philosophy of Juran, discovering what method produces better teams, will lead to better quality and a leaner manufacturing process, leading to increased profits for industry.

Further, creating better teams, that display a greater perception of satisfaction and increased team member contribution in the classroom setting might benefit industry after students enter the workforce. "The restructuring and realignment of business and industry reflect the reinvented concept of teamwork" (Scarnati, 2001, para. 24).

Scarnati illustrates through example that not only does industry desire teamwork, but in some instances, industry owes its livelihood to implementation of teams.

> Teamwork creates commitment because everyone must accept ownership and responsibility for the success or the failure of a project. Prior to 1980, the joke among consumers was that FORD was an acronym for Fix Or Repair Daily. Ford, a company not noted for quality, began its turn-around in 1983 when it embraced the quality teachings of Dr. W. Edwards Deming. The company removed the old top-down concept of operation and replaced it with a team concept in which every individual has a vested interest in success (Scarnati, 2001, para. 12)
>
> The 1994 Ford Mustang was also developed and implemented by a 450-member "Team Mustang". The team accomplished the task in three years instead of the usual four-year cycle. Again, the team effort saved Ford considerable money by speeding the transition from concept to product. Today's technology and computer-aided design are making the interval between concept and production constantly shorter. Working as an integrated unit to solve problems answers everyone's "who, what, when, where?", and, most importantly, "why?" questions. When individuals or groups know the

> answer to these questions they are more motivated and committed to accomplishing the task. (Scarnati, 2001, para, 13)

2.4 General Characteristics of a Great Team

"Like it or not, all teams are potentially dysfunctional. This is inevitable because they are made up of fallible, imperfect human beings" (Lencioni, 2006, p. 6). Teamwork is not a natural function but must be learned (Deeter-Schmelz & Ramsey, 1998). So what makes a team great? Is it a strong leader with ultimate control (dictatorship)? Is it a team where all members have equal say (democracy), or is it a blend of the two? There are many different aspects of teams that could be examined, such as age, race, and gender of the individual members. The possibilities of traits are extensive, and for the purpose of this study too numerous to try and account for all possible traits. For the purpose of this study the following traits were utilized to formulate teams: gender, age, class year in college, writing skills, leadership role, and leadership preference. These traits are already imbedded within the CATME Team Maker program, along with several other traits. Traits that were deemed repetitive, or non-contributing by the researcher were excluded from the CATME Team Maker list.

> Mixed gender groups are likely to engage in task conflicts (as men are task orientated) and at the same time, have more effective strategies to deal with the disruptive effects of power differences in groups (as women have a relational orientation in collaborative settings). We therefore argue that the presence of both task and relational orientation in mixed-gender groups alleviates the negative and foster the potential positive influence of power differences on GCC [group cognitive complexity] and satisfaction with the group. (Curseu & Sari, 2015)

Gender was selected, with genders being distributed, due to males and female genders approaching task conflict from different perspectives. Age and class year in college were both distributed to minimize the impact of chronological age versus subjective age (Galambos, Turner, & Weaver, 2005). Writing skills were selected, with different levels of self-reported writing skills being distributed, to minimize the effect of writing due to the number of ESL students in the Tech12000, *Design Thinking in Technology*, class (Kellogg & Raulerson III, 2007). The leadership role was selected, with self-reported leaders being distributed to each team, due to teams having increased effectiveness when led by a strong leader (Suk Bong, Kihwan, Sueng-Wan, 2017). Leadership preference was chosen to disperse students who self-reported either a following preference, or shared leadership preference. The CATME Team-Maker software program was utilized to compile teams using the above referenced traits. There is evidence that there is no difference in outcomes between student selected and instructor selected teaming, in fact, “the results showed that students had an overall positive attitude and the final grades were similar in both instances (Wolfe, Kyung-Eun, Chi-Mei, Gould, 2003). The evidence is based on a study of 86 students, divided into 27 teams, taking an introductory tourism class at the collegiate level.

The team size for this study consisted of CATME Team Maker generated, or instructor/student generated, teams of four, or five, depending on number of participants in the section and with the goal of keeping each section at eight teams. The team size of four, or five, is consistent with a study that showed 90.3% of subjects, if allowed to self-select, would choose a team size of between one and seven (Harrell, 2007). A study by Behfar, Friedman, & Oh (2016) addresses the problem of individuals introducing personal bias into a team setting and the impact of said personal bias on the team. Behfar, Friedman, and Oh determined that “two empirical studies, one scenario and one field study, consistently show that individuals who are unsatisfied with their team members show bigger self-serving bias” (2016, p. 98).

2.5 Gender Teaming

Research has shown that gender can play a role in the creation of teams. When considering gender teaming there are five possible combinations that could be considered. These combinations are male-only, male-dominated, equal, female-dominated, and female-only. A 2015 study examined 588 undergraduate students enrolled in a digital design course in a public university in south China. They were freshmen aged from 17 to 22 years old. Among them, 287 were male and 301 were female (Zhan, Fong, Mei, Liang, 2015). The research looked at the five possibilities of team combinations and discovered that in team performance, the equal and female only teams outperformed the other teamings (Zhan, Fong, Mei, Liang, 2015). This study provides results that are consistent with a 2015 study by Petru Curseu and Kimzana Sari. The Curseu and Sari study hypothesized that “gender variety alleviates the negative impact of power disparity on GCC [group cognitive complexity] and satisfaction” (Curseu, Sari, 2015). The hypothesis was tested using a sample of 87 student teams, comprised of 487 students, with an average age of 20. Gender was split in the study with women numbering 182, and men 305. This researcher chose to have the CATME Team Maker teams created with males and females distributed to “foster[s] the potential positive influence” described in the Curser and Sari (2015, para. 22) study and the equal and female teaming outperforming teaming of all male, male dominated, female dominated findings of Zhan, Fong, Mei, & Liang (2015). In addition, the researcher chose to distribute gender based on a study by Baugher, Varanelli, Jr., Weisbord & Ellen (2000). “Self-formed work groups will have less gender diversity than groups formed through random selection” (Baugher, Varanelli, Jr., Weisbord & Ellen, 2000, p. 394). This is the hypothesis examined in a study consisting of 358 undergraduate seniors, enrolled in a capstone business course. The gender mix of the sample consisted of 37.7% females and 62.3% males. The study utilized eight sections, and three instructors. The maximum team size was capped at six, and after the teams had been generated, the teams mean was 4.48 members. Eighty teams were formed across the eight class sections. To test the difference between self-selected teams and randomly generated teams, 80 phantom teams that matched the self-generated teams in size were generated. The study showed that “self-formed teams are typified by less diversity than the randomly formed teams” (Baugher, Varanelli, Jr., & Weisbord, 2000, p. 400). The study showed that this was the case in each of the eight sections with a mean gender diversity of the self-selected teams ranging from .186 to .322 females to males, while the random teaming ranging from .320 to .422. In this study, a perfectly diverse team would have a score of .500. The closer the score to .500 the more homogenous the team. “Students chose homogeneity quickly even though there was ample time to organize in a diverse manner. In fact, most teams were established in a matter of minutes” (Baugher, Varanelli, Jr., & Weisbord, 2000, p. 404). The implication is that “these findings suggest that diverse work groups will not arise simply because workers [students] are inclined to assemble in a diverse way” (Baugher, Varanelli, Jr., & Weisbord, 2000, p. 404).

2.6 Age and Class Year in College Teaming

Due to the fact that chronological age and class year do not always coincide, these two categories were chosen to ensure that all teams were represented by a diverse sampling of ages and class year. Teams of all younger, or all older, all upperclassmen, or all underclassmen, were avoided in favor of balanced teams, in hopes that all teams would be able to benefit equally from life experience typically gained as age and class year progress.

A 2005 study by Galambos, Turner, and Tilton-Weaver of 190 university students, consisting of 140 females and 50 males examined the concept of subjective age versus chronological age (Galambos, Turner, & Weaver 2005). The subjects of this study were asked a series of questions that assessed the following: subjective age, psychosocial maturity, role transitions, financial dependence, economic pressure, and alcohol use (Galambos, Turner, &

Tilton-Weaver, 2005. The researcher focused on the following areas as they could be applied to the current study: subjective age, psychosocial maturity, and role transitions.

Subjective age, or how old the subject perceived they were, was found to be inversely proportional to chronological age (Galambos, Turner, & Tilton-Weaver, 2005). In fact, after reviewing all cases (n=190), it was found that a crossover occurred at the age of 25.5 years (Galambos, Turner, & Tilton-Weaver, 2005). The researcher in the current study chose age as a teaming factor due to the variety of students ages in the class sections. The researcher chose to not form homogenous teams by age, but rather, non-homogenous teams with each of the teams having a variety of ages represented. The researcher chose this method to help mitigate creating teams that would have an older perception of age and teams that had a younger perception of age. This method creates teams of mixed ages, which in turn, may lead to teams of mixed maturity.

Psychosocial maturity was measured using 35 items from the Erikson psychosocial inventory scale (Galambos, Turner, & Tilton-Weaver, 2005). These items measured the following:

> Items for the autonomy ("I am able to take things as they come." "I like to make my own choices"), identity ("The important things in life are clear to me." "I like and am proud of what I stand for"), and intimacy (I'm ready to get involved with a special person." "I care deeply for others"). (Galambos, Turner, & Tilton-Weaver, 2005, p 545)

While the subjective age was perception based, the psychological maturity, although still qualitatively measured, was measured using more concrete examples of how the subjects perceived their age. The last area from the Galambos, Turner, & Weaver study was role transitions:

> The number of role transitions ranged from 0(12% of the sample) to 3(5.8%). The majority of participants had experienced one (53.7%) or two (28.4%) role

> transitions. The most common transition was having left home (68% of the sample). (2005, p 545)

Looking at the data provided by the Galambos, Turner, & Tilton-Weaver study, the researcher decided to include age as a factor in team building. Non-homogenous age teaming was chosen to account for the difference in growth rates of the individual students. A non-homogenous teaming may allow each team to possess students at varying rates of maturity and age.

2.7 Writing Skills Teaming

This study dispersed the CATME Team Maker participants evenly throughout the teams based on those who indicated they are strong writers, or not as strong of writers. This ensured that no team had all participants as self-reporting a lack of writing skill. "Effective writing skills are central both in higher education and the world of work that follows" (Kellogg & Raulerson III, 2007, p. 237). The ability to write effectively is not only academically beneficial, today's industry is demanding the ability to write effective of its workforce.

> Effective use of [writing] knowledge will require that college students deliberately practice the craft of writing extended texts, in English composition courses and across the curriculum in all subjects. Without training to use what they know, their knowledge too often remains inert during composition. (Kellogg & Raulerson III, 2007, p.238)

2.8 Leadership Role Teaming

Much like teaming by gender, several possibilities exist for creating teams using leadership role and leadership preference teaming. The leadership role can be either led by one person, or the leadership role can be shared among the team. A 2017 study by Suk Bong, Kihwan, & Sueng-Wan noted that each type of leadership has advantages. Teams that are led by a strong leader have increased output effectiveness, whereas, shared leadership teams improved organizing and planning effectiveness (Suk Bong, Kihwan, Sueng-Wan, 2017).

> Successful team leaders put team performance first. Their goal is team, not individual, achievement-their own included. In working groups, where performance depends entirely on optimizing discrete individual contributions. (Katzenbach & Smith, 1992, para. 1)

A study by Feldman suggested that optimizing individual contributions of team members goes beyond just selecting the right people for a team:

> Besides the work of finding the right people to join the team, there is the work of building relationships, engendering trust, and setting an agenda that built on mission, vison, core values, and a strategic plan. (Feldman, 2018, p. ?)

2.9 Leadership Preference Teaming

Leadership preference can be divided into three categories. These categories are those who prefer to lead, those who prefer to have shared leadership, and those who prefer to follow a leader. Participants that reported preferring to share leadership roles, or follow, were distributed as evenly as possible throughout the teams generated using the CATME Team Maker software. What makes a leader worth following? Claude Bartlett attempted to answer this question in 1959. Bartlett used an introductory course in educational psychology as the platform for his study (1959). The instructor of the course divided the class into teams of four to six students to work on various projects throughout the duration of the course (Bartlett, 1959). Separately, the study had three classes, numbering about 75 students total, write essays describing the behaviors of the most outstanding leader in their discussion team[s] (Bartlett, 1959). The students writing the essay were instructed to use the following definition for leadership. “Leadership was defined as being perceived as a leader by the other members of a discussion group” (Bartlett, 1959, abstract). From these essays 300 descriptions were obtained and organized by graduate students into a six category checklist. The methodology for administering the checklist is as follows:

> The checklist was administered to 100 students of the introductory educational psychology class, divided into three approximately equal groups. The first group was asked to think of someone in the upper half of the class in terms of leadership qualities. The second group was asked to think of a person from the lower half in terms of leadership. The rest were asked to think of someone who was about average. (Bartlett, 1959, pp. 280-281)

After the students had completed the checklist, they were asked to rate each member of the team as to their perception of the overall leadership displayed by the rated team member. The leadership score was correlated with the 300 phrases obtained by the essay writing teams. After performing a statistical analysis, scores that displayed positive correlation were examined. The examination revealed a general factor and four team factors (Bartlett, 1959). The general factor was described as a halo factor. This factor was persistent throughout the ratings in all teams. Items from the checklist that scored well in this are included "Ideas show good judgement", "Ideas are excellent", "Makes many worthwhile comments", and "Answers wisely" (Bartlett, 1959, p. 281). The team factors in the study were labeled "Contribution of Ideas and Information", "Contribution of Friendly Atmosphere", "Contribution of Labor and Effort", and "Contribution of Policy and Decisions" (Bartlett, 1959, p. 283). The Bartlett study was "done to examine the dimensions of leadership behavior in a classroom discussion situation" (1959). This study showed that people have definite perceptions of what behaviors a good leader should possess.

2.10 Summary

In summary, teams are not a new concept and are present in almost all facets of life from the school playground to industry. The demand for effective teams is a common current flowing in both educational settings and industry. Throughout history there have been many methods of choosing teams, many of the teaming methods derive out of necessity, or accessibility of participants; both industry and classrooms are not exempt from the variety in types of team formations.

As demonstrated by the Bartlett (1959) study, people have clear expectations and perceptions of what behaviors leaders demonstrate. Often, due to time restrictions, the instructor team students out of convenience(ease of implementation) and expediency. This study hypothesized that by utilizing CATME Team Maker software to generate teams, participants will be more satisfied with the team performance and have higher team member contribution versus instructor/student selected teams.

CHAPTER 3. METHODOLOGY

3.1 Introduction

This thesis was designed to measure the difference in effectiveness, if any, between CATME Team Maker computer software-generated teams and instructor/student-selected teams. The students for this study were selected from the Tech12000, *Design Thinking in Technology*, course at Purdue University. Multiple sections were selected, with the treatment sections comprised of CATME Team Maker software-generated teams, and the comparison sections comprised of instructor/student selected teams. Students were asked to self-report their perceptions of satisfaction with their team and individual participation from their team members at five time points during the study.

3.2 Hypotheses

This study examined the following hypotheses:

1. Ho: The treatment sections will not display a higher perceived team member contribution versus comparison sections.

   Ha: The treatment sections will display a higher perceived team member contribution versus comparison sections.

2. Ho: The treatment sections will not display a higher perception of team member satisfaction versus comparison sections.

   Ha: The treatment sections will display a higher perception of team satisfaction versus comparison sections.

3. Ho: The treatment sections will not display a higher overall course grade versus comparison sections.

Ha: The treatment sections will display a higher overall course grade versus comparison section.

4. Ho: The treatment sections will not display a higher perceived consistency of team member contribution across team members versus comparison sections.

   Ha: The treatment sections will display a higher perceived consistency of team member contribution across team members versus comparison sections.

5. Ho: The treatment sections will not display a higher perceived consistency of team member satisfaction across team members versus comparison sections.

   Ha: The treatment sections will display a higher perceived consistency of team member satisfaction across team members versus comparison sections.

3.3 Sample

The students for this study were selected from sections of the Tech12000, *Design Thinking in Technology*, course at Purdue University. Purdue University has an undergraduate enrollment of approximately 31,000 students, with a gender distribution of 57% male, 43% female, and an international population of 16% (Student Enrollment, 2017). In order for a section to qualify for the study, the instructor for the course had to teach two sections, allowing one section to receive treatment and the other section to be used as the comparison. Restricting the study to instructors teaching both a treatment team, and comparison team, aided in the possibility of reducing the impact of the instructor influence on the study. In order to mitigate the effect of selection bias, the researcher randomly assigned which section would receive treatment for each instructor. The students in the treatment section were divided into teams of four, or five, using the software program, CATME Team Maker.

The demographics of the Tech12000, *Design Thinking in Technology*, classes used in this study are shown in table 1.

Table 1. *Demographics of the Tech12000, Design Thinking in Technology, used in study.*

	Comparison Group	Treatment Group
Number of Sections	5	5
Total Number of Students	203	196
Male Students	171	143
Female Students	32	52
Non-Binary Gender Students	0	1

3.4 Study Design

In this quasi-experimental study design, both the treatment teams and the comparison teams received the same coursework during the course of study. The treatment team was defined by having teams formed using a brief survey in CATME Team Builder, in which the students self-reported how they rated themselves on the following categories: Gender, Age, Leadership Preference, Leadership Role, Writing Skills, and Class Year. The comparison team was defined by having instructor/student-selected teams.

Students participating in the Tech12000, *Design Thinking in Technology*, Fall 2018 semester selected their section during the registration process for the Fall 2018 session. All students in the study sections were required to participate, as the activity requiring teams was already a requirement for the class.

3.5 Procedure

Before starting this study, the research underwent an Institutional Review Board (IRB) approval process. This study utilized data that were collected regardless of whether this study was conducted, or not, and because the formation of teams was also a process already utilized in this course, no informed consent, written, or otherwise, was required. In addition, the use of preexisting data that IRB determined the study to be exempt.

For this study, two types of team formation were examined in the Tech12000, *Design Thinking in Technology*, course. This course was comprised of mainly freshmen students participating in their first semester of college. Although the students come from varied educational backgrounds, it was assumed that they all had similar educational backgrounds in exposure to design thinking. The activity utilized in this study was the capstone project for the course. The subject matter of the course was not the subject of the study, but rather how the teams were formed for the capstone project. Although, for the purpose of this study, the self-reported leaders were not able to select their team members. Students in the treatment sections who indicated that they preferred to lead were separated into separate teams where possible. This insured that each CATME Team Maker generated team had the same leadership structure of being led by a self-identified leader. The researcher's instructions to instructors for setting up the CATME Team Maker teams are outlined in Appendix A. CATME Team Maker was designed to:

> create an algorithm to codify the team-assignment process and implement it in an easy-to-use Internet-based interface. Their specific goals for the system included:
> * automating the team-assignment process consistent with well-established methods for manually assigning students to cooperative learning teams
> * increasing the likelihood that instructors' team-formation criteria are met compared to manually-assigned teams
> * providing a team "compliance score" to assess the extent to which all of the team-formation criteria have been met
> * allowing instructors to explore multiple solutions to the team-assignment problem; and
> * availability of the program to faculty everywhere. (Layton, Loughry, Ohland, & Ricc(2010)

The CATME Team Maker creates teams by first having:

> …students to teams based on their responses to an online survey. Instructors create the student survey by choosing the variables that they want to be included in their survey

> from the list of variables in Team-Maker's "inventory". The variables have associated with them the questions that the students will be asked and the responses from which they will be permitted to choose. (Layton, et. al., 2010, para. 16)

After the students have completed the survey:

> The instructor assigns a decision/distribution rule/weight to each survey variable that indicates 1) whether the instructor wants students with similar or dissimilar responses to be grouped, and 2) how heavily that variable should be weighted when creating teams. The team-assignment algorithm generates a "question score" for each variable characterizing how well the team's distribution of that variable complies with the instructor's wishes -- higher positive values are better. Team-Maker's algorithm then generates a "compliance score" for each team characterizing how well the team's distribution of all variables complies with the instructor's wishes -- again, higher positive values are better. The team's compliance score is the average of the team's question scores on all variables. Team-Maker works by randomly assigning students iteratively changing the team assignments to attempt to maximize the minimum compliance score of the set of teams. (Layton, et. al., 2010, para. 17)

The researcher chose to create teams by grouping variables as either similar, or dissimilar. The teams for the comparison group were instructor/student-selected teams. These teams were formed by having the students gather into teams, or having the instructor place the students into teams after gathering information about which Grand Challenge the students wanted to explore.

At each measured time point in the study, the students participating in the study completed team ratings in the CATME Bars system. The CATME Bars survey allowed the students to rate their teammates, and themselves, on a scale from one to five, to questions in the following individual participation categories: Contributing to the Team's Work[C], Interacting with Teammates[I], Keeping the Team on Track[K], Expecting Quality[E], and Having Related Knowledge, Skills, and Abilities[H] and the following three team satisfaction categories: I am satisfied with my present teammates[Q1], I am pleased with the way my teammates and I work together[Q2], and I am very satisfied with working in this team[Q3]. The team participation team satisfaction used the following scale in their measurements:

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree, Nor Disagree, 4 = Agree, 5 = Strongly Agree

The satisfaction instrument was developed by Vegt, et al. in 2001 and the participation instrument was developed by Ohland, et al and Loughry, et al. in 2012, and 2007 respectively. Scores, comprised of the average mean scores and average standard deviations, were compiled in CATME Bars program that showed the individual team members rating data points in each category, overall rating without the student's personal rating, and the overall rating with the student's personal rating included. The researcher extracted the average scores for use in data analysis.

3.6 Data Analysis

Analysis was performed on the data through means of a statistical t-test with an alpha level of .05, visualization of regression lines, and ANOVA over time with an alpha level of .05. Data analysis were performed on the student reported individual participation and satisfaction characteristics of the CATME Bars survey: Contributing to the Team's Work[C], Interacting with Teammates[I], Keeping the Team on Track[K], Expecting Quality[E], Having Related Knowledge, Skills, and Abilities[H], I am satisfied with my present teammates[Q1], I am pleased with the way my teammates and I work together[Q2], and I am very satisfied with working in this team[Q3]. Data were compiled as a section result, therefore, the statistical t-test for individual participation between comparison and treatment occurred at the section level. A statistical t-test was performed on the data to test for differences between the comparison and treatment sections.

3.7 Summary

Since the students in this study were not truly randomly assigned to teams or groups, the design of this study does not qualify as a true experimental design. However, since the study does explore a causal relationship it can be classified as a quasi-experimental design. This quasi-experimental study was designed to compare teams generated using the CATME Team Maker software and instructor/student-selected teams. Specifically, the study examined if one method of team-making generated higher perception of team's satisfaction and individual contribution. The researcher was able to make this comparison using a statistical t-test and determine to what extent, if any, differences existed between the comparison and treatment teams.

CHAPTER 4. RESULTS

4.1 Introduction

This chapter reports the results of the quasi-experimental study. Ten sections of students enrolled in the Purdue Tech 12000, *Design Thinking in Technology*, course were divided evenly into two groups. Within the comparison group, students were placed into final project teams using instructor/student selected teams, while the treatment sections were placed into groups utilizing the CATME Team Maker software. The comparison grouping consisted of 42 groups representing 196 students, while the treatment grouping consisted of 45 groups representing 203 students.

Data were collected at five different time points over eight weeks during the study. Data collection occurred at the following times: Problem Definition, Ideation, Prototyping, Design Journal, and Presentation. Using CATME Bars, students were asked to rate both themselves and their group members on the following statements which measured participation during the various activities. The statements utilized during this phase were: Contributing to the Team's Work "C", Interacting with Teammates "I", Keeping the Team on Track "K", Expecting Quality "E", Having Related Knowledge Skills, and Abilities "H". Students were then asked to rate themselves on three statements that measured satisfaction. The statements were: I am satisfied with my present teammates, I am pleased with the way my teammates and I work together, and I am very satisfied with working in this team. Both set of statements asked the students to provide a ranking on a scale of 1 – 5, where one represented a low score (minimal contribution/satisfaction) and 5 represented a high score (high levels of contribution/satisfaction). Data were also collected to test for differences between the comparison and treatment teams final course grades.

The analysis of these data took place in three phases. The first phase utilized t-tests to test for differences in team participation and team satisfaction between comparison and treatment groups overall (averaging the scores of the five time points of Problem Definition, Ideation, Prototyping, Design Journal, and Presentation together). The time points were averaged to examine the team as whole. A t-test was also used to test for differences in overall course grades between the comparison and treatment teams. The data were then plotted across time with regression lines to visualize the data, which produced a crossing pattern between the comparison and treatment team's regression lines. A repeated measures ANOVA was implemented to test for differences across time because of the crossing pattern observed in the regression lines data to see if time was a significant factor.

4.2 Sample Characteristics Participation Mean

A Shipiro-Wilk's test ($p > .05$), (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that the participation mean scores were approximately normally distributed for both treatment and comparison groups. The test also showed a skewness of -0.587(*SE* = 0.403) and a kurtosis of 0.291(*SE* = 0.788) for the treatment group and a skewness of 0.243(*SE* = 0.393) and a kurtosis of -0.150(*SE* = 0.768) for the comparison group(Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011). Figures 1 - 5 present the results for the participation mean histograms, normal Q-Q plots and box plots, respectively. The results of the Shipiro-Wilk's test failed to reject the null-hypothesis that the data were normally distributed, comparison group $p = .193$, treatment $p = .789$. Since the data were fairly normally distributed, *t* –test and ANOVA parametric testing was conducted.

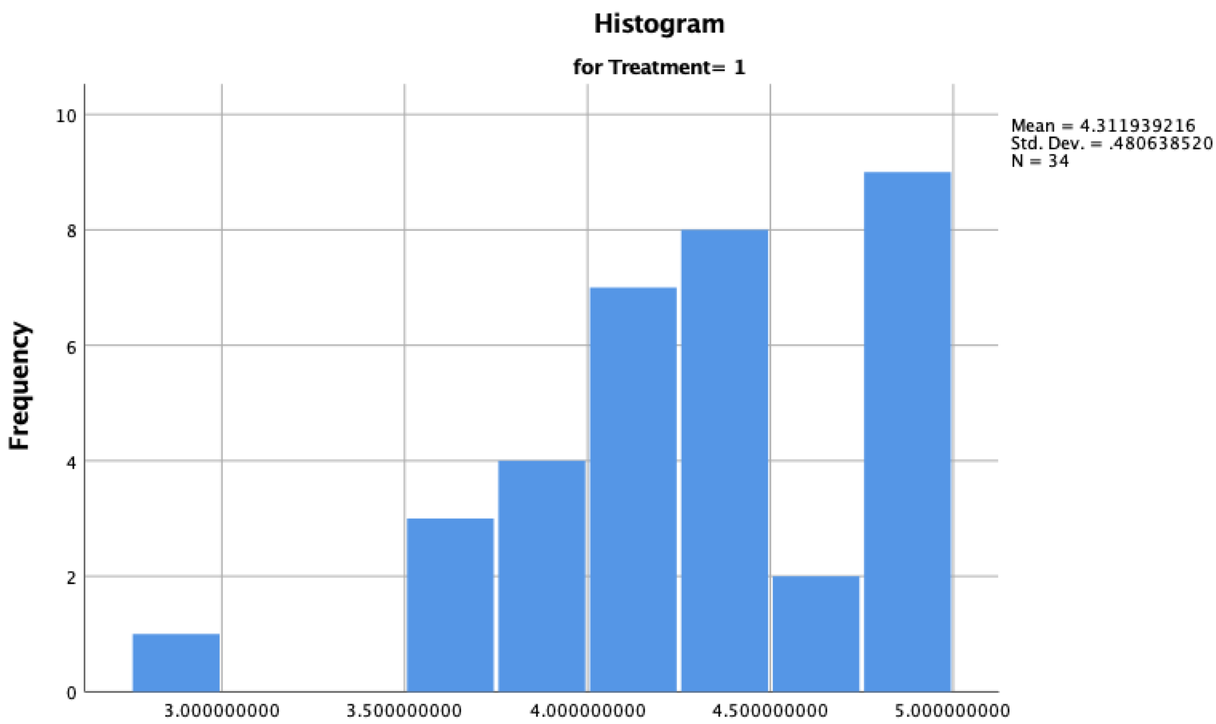

Figure 1. *Participation Mean Histogram Comparison Group*

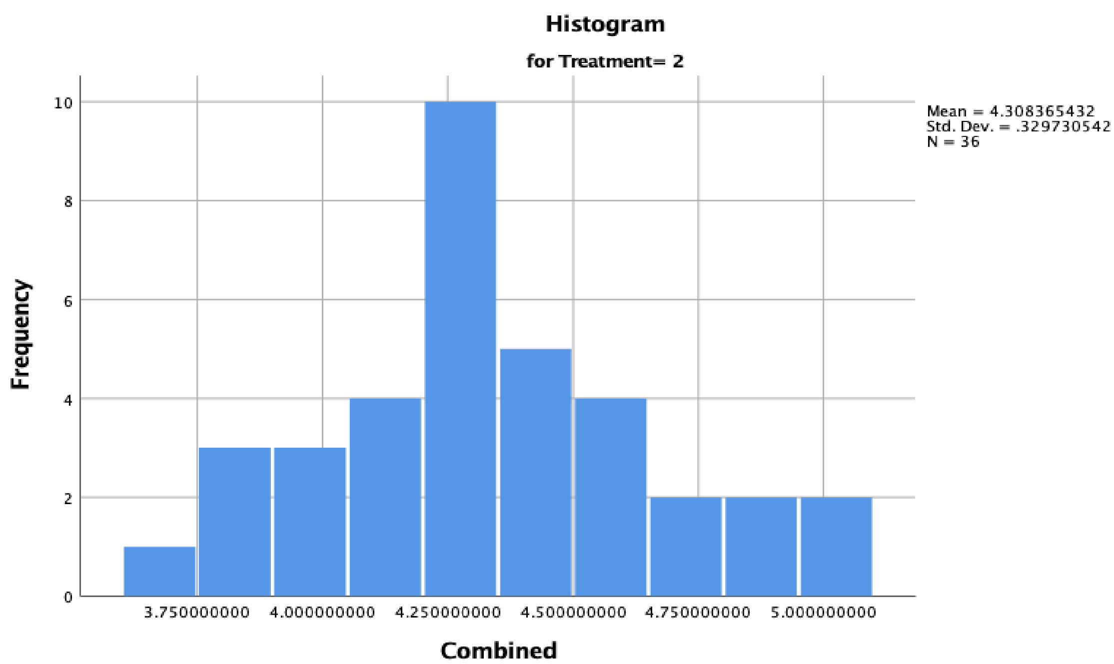

Figure 2. *Participation Mean Histogram Treatment Group*

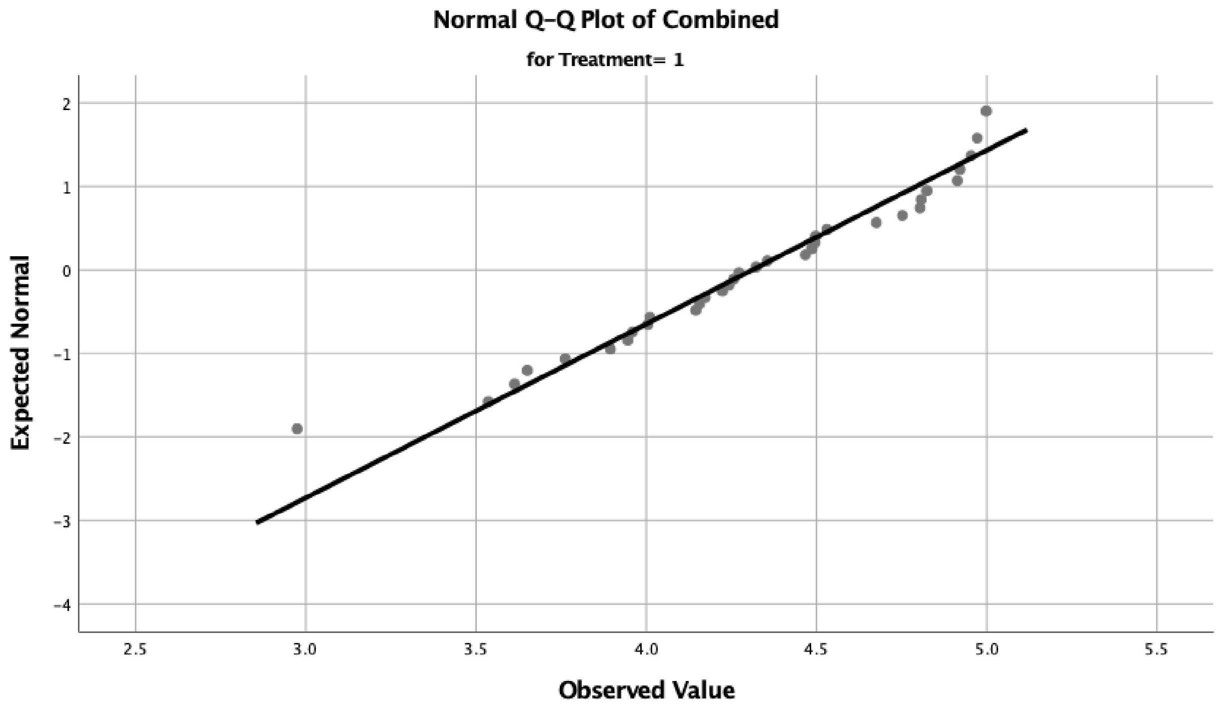

Figure 3. *Participation Mean Normal Q-Q Plot Comparison Group*

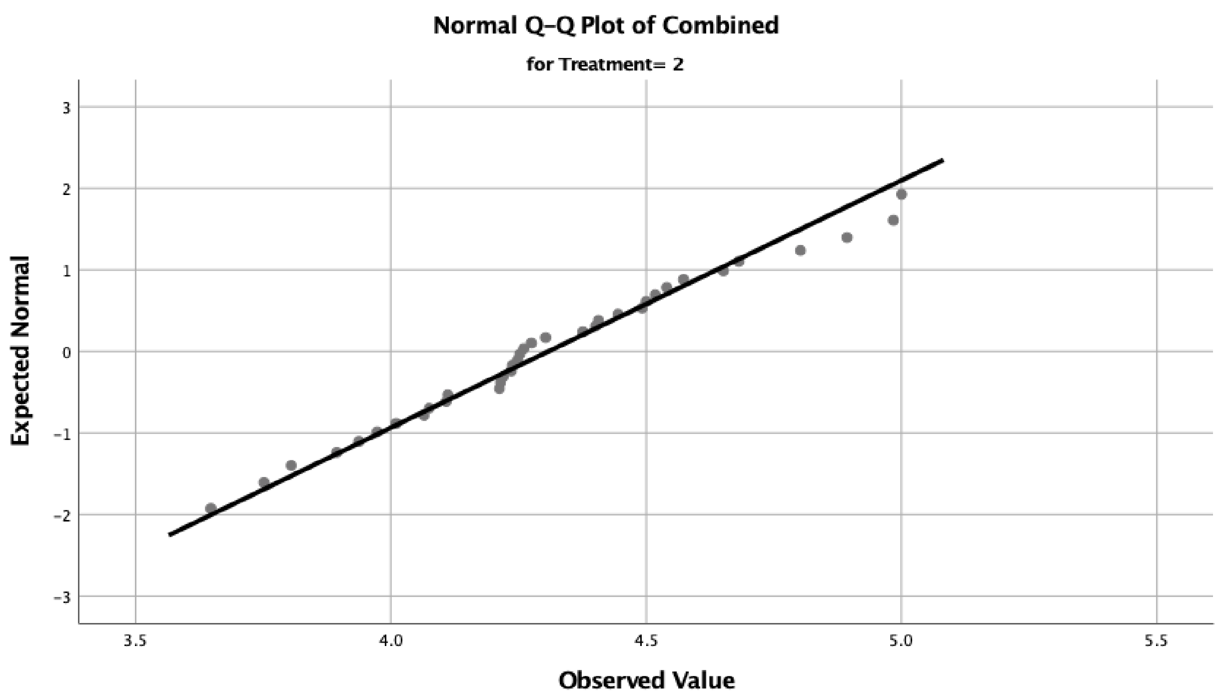

Figure 4. *Participation Mean Normal Q-Q Plot Treatment Group*

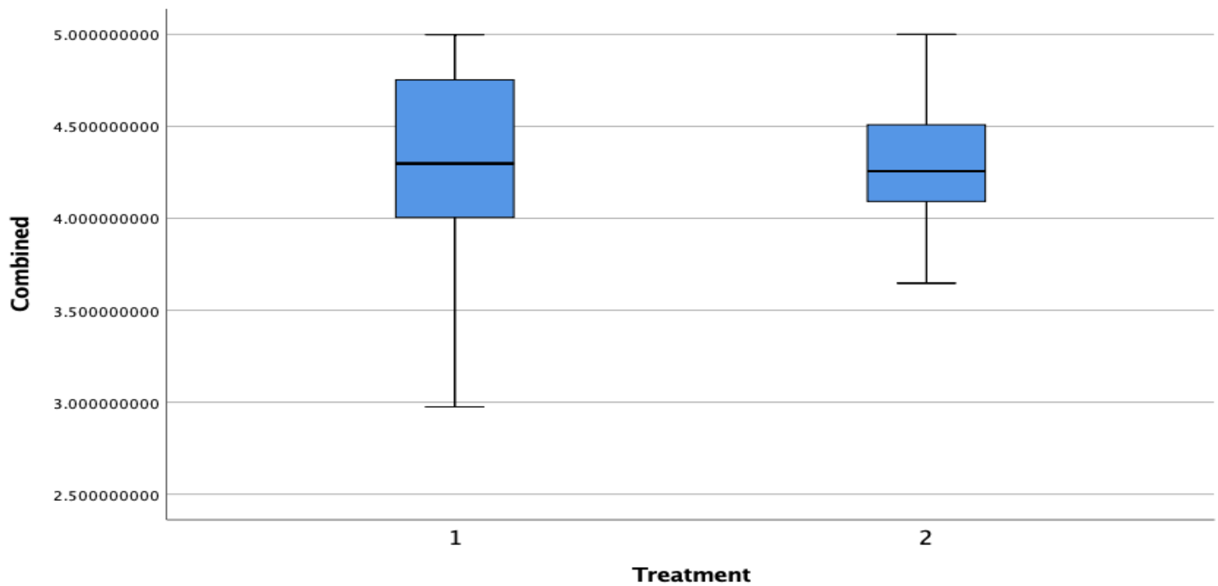

Figure 5. *Participation Mean Box Plot, 1 = Comparison, 2 = Treatment*

4.3 Sample Characteristics Satisfaction Mean

A Shipiro-Wilk's test ($p > .05$), (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that the satisfaction mean scores were approximately normally distributed for both treatment and comparison groups The test also showed a skewness of -0.645(*SE* = 0.403) and a kurtosis of -0.203(*SE* = 0.788) for the treatment group and a skewness of -0.552(*SE* = 0.393) and a kurtosis of -0.560(*SE* = 0.768) for the comparison group(Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011). Figures 6 - 10 present the results for the participation mean histograms, normal Q-Q plots and box plots, respectively. The results of the Shipiro-Wilk's test failed to reject the null-hypothesis that the data was normally distributed, comparison group $p = .118$, treatment $p = .110$. Since the data were fairly normally distributed, *t* –test and ANOVA parametric testing was conducted.

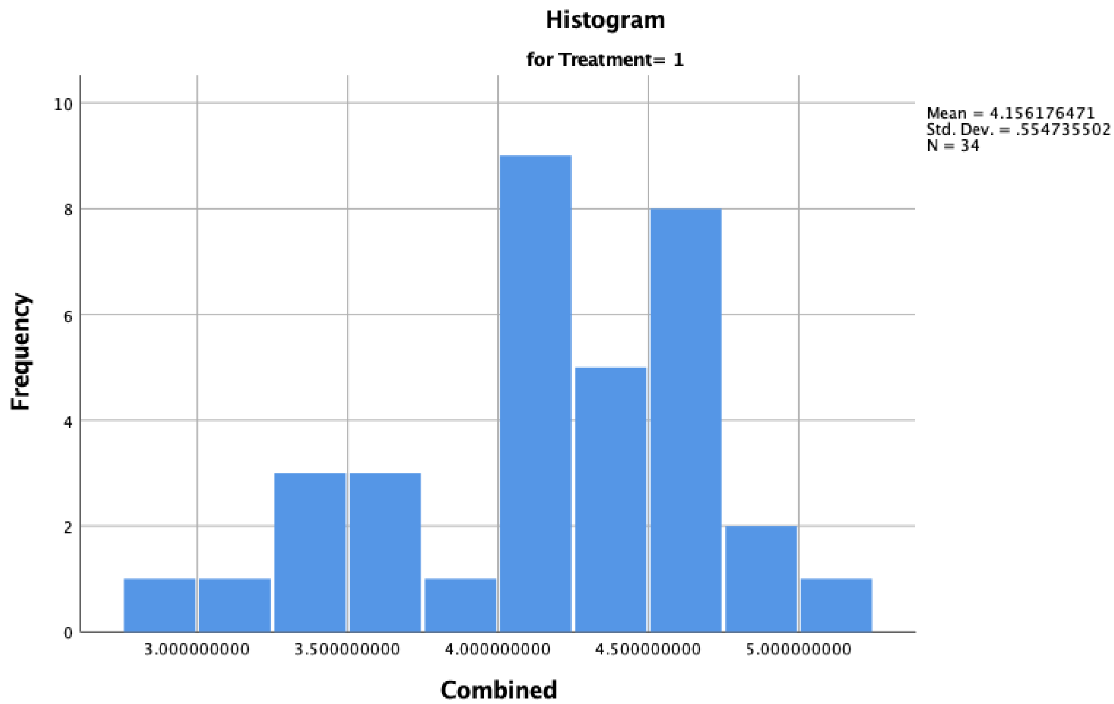

Figure 6. *Satisfaction Mean Histogram Comparison Group*

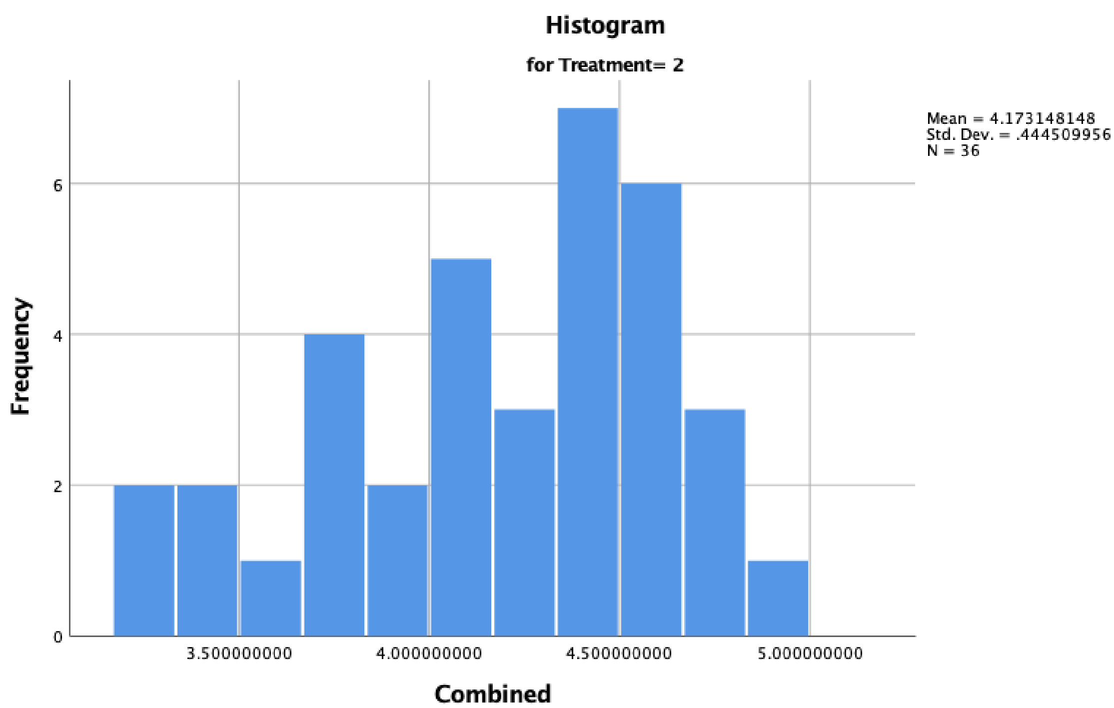

Figure 7. *Satisfaction Mean Histogram Treatment Group*

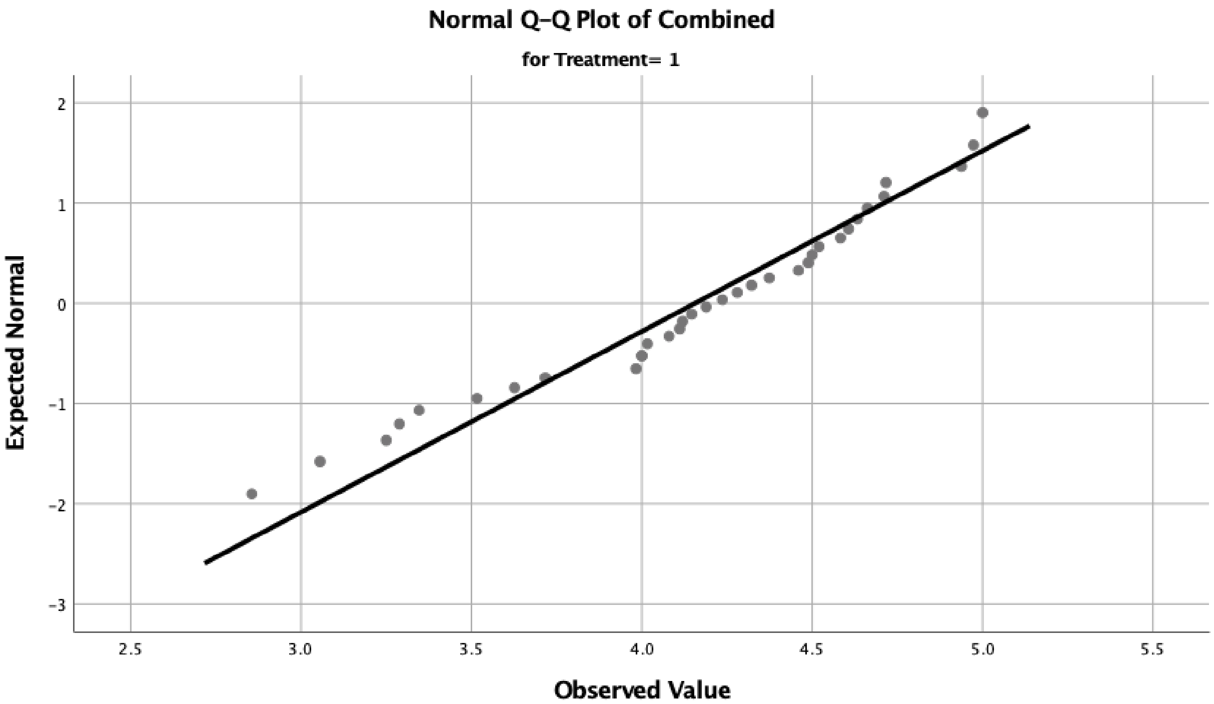

Figure 8. *Satisfaction Mean Normal Q-Q Plot Comparison Group Mean*

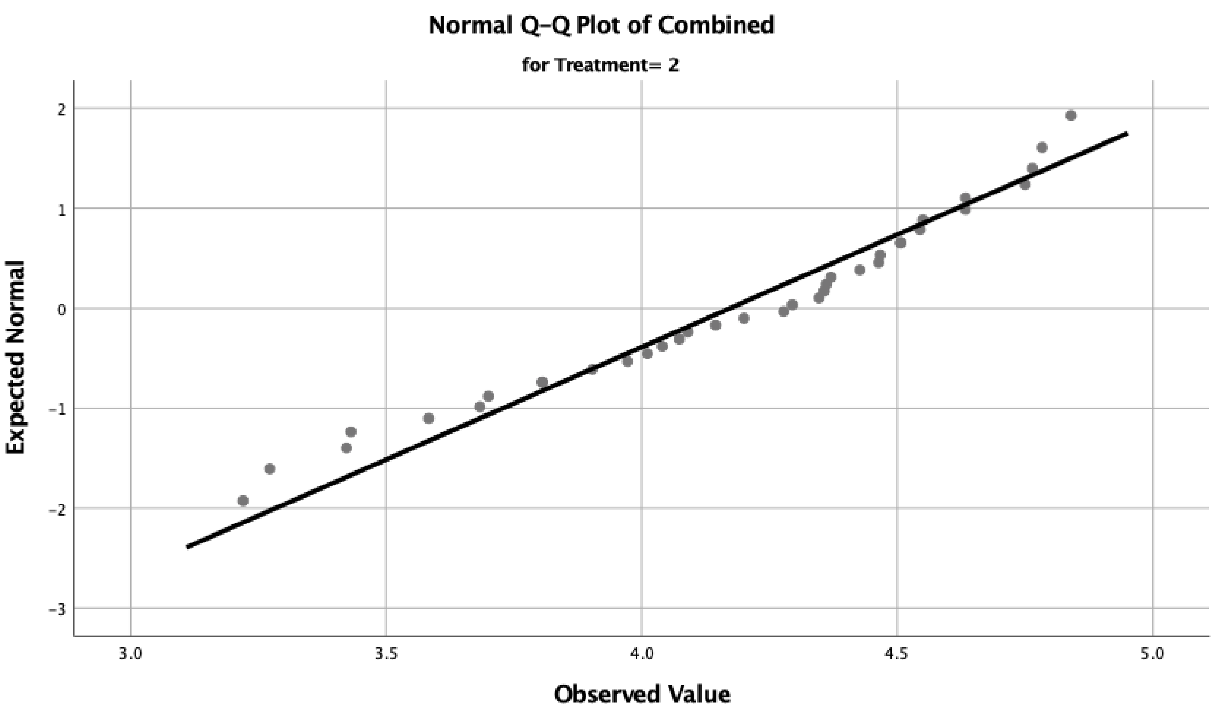

Figure 9. *Satisfaction Mean Normal Q-Q Plot Treatment Group*

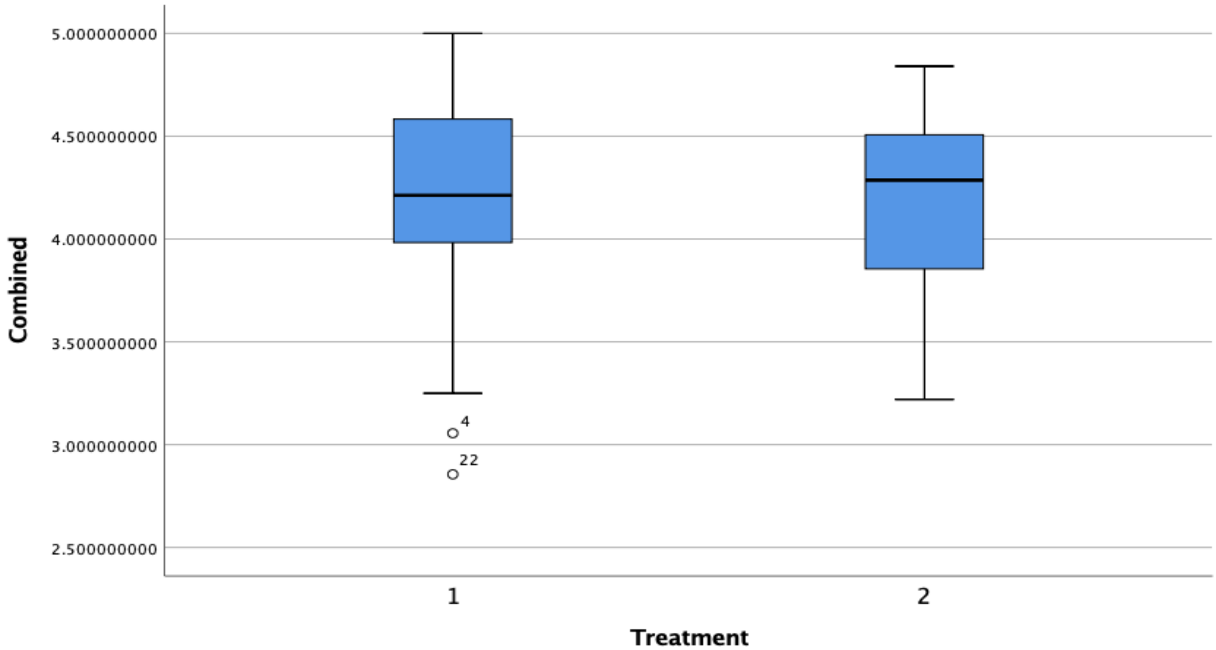

Figure 10. *Satisfaction Mean Box Plot, 1 = Comparison, 2 = Treatment*

4.4 Sample Characteristics Course Grade

A Shipiro-Wilk's test (*p* > .05), (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots indicated that the course grades were not normally distributed for both treatment and comparison groups. The test also showed a skewness of -2.514(*SE* = 0.176) and a kurtosis of 8.472(*SE* = 0.350) for the treatment group and a skewness of -2.341(*SE* = 0.175) and a kurtosis of 7.126(*SE* = 0.348) for the comparison group(Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011). Figures 11 - 15 present the results for the participation mean histograms, normal Q-Q plots and box plots, respectively. The results of the Shipiro-Wilk's test rejected the null-hypothesis that the data was normally distributed, comparison group *p* = <.001, treatment *p* = <.001. The researcher originally assumed normality and a *t*-test was performed on the data returning that there was not a significant difference (*p* = .124) between comparison and treatment course grades. Due to the data not being fairly normally distributed, a non-parametric test was indicated. A Mann-Whitney confirmed that there was not a significant difference (p = .152) between comparison and treatment course grades.

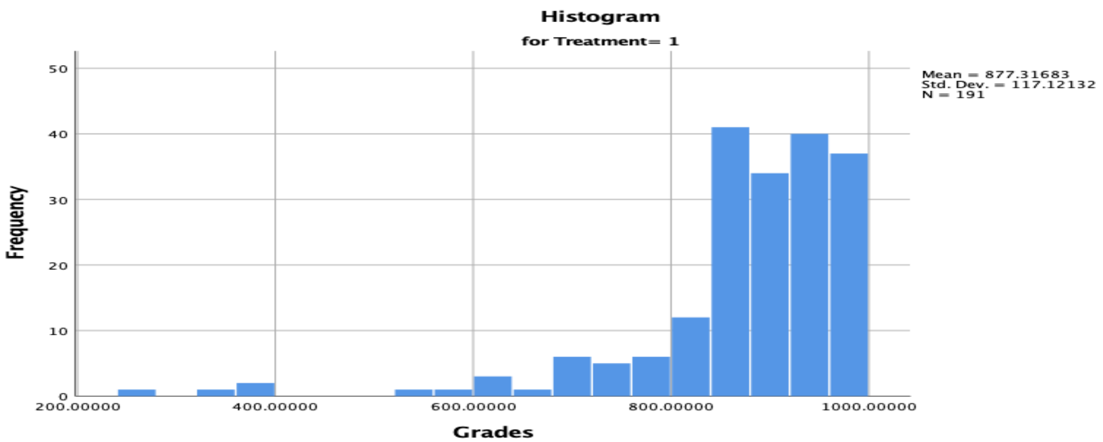

Figure 11. *Course Grade Histogram Comparison Group*

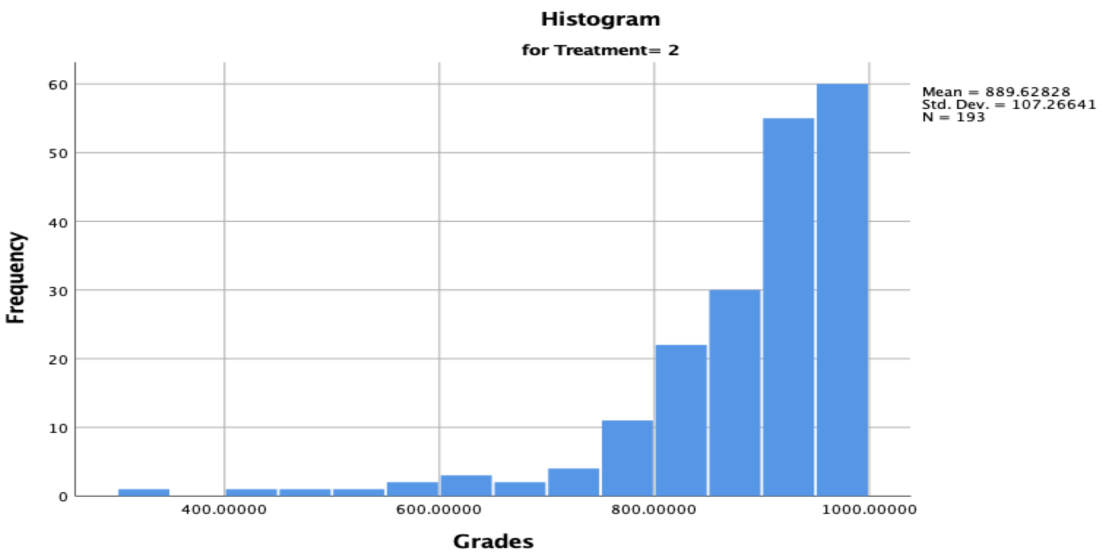

Figure 12. *Course Grade Histogram Treatment Group*

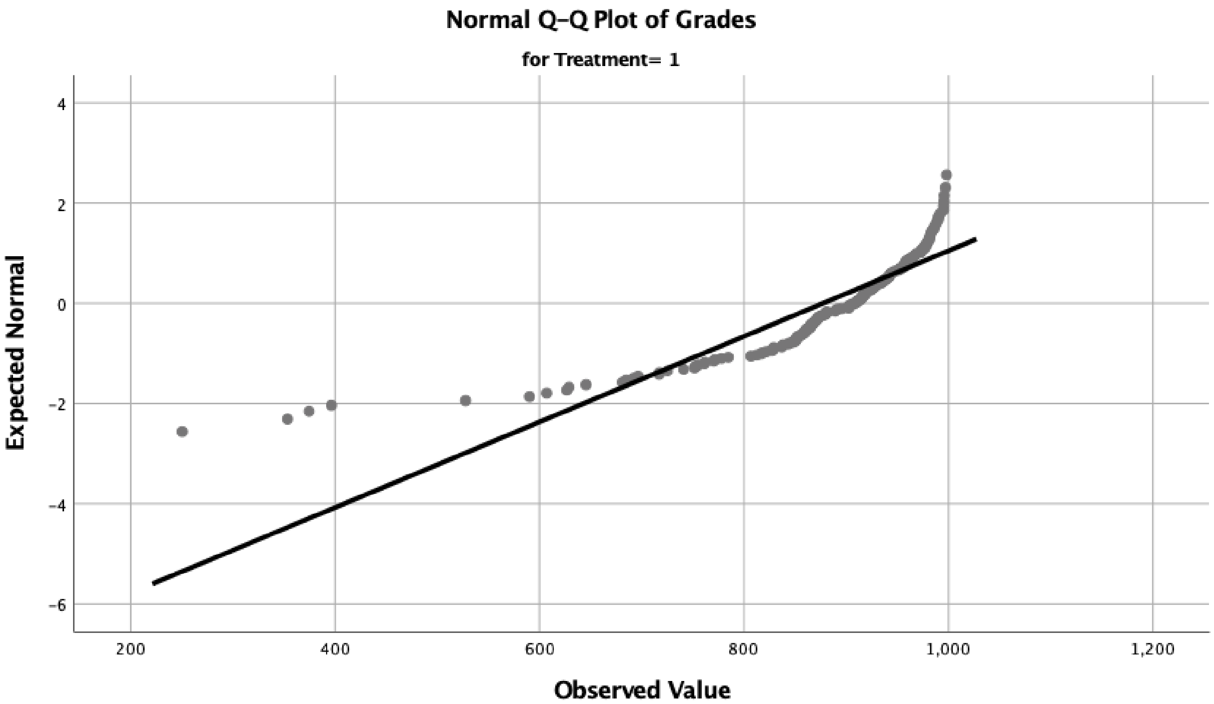

Figure 13. *Course Grade Q-Q Plot Comparison Group*

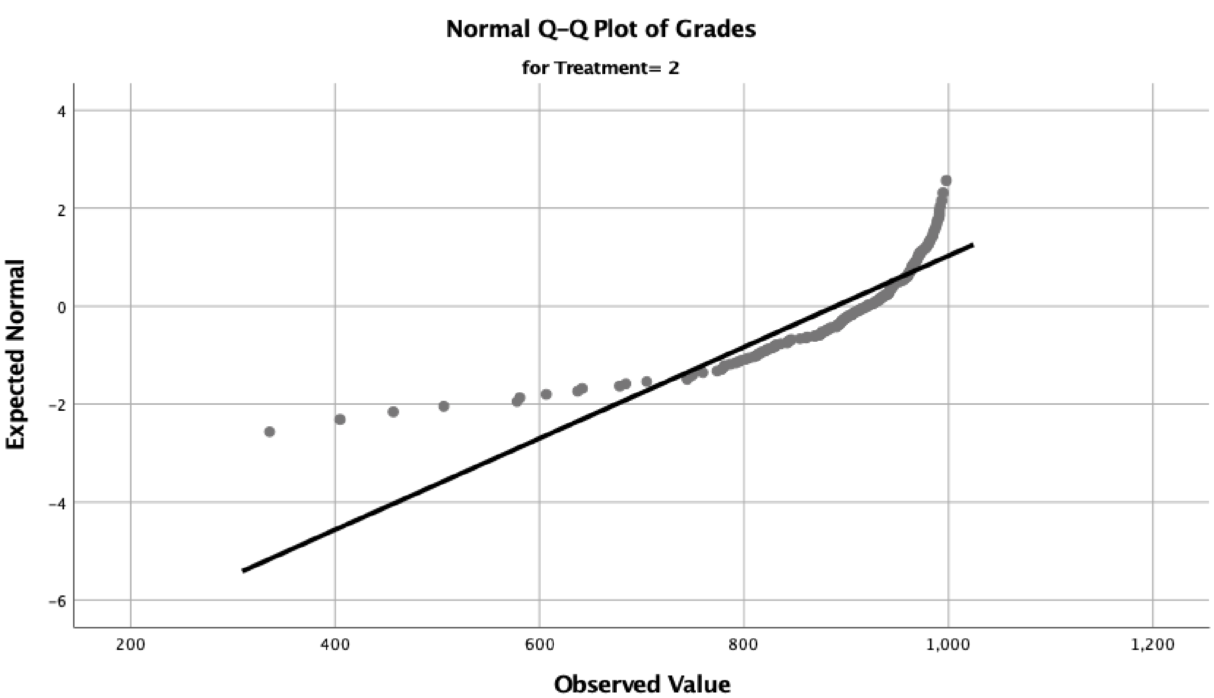

Figure 14. *Course Grade Q-Q Plot Treatment Group*

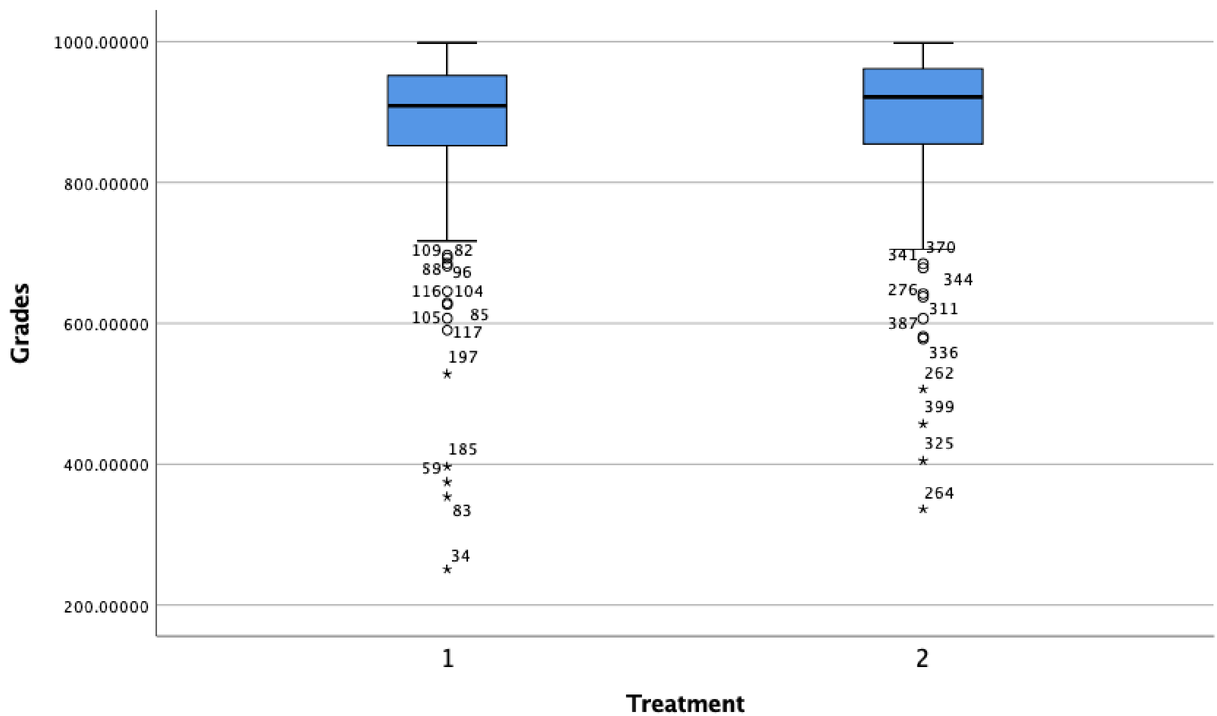

Figure 15. *Course Grade Box Plot, 1 = Comparison, 2 = Treatment*

4.5 Sample Characteristics Participation Standard Deviation

A Shipiro-Wilk's test (*p* > .05), (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that the participation standard deviation scores were approximately normally distributed for both treatment and comparison groups. The test also showed a skewness of -0.028(*SE* = 0.403) and a kurtosis of -0.192(*SE* = 0.788) for the treatment group and a skewness of 0.348(*SE* = 0.393) and a kurtosis of 1.520(*SE* = 0.768) for the comparison group(Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011). Figures 16 - 20 present the results for the participation mean histograms, normal Q-Q plots and box plots, respectively. The results of the Shipiro-Wilk's test failed to reject the null-hypothesis that the data was normally distributed, comparison group *p* = .801, treatment *p* =

.096. Since the data were fairly normally distributed, *t* –test and ANOVA parametric testing was conducted.

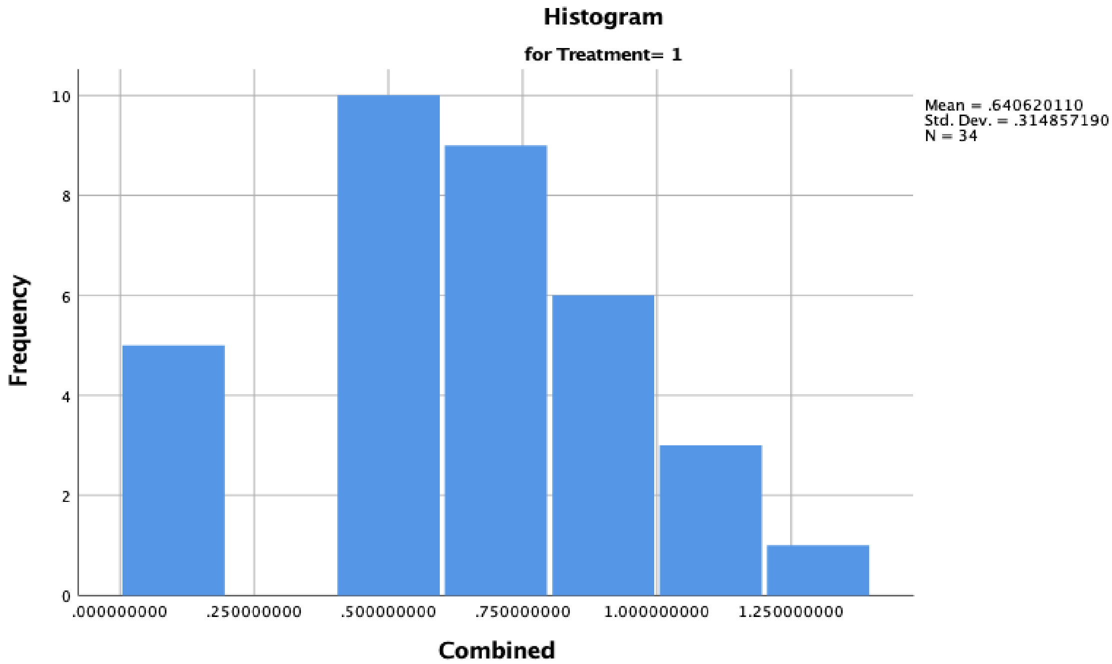

Figure 16. *Participation Standard Deviation Histogram Comparison Group*

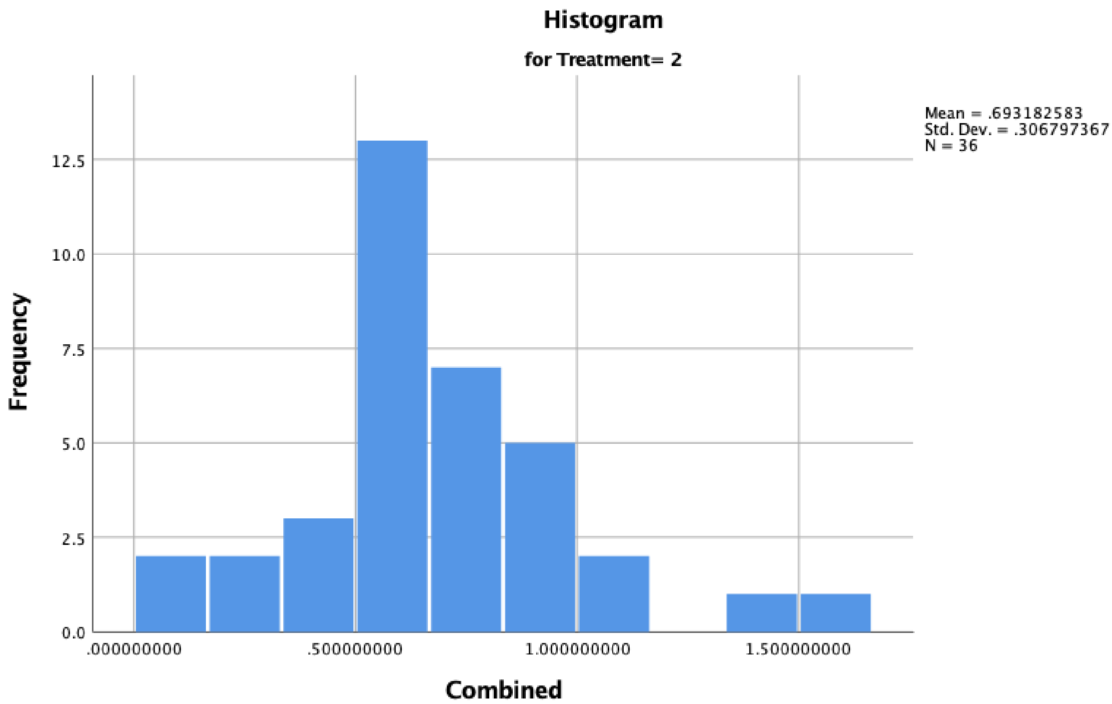

Figure 17. *Participation Standard Deviation Histogram Treatment Group*

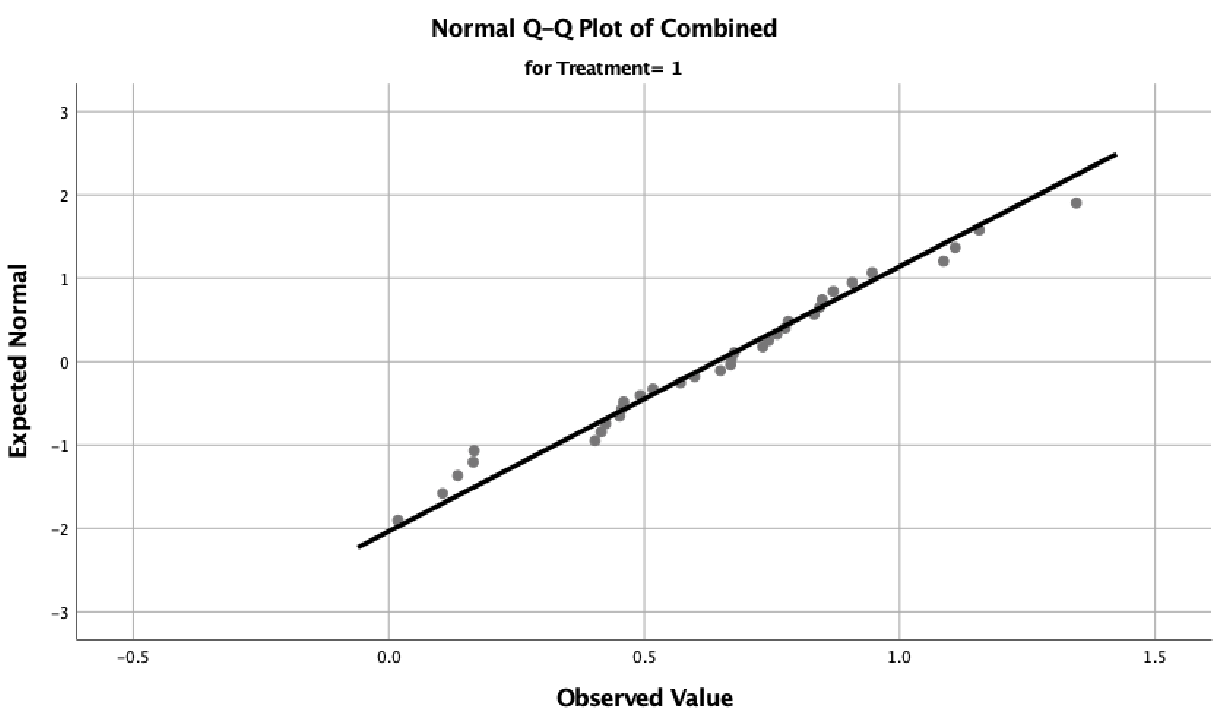

Figure 18. *Participation Standard Deviation Q-Q Plot Comparison Group*

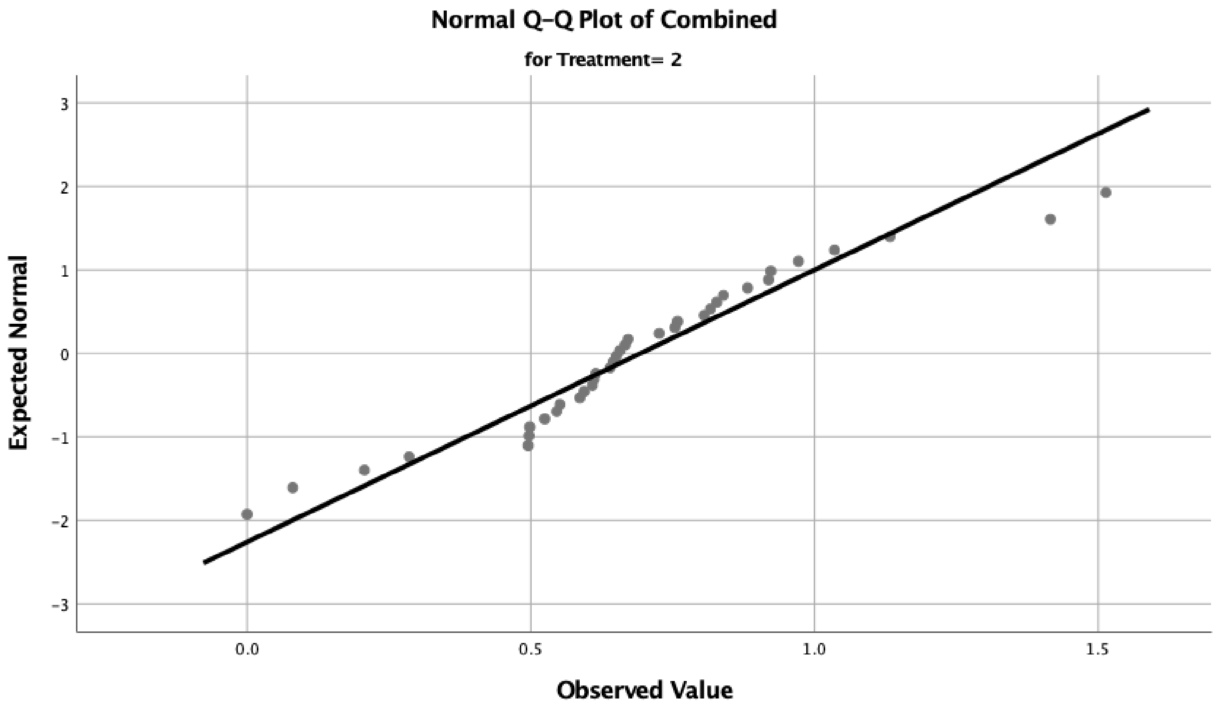

Figure 19. *Participation Standard Deviation Q-Q Plot Treatment Group*

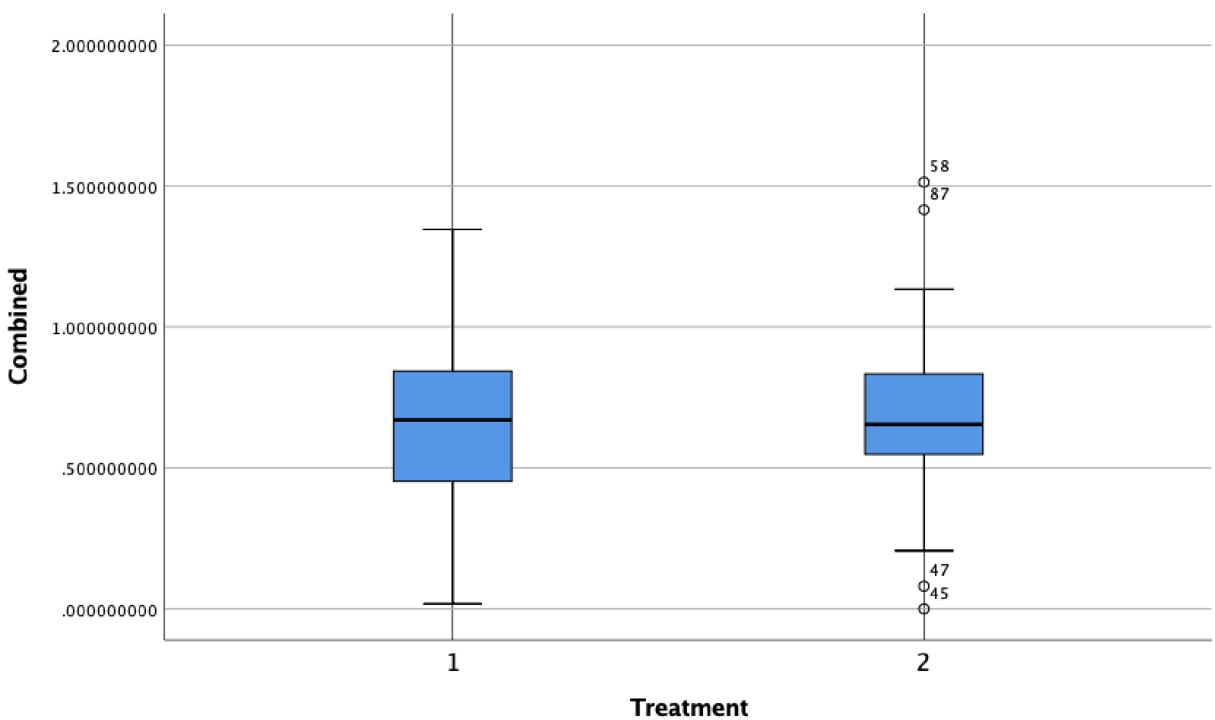

Figure 20. *Participation Standard Deviation Box Plot, 1 = Comparison, 2 = Treatment*

4.6 Sample Characteristics Satisfaction Standard Deviation

A Shipiro-Wilk's test (*p* > .05), (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that the satisfaction mean scores were approximately normally distributed for both treatment and comparison groups. The test also showed a skewness of 0.037(*SE* = 0.403) and a kurtosis of 0.125(*SE* = 0.788) for the treatment group and a skewness of 0.797(*SE* = 0.393) and a kurtosis of 0.839(*SE* = 0.768) for the comparison group(Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011). Figures 21 - 25 present the results for the participation mean histograms, normal Q-Q plots and box plots, respectively. The results of the Shipiro-Wilk's test failed to reject the null-hypothesis that the data was normally distributed, comparison group *p* = .582, treatment *p* = .112. Since the data were fairly normally distributed, *t* –test and ANOVA parametric testing was conducted.

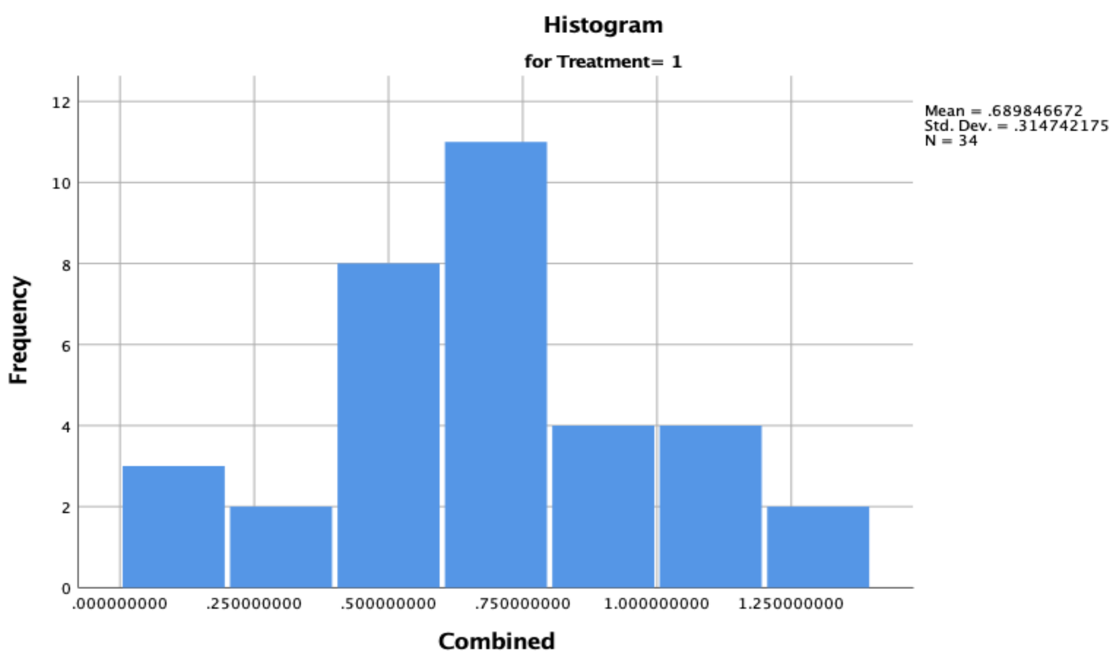

Figure 16. *Satisfaction Standard Deviation Histogram Comparison Group*

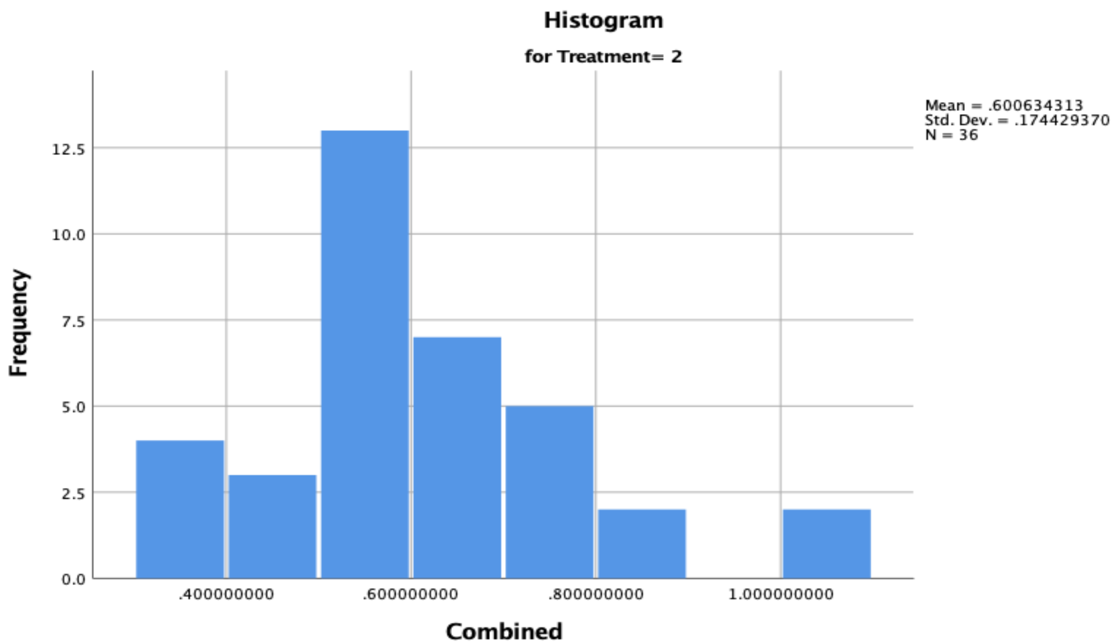

Figure 17. *Satisfaction Standard Deviation Histogram Treatment Group*

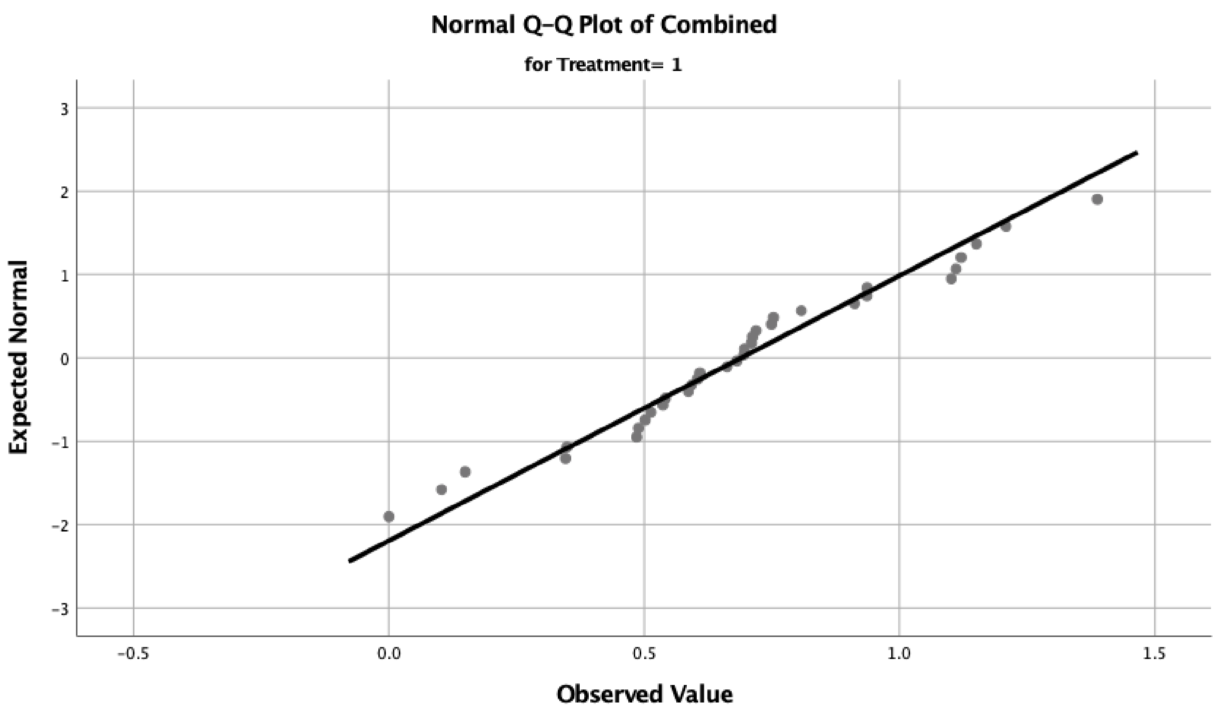

Figure 18. *Satisfaction Standard Deviation Q-Q Plot Comparison Group*

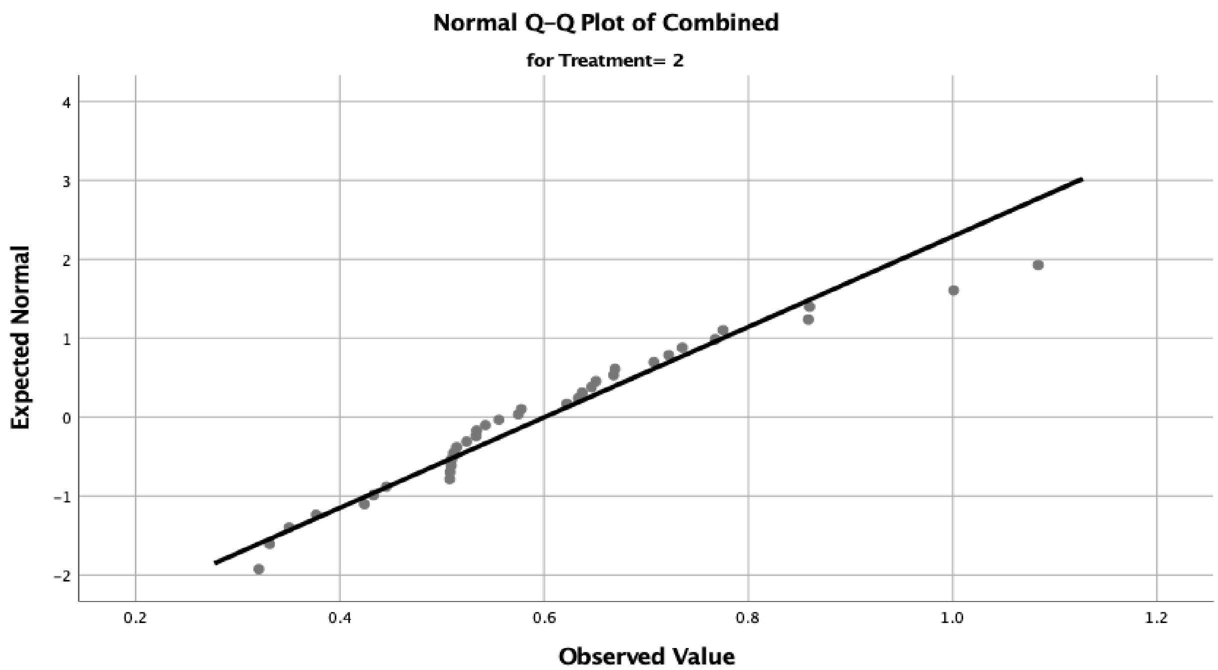

Figure 19. *Satisfaction Standard Deviation Q-Q Plot Treatment Group*

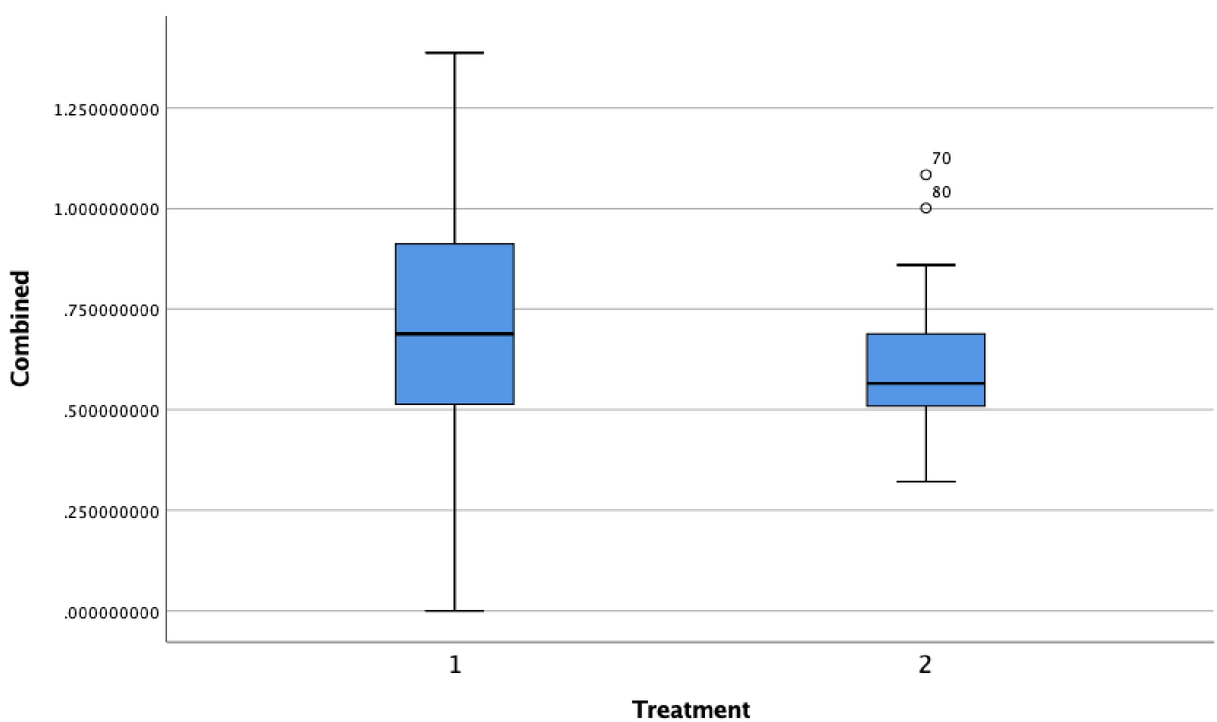

Figure 20. *Satisfaction Standard Deviation Box Plot, 1 = Comparison, 2 = Treatment*

4.7 Overall Participation and Satisfaction Comparison

F-tests were performed to measure variance equality, or inequality, of the combined mean and combined standard deviations for participation and satisfaction and overall course grades. The results of these *F*-tests determined which *t*-test, equality assumed, or not assumed, to be performed on the data. In addition to the combined mean and combined standard deviation for participation and satisfaction, *F*-tests and *t*-tests were performed on the means and standard deviations of the individual categories of "C", "I", "K", "E", "H", "Q1", "Q2", and "Q3" at each of the five phases of the study, which were Problem Definition, Ideation, Prototyping, Design Journal, and Presentation. *F*-tests and *t*-tests were also used to examine the results for Overall Course Grade.

The combined participation mean data produced neither statistically or practically different results from the comparison (M = 4.317) and treatment (M= 4.331), $t(5) = .361$. For the satisfaction combined mean data, the treatment group (M = 4.187) was neither statistically or practically different from the comparison (M = 4.176), $t(5) = -.155$, $p = .44$. Examination of the standard deviations showed that no significant results were produced for the combined satisfaction, for either the comparison (M = .686) or treatment (M = .617), $t(5) = 1.448$, $p = .093$. Combined participation standard deviations produced no significant results for the comparison (M = .666) or treatment (M = .681), t(5), $p = .284$. Tests performed on the individual categories of "C", "I", "K", "E", "H", "Q1", "Q2", and "Q3" produced no significant results.

4.8 Data Visualization with Regression Line

During the analysis of the *t*-test the researcher compiled the results into a chart to organize the data. Although the results of the *t*-test produced no significant differences in mean scores between the groups, the researcher noticed that a crossing pattern appeared to be developing in the data. To further explore this crossing pattern, the researcher graphed the data with regression lines. Representing the data visually assisted in seeing patterns that might have been lost when simply examining the numerical values of the data. In each graph, the red line represents the treatment group and the blue line represents the comparison group.

Figures 26 & 27 demonstrate the crossing pattern previously discussed in the raw data. The crossing pattern can now be seen when the two data lines cross. In both cases, once the crossing occurs the data runs almost parallel for the remainder of the study with no additional crossing of the data lines. This same crossing pattern was observed when the individual categories of “C”, “I”, “K”, “E”, “H”, “Q1”, “Q2”, and “Q3” were examined.

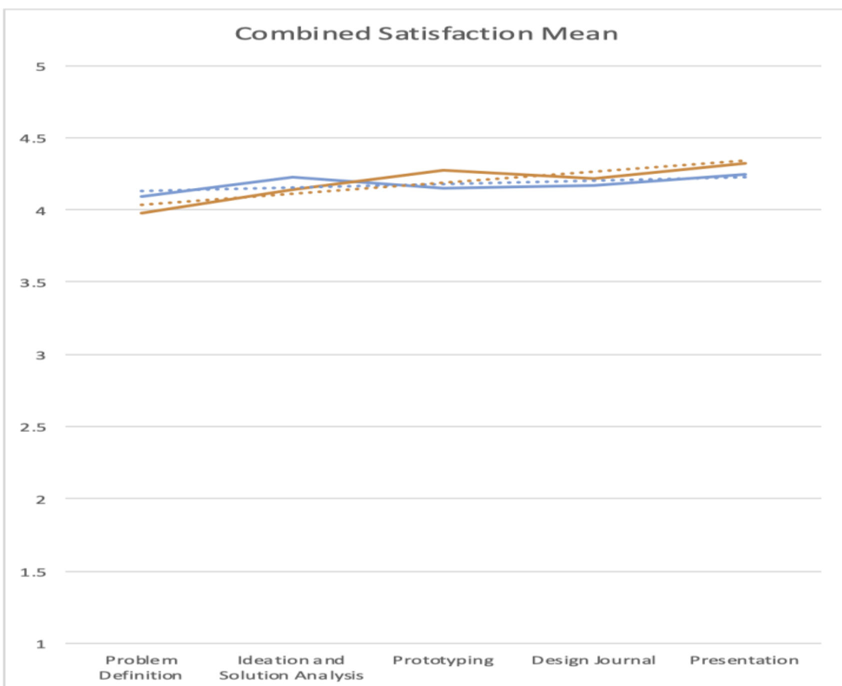

Figure 21. *Combined Satisfaction Mean Data with Regression Lines. Red Lines Represent the Treatment Group, Blue Lines Represent Comparison Group.*

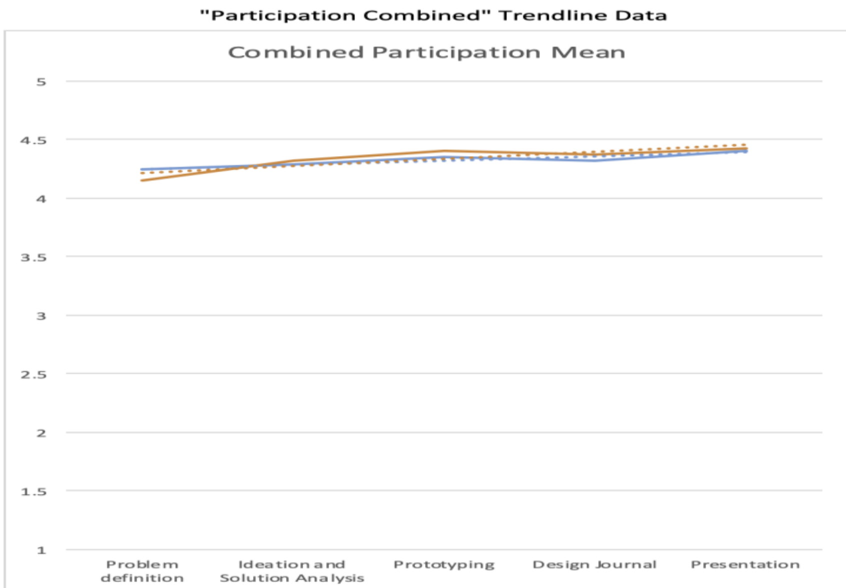

Figure 22. *Combined Participation Mean Data with Regression Lines. Red Lines Represent the Treatment Group, Blue Lines Represent Comparison Group.*

The visual results (figures 28 & 29) for the standard deviations do exhibit a crossing pattern, however the regression lines produced are almost parallel and lie on top of each other.

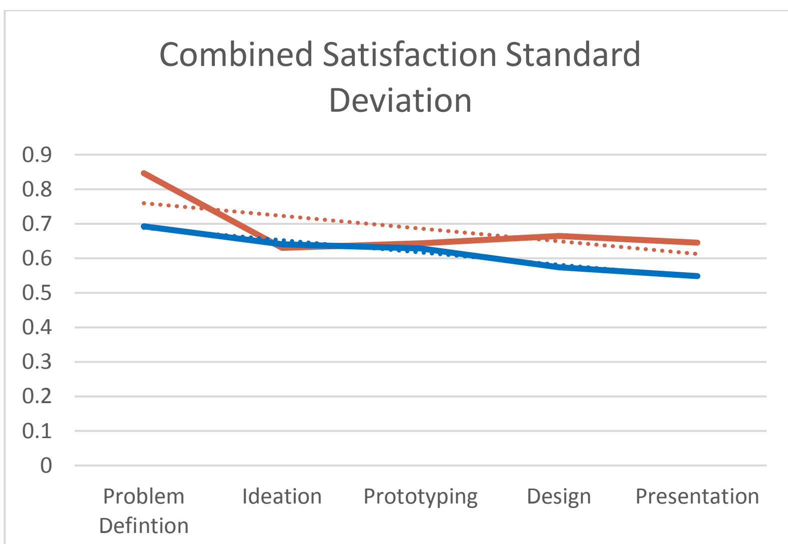

Figure 23. *Combined Satisfaction Standard Deviation with Regression Lines. Red Lines Represent the Treatment Group, Blue Lines Represent Comparison Group.*

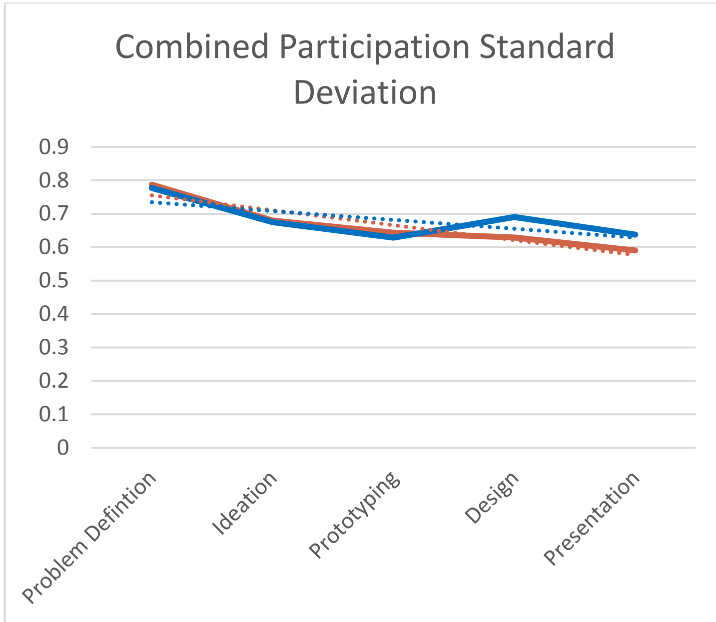

Figure 24. *Combined Participation Standard Deviation with Regression Lines. Red Lines Represent the Treatment Group, Blue Lines Represent Comparison Group.*

4.9 Analysis of Group Differences Across Time

The initial analysis of the data averaged the five distinct points in the project and did not investigate changes across time. The data in tables 2, 3, 5, & 6 suggested that an investigation into the effect time had on the data may be warranted. A repeated measures ANOVA was chosen as the analysis tool to determine if the effect of time a factor for differences in participation, or satisfaction.

Table 2 provides the descriptive statistics for the participation mean data at each of the five points of the study. In should be noted that when looking at the mean data, both groups 1 & 2 demonstrated growth over the course of the study. A one-way repeated measures ANOVA was conducted to compare the effect of time on participation during the five measured points of the study. A Wilks' Lambda test revealed that the main effect of time showed significant differences between one, or more, time points, Wilks Lambda = .649, $F(4, 65) = 8.779$, $p = <.001$. However, related to the research question, the interaction between time and group was not significant, Wilks' Lambda = .945, $F(4, 65) = .947$, $p = .443$.

Table 2. *Particpation Mean Descriptive Statistics. 1 = Comparison, 2 = Treatment*

	Treatment	Mean of the Standard Deviation	Standard Deviation of the Standard Deviations	N
Problem Definition	Comparison	4.240	0.469	34.000
	Treatment	4.152	0.388	36.000
	Total	4.194	0.428	70.000
Ideation and Solution Analysis	Comparison	4.289	0.500	34.000
	Treatment	4.289	0.342	36.000
	Total	4.289	0.423	70.000
Prototyping	Comparison	4.346	0.512	34.000
	Treatment	4.374	0.362	36.000
	Total	4.361	0.438	70.000
Design Journal	Comparison	4.306	0.537	34.000
	Treatment	4.337	0.360	36.000
	Total	4.320	0.452	70.000
Presentation	Comparison	4.378	0.515	34.000
	Treatment	4.389	0.383	36.000
	Total	4.384	0.448	70.000

Table 3 provides the descriptive statistics for the satisfaction mean data at each of the five points of the study. It should be noted that when looking at the mean data, both groups 1 & 2 demonstrated growth over the course of the study. A one-way repeated measures ANOVA was conducted to compare the effect of time on satisfaction during the five measured points of the study. A Wilks' Lambda test revealed that the main effect of time showed significant differences between one, or more, time points, Wilks' Lambda = .735, $F(4, 65) = 5.846$, $p = <.001$. In addition, the interaction between time and group was significant, Wilks' Lambda = .865, $F(4, 65) = 2.533$, $p = .049$. This test showed that a significant difference existed at one, or more points in time, but does not at which point, or points the difference occurs. In order to determine at what point in time the effect took place, a test of within-subjects contrasts was examined.

Table 3. *Satisfaction Mean Descriptive Statistics*

	Treatment	Mean of the Standard Deviation	Standard Deviation of the Standard Deviations	N
Problem Definition	Comparison	4.091	0.490	34.000
	Treatment	3.974	0.630	36.000
	Total	4.031	0.565	70.000
Ideation and Solution Analysis	Comparison	4.251	0.597	34.000
	Treatment	4.153	0.513	36.000
	Total	4.201	0.554	70.000
Prototyping	Comparison	4.099	0.648	34.000
	Treatment	4.250	0.407	36.000
	Total	4.177	0.539	70.000
Design Journal	Comparison	4.133	0.651	34.000
	Treatment	4.204	0.497	36.000
	Total	4.170	0.574	70.000
Presentation	Comparison	4.207	0.625	34.000
	Treatment	4.283	0.498	36.000
	Total	4.246	0.560	70.000

Examination of the within-subjects contrasts results (table 4) indicated that there was a significant difference in the mean scores between the Ideation and Prototyping (p = .012) phases of the study.

Table 4. *Satisfaction Tests of Within-Subjects Contrasts*

Source	Time	*p*-value
Time*Treatment	Problem Design vs Ideation	0.855
	Ideation vs Prototyping	0.012
	Prototyping vs Design Journal	0.349
	Design Journal vs Presentation	0.932

Table 5 provides the descriptive statistics for the participation standard deviation data at each of the five points of the study. This standard deviation illustrates how consistent the responses are across teammates. A one-way repeated measures ANOVA was conducted to compare the effect of time on the mean of the participation standard deviation during the five measured points of the study. A Wilks' Lambda test revealed that the main effect of time showed significant differences between one, or more, time points, Wilks Lambda = .559, $F(4, 65)$ = 12.805, p = <.001. However, related to the research question, the interaction between time and group was not significant, Wilks' Lambda = .932, $F(4, 65) = 1.181$, $p = .327$.

Table 5. *Participation Standard Deviation Descriptive Statistics*

	Treatment	Mean of the Standard Deviation	Standard Deviation of the Standard Deviations	N
Problem Definition	Comparison	0.787	0.306	34.000
	Treatment	0.777	0.296	36.000
	Mean	0.782	0.299	70.000
Ideation and Solution Analysis	Comparison	0.644	0.344	34.000
	Treatment	0.666	0.285	36.000
	Mean	0.656	0.313	70.000
Prototyping	Comparison	0.613	0.323	34.000
	Treatment	0.643	0.353	36.000
	Mean	0.628	0.336	70.000
Design Journal	Comparison	0.590	0.375	34.000
	Treatment	0.724	0.385	36.000
	Mean	0.659	0.383	70.000
Presentation	Comparison	0.568	0.378	34.000
	Treatment	0.655	0.388	36.000
	Mean	0.613	0.383	70.000

Table 6 provides the descriptive statistics for the satisfaction standard deviation data at each of the five points of the study. A one-way repeated measures ANOVA was conducted to compare the effect of time on satisfaction standard deviation during the five measured points of the study. A Wilks' Lambda test revealed that the main effect of time showed significant differences between one, or more, time points, Wilks Lambda = .785, $F(4, 65) = 4.463$, $p = .003$. However, related to the research question, the interaction between time and group was not significant, Wilks' Lambda = .910, $F(4, 65) = 1.613$, $p = .182$.

Table 6. *Satisfaction Standard Deviation Descriptive Statistics*

	Treatment	Mean of the Standard Deviation	Standard Deviation of the Standard Deviations	N
Problem Definition	Comparison	0.846	0.398	34.000
	Treatment	0.693	0.349	36.000
	Mean	0.767	0.379	70.000
Ideation and Solution Analysis	Comparison	0.592	0.352	34.000
	Treatment	0.614	0.233	36.000
	Mean	0.603	0.295	70.000
Prototyping	Comparison	0.694	0.381	34.000
	Treatment	0.571	0.303	36.000
	Mean	0.631	0.346	70.000
Design Journal	Comparison	0.662	0.373	34.000
	Treatment	0.584	0.207	36.000
	Mean	0.622	0.300	70.000
Presentation	Comparison	0.654	0.384	34.000
	Treatment	0.542	0.249	36.000
	Mean	0.597	0.324	70.000

4.10 Overall Course Grade

The results for the overall grade when analyzed using t-test produced no significant results between the comparison and treatment groups. A Shipiro-Wilk's test rejected the null-hypothesis that the overall course data was normally distributed, comparison group $p = <.001$, treatment $p = <.001$. After confirming with the non-parametric Mann-Whitney test confirmed that there was not a significant difference (*p* = .152) between comparison and treatment course grades, the researcher chose to report the more commonly used t-test.

4.11 Summary

Ten sections of Tech12000, *Design Thinking in Technology*, students were divided into a treatment group of five sections and a comparison group of five sessions. These groups were further divided into teams of four to five students. Data were collected at five intervals throughout the study. Test performed on this data showed that there were no significant results for participation mean, participation standard deviation, satisfaction standard deviation and overall course grade, however significant results between the Ideation & Solution Analysis and Prototyping were produced for satisfaction mean data (p = .012).

CHAPTER 5. CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

5.1 Introduction

Teams have been around for a significant period of time. While the days of teams banding together for survival may not be as prevalent today as in the past, one can still find examples today, including military, industry and education. The formation of teams can be seen in our entertainment - think of any sports team, in industry - think assembly lines, and the academic world - think collaborative learning. This study utilized a quasi-experimental design to examine teams in an academic setting, specifically the Purdue University class Tech12000, *Design Thinking in Technology*.

Ten sections of Tech12000 participated in this study, with five sections acting as a comparison group and five sections assuming the role of treatment group. The study focused on two different types of team formation during the final project of the class. Instructor/student selected teams were the comparison group, and CATME Team Maker generated teams were the treatment group. The CATME Team Maker generated teams were formed using six criteria that research supported as being a factor, or quality, of a team dynamic. These criteria were Gender, Age, Leadership Preference, Leadership Role, Writing Skills, and Class Year. The researcher had CATME Team Maker group similar responses for the criteria of Leadership Preference, all other criteria had dissimilar responses grouped. Subjects were asked to report, at five time points throughout the project, their satisfaction and participation. Satisfaction consisted of three statements: I am satisfied with my present teammates[Q1], I am pleased with the way my teammates and I work together[Q2], and I am very satisfied with working in this team[Q3]. Participation consisted of five statements: Contributing to the Team's Work "C", Interacting with Teammates "I", Keeping the Team on Track "K", Expecting Quality "E", Having Related Knowledge Skills, and Abilities "H". All of the statements asked the students to provide a ranking on a scale of 1 – 5, where one represented a low score (minimal contribution/satisfaction) and 5 represented a high score (high levels of contribution/satisfaction).

The overarching research questions driving this study were:

1. What is the impact of team formation on team member contribution, satisfaction and end of course grades?

2. Does team formation influence perceived consistency of team member contribution and satisfaction with in the team.

Five specific research questions guided this study:

Research question 1a: What is the impact of team formation on perceived team member contribution?

Research question 1b: What is the impact of team formation on team member satisfaction?

Research question 1c: What is the impact of team formation on end of course grades?

Research question 2a: Does team formation impact perceived consistency of team member contribution across team members?

Research question 2b: Does team formation impact perceived consistency in team member satisfaction across team members?

While attempting to answer these questions the data analysis was initially focused on strictly *t*-tests. The *t*-tests indicated there were no differences in mean scores of participation and satisfaction between the treatment and comparison groups. However, during the analysis, the researcher noticed crossing patterns in that seemed to be developing between the comparison and treatment data. The data was then graphed with regression lines to further explore this crossing pattern in visual form. After examination, the crossing pattern was evident in every data set. The fact that the crossing pattern occurred in each comparison and treatment data set influenced the researcher to perform a repeated measures ANOVA on the data.

In order to answer question 1, *What is the impact of team formation on perceived team member contribution?*, the study looked at the mean score of the participation scores combined at each of the five time points. The ANOVA did show that time was a significant factor, Wilks Lambda = .649, $F(4, 65) = 8.779$, $p = <.001$, but for the purpose of this study there was no significant interaction between time and groups, Wilks' Lambda = .945, $F(4, 65) = .947$, $p = .443$. The method of team formation did not significantly impact student participation or participation changes across time. It should be noted that the initial mean scores for the comparison group was higher than the mean scores for the treatment group at the beginning of the project, but had switched between the Ideation and Prototyping points in the project so that the treatment group ended the project with higher mean scores than the comparison group. This suggests that although there was not a significant difference between the comparison and treatment groups it appears that the CATME Team Maker software had some influence on the treatment group, but that influence was slight and could have been chance and chance alone. Although the influence was not significant, the crossing, or switching pattern occurred in research questions 1, 2, 4, & 5 at the same point, between Ideation and Prototyping.

In order to answer question 2, *What is the impact of team formation on team member satisfaction?*, the study looked at the mean score of the satisfaction scores combined at each of the five time points. The ANOVA did show that time was a significant factor, Wilks Lambda = .735, $F(4, 65) = 5.846$, $p = <.001$. The ANOVA also showed that there was significant difference occurring at one or more time points, Wilks' Lambda = .865, $F(4, 65) = 2.533$, $p = .049$. A within-subject contrast showed that the significance occurred between the Ideation and

Prototyping time points. The method of team formation did impact student satisfaction and satisfaction across time. It should be noted that the initial mean scores for the comparison group was higher than the mean scores for the treatment group at the beginning of the project, but had switched between the Ideation and Prototyping points in the project so that the treatment group ended the project with higher mean scores than the comparison group. This suggests that the CATME Team Maker software influenced the perception of participation and satisfaction of the treatment group as the project progressed, but that influence was slight and could have been chance and chance alone. Although the influence was not significant, the crossing, or switching pattern occurred in research questions 1, 2, 4, & 5 at the same point, between Ideation and Prototyping.

Question 3, *What is the impact of team formation on end-of-course grades?*, used a t-test and produced no significant results between the two groups for overall course grades ($p = .124$). The method of team formation did not significantly impact student overall course grades. There was a violation in normality requiring a non-parametric test. A Mann-Whitney test confirmed that there was not a significant difference ($p = .152$) between the comparison and treatment end-of-course grades. The researcher chose to report the more common parametric t-test results.

Question 4, *Does team formation impact perceived consistency of team member contribution across team members?*, used the ANOVA to look at the standard deviations of the response at the five time points. The results showed that the effect of time was significant, Wilks Lambda = .559, $F(4, 65) = 12.805$, $p = <.001$. However, related to the research question, the interaction between time and group was not significant, Wilks' Lambda = .932, $F(4, 65) = 1.181$, $p = .327$. The method of team formation did not significantly impact differences in perceived contribution or perceived contribution across time. It should be noted that the initial mean scores for the comparison group was higher than the mean scores for the treatment group at the beginning of the project, but had switched between the Ideation and Prototyping points in the project so that the treatment group ended the project with higher mean scores than the comparison group. This suggests that although there was not a significant difference between the comparison and treatment groups it appears that the CATME Team Maker software had some influence on the treatment group, but that influence was slight and could have been chance and chance alone. Although the influence was not significant, the crossing, or switching pattern occurred in research questions 1, 2, 4, & 5 at the same point, between Ideation and Prototyping.

Question 5, *Does team formation impact perceived consistency in team member satisfaction across team members?,* used the ANOVA to look at the standard deviations of the response at the five time points. The results showed that the effect of time was significant, Wilks Lambda = .785, $F(4, 65) = 4.463$, $p = .003$. However, related to the research question, the interaction between time and group was not significant, Wilks' Lambda = .910, $F(4, 65) = 1.613$, $p = .182$. The method of team formation did not significantly impact differences in perceived satisfaction or perceived satisfaction across time. It should be noted that the initial mean scores for the comparison group was higher than the mean scores for the treatment group at the beginning of the project, but had switched between the Ideation and Prototyping points in the project so that the treatment group ended the project with higher mean scores than the comparison group. This suggests that although there was not a significant difference between the comparison and treatment groups it appears that the CATME Team Maker software had some influence on the treatment group, but that influence was slight and could have been chance and chance alone. Although the influence was not significant, the crossing, or switching pattern occurred in research questions 1, 2, 4, & 5 at the same point, between Ideation and Prototyping.

5.2 Potential Issues with Validity

This research is like other research studies and is subject to threats of internal and external validity. Areas that the researcher feels may be present in this study are:

1. Extraneous, or Confounding Variables – Due to the complex nature of human subjects, the researcher could not account for, or include all possible variables that the subjects might possess during team formation. Specifically, one, or more, of the six variables utilized in this study might be the wrong variable to use during team formation.

2. Comparison Group Team Formation – Due to now knowing how the student-selected teams were formed, specifically, what criteria each team utilized during the decision process, the student process could have been very similar to the CATME Team Maker process in making sure that the team had a variety of talents.

3. Subject Selection – The subjects selected what class section they would enroll in through the university. The researcher could not control the equivalency of the subjects in each course section.

4. Population Validity – The researcher could not control the population make-up of the course sections, due to the subjects' self-selection of what section the participants enrolled in.

5. Peer Pressure – The results from the CATME Bars are visible to members of the team. Even though identifying characteristics are removed before allowing the subjects to view the CATME Bars results, there could be pressure for everyone in the group to give higher scores.

6. Limited Response Categories – With satisfaction being comprised of three statements and participation comprised of five questions, there is the possibility that additional items could be added, or replace, existing items to better measure subject perceptions of satisfaction and participation.

7. Personal Bias – Conflicts, or bias, within the teams that would cause one, or more, groups members to maliciously score one, or more, team members low ratings.

5.3 Implications for Education

In the educational classroom, collaborative learning is an accepted educational practice. Educators have used a variety of methods in order to group students for the collaborative learning. Grouping students of like ability (Wilkinson, Penny, & Allin, 2015), across abilities (Hallam, 2002, p. 24), software that focuses on students' problem solving style (Schroth, et. al., 2015), instructor selected, and student selected are examples of methods that educators have utilized to form collaborative learning teams. The CATME Team Maker software used in this study was shown to produce results that were at least comparable to instructor/student generated teams. In fact, the results demonstrated at least slightly higher scores in participation and satisfaction versus instructor/student generated teams. The process of generating teams with CATME Team Maker has the students fill out a brief survey, eliminating the need for the instructor to manually gather team making information, the instructor could have students fill out one survey at the beginning of the year and generate any teams needed from this survey. Having the instructor only gather information one time and then generate any teams needed from this data, the instructor could reasonably save time in team generation and utilize this time for other activities. This is possible because the instructor can choose which factors to include, or not include, when generating teams based on the project. In addition, the CATME Team Maker software allows instructors to control which students should, or should not work together, and if desired, create teams that have individuals who have not worked together on previous projects.

The researcher for this study was also an instructor for two sections, one comparison section and one treatment section, of the Tech12000, *Design Thinking in Technology*, class. Researcher observations throughout the study confirmed that the actions of the teams mirrored what the crossing pattern in the data showed. Treatment teams were more hesitant to engage at the beginning of the project versus the comparison teams. As the project progressed the treatment teams were able to engage more quickly, and appeared to be more focused, in the various activities of the project than the comparison teams. The team members of the treatment group appeared to participate at a higher level with each team member bringing a different talent to the team. The researcher also observed a higher level of satisfaction in the treatment teams, which could be due to each team member being able to contribute at a higher level. The researcher has taught previous sections of the Tech12000, *Design Thinking in Technology*, class, where the researcher generated teams using methods similar to the instructor/student generated teams in this study. When using these methods, the researcher was spent approximately one hour to generate the teams, which means the researcher had to set apart this time outside of class, or essentially use an entire class meeting to generate teams. When using the CATME Team Maker software, the researcher spent approximately fifteen minutes setting up the software and generated teams in under five minutes. Once the CATME Team Maker software had been setup, the researcher could generate multiple sets of teams for different projects, within a few minutes. The Tech12000, *Design Thinking in Technology*, project covered fifteen meetings, which means that if the researcher did not have to spend one class meeting generating teams, a time savings of almost seven percent, that time could be spent engaging in educational activities. Educators who teach high school and use collaborative learning groups could reap even larger time saving returns due to the length of the school year. Every five projects that the CATME Team Maker software was utilized would translate into a full week of educational opportunities created based on a high school period of 45 minutes and the time saved manually creating teams. A high school teacher that during the course of the school year uses twelve collaborative learning projects could potentially reclaim over two weeks of educational time. The flexibility and potential time savings offered from the CATME Team Maker software, and the ability to produce at least comparable teams, are traits that warrant educators looking at the CATME Team Maker software to enhance the future educational opportunities for their students.

5.4 Implications for Industry

"The restructuring and realignment of business and industry reflect the reinvented concept of teamwork" (Scarnati, 2001, para. 24). Scarnati further elaborated, "Teamwork creates commitment because everyone must accept ownership and responsibility for the success or the failure of a project" (Scarnati, 2001, para, 13). This study can be applied to industry in two ways. First, the study demonstrated, although not significantly, slightly higher levels of perceived contribution, perceived satisfaction, and overall grades(output) from the computer generated teams. Secondly, this suggests the process of using the CATME Team Maker software shows promise of a time savings in team generation, a time savings for industry could be realized. Management would not have to create spreadsheets, or other organizational methods, as the computer software eliminates the need for such methods. The higher levels of satisfaction, participation, and overall output (grades) is in line with Scarnati who stated that, "everyone must accept ownership and responsibility for the success or the failure of a project” (Scarnati, 2001, para, 13). The reduction of time could allow for management to devote the time saved on other tasks.

5.5 Future Research

Future research in computer software generated teams should focus on addressing the limitations found in this study. Specifically, future researchers could further examine the six variables utilized for this study to determine if deletion of existing, or addition of other categories, would increase the effectiveness of computer software generated teams. Additions of course specific skills, such as ideation, CAD capabilities, and previous course work would be good launching points for this research. Secondly, future researchers could expand the broad response choices from the current five for participation and three for satisfaction to include more specifically focused questions and potentially isolate areas that might be significantly impacted by using computer software to generate teams.

5.6 Summary

The overarching research questions driving this study were :

1. What is the impact of team formation on team member contribution, satisfaction and end-of-course grades?
2. 2. Does team formation influence perceived consistency of team member contribution and satisfaction with in the team.

The Five specific research questions that guided this study:

Research question 1a: What is the impact of team formation on perceived team member contribution?

Research question 1b: What is the impact of team formation on team member satisfaction?

Research question 1c: What is the impact of team formation on overall course grades?

Research question 2a: Does team formation impact perceived consistency of team member contribution across team members?

Research question 2b: Does team formation impact perceived consistency in team member satisfaction across team members?

This study was able to answer the five research questions and showed that the CATME Team Maker software generated teams were at least as successful as instructor/student generated teams. In fact, the treatment group was able to produce at least slightly higher mean scores in all categories for participation and satisfaction. This, coupled with the potential time savings the CATME Team Maker computer software provides, warrants additional studies to further isolate, or generate, additional criteria that will lead to better team generation from the computer software.

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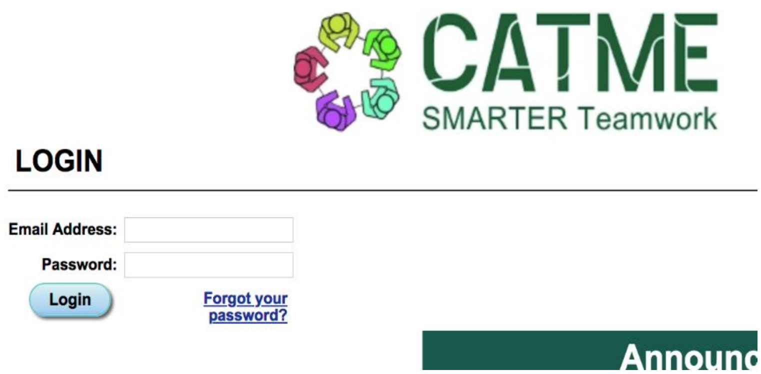
APPENDIX

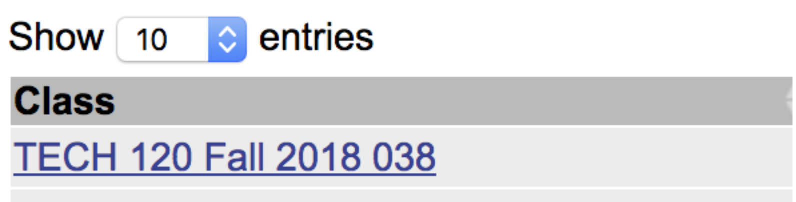
CATME Instructions for Instructors

Use the following procedure to create teams in CATME for project 3. If you are teaching multiple sections, please select one section that will create teams on their own (student selected), and another section that will have team created by CATME (computer generated). I will leave the section choice to you. The ideal is to have each instructor have sections that represent both methods. You will be using the same data that was used to create the CATME calibration from project 2.

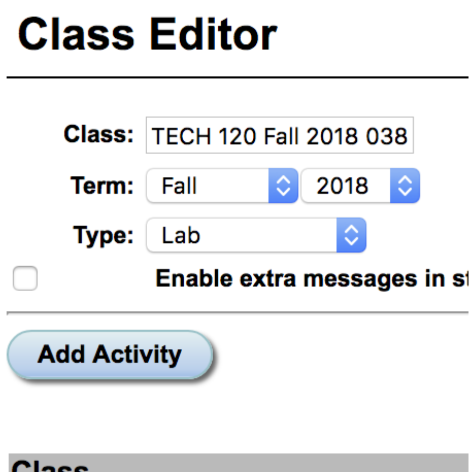
1 Sign in to your CATME account.



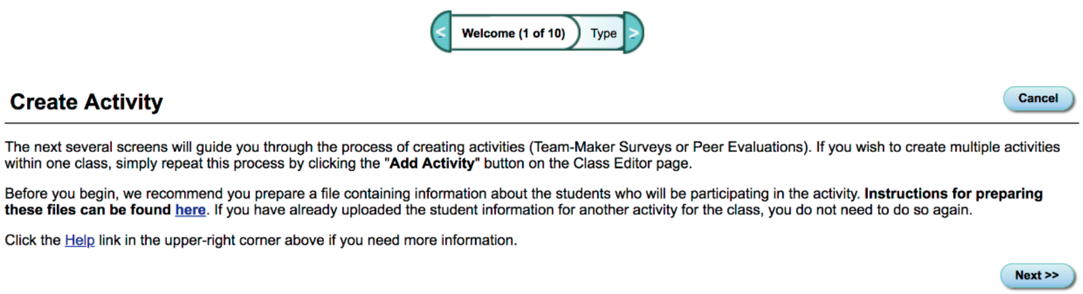
2 Select which section you will be using CATME for team formation by selecting that section under the class heading.



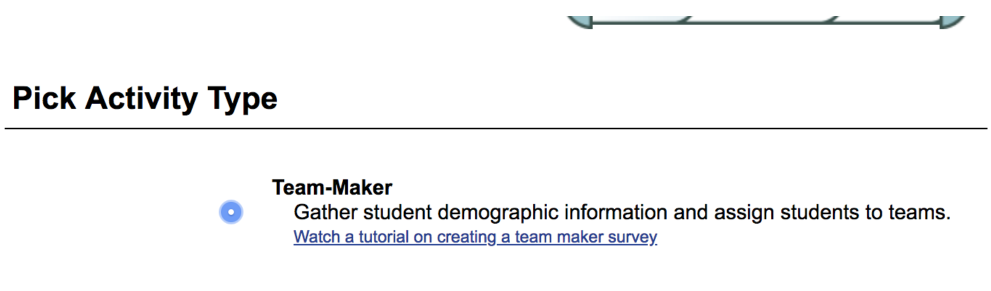
3 Select Add Activity



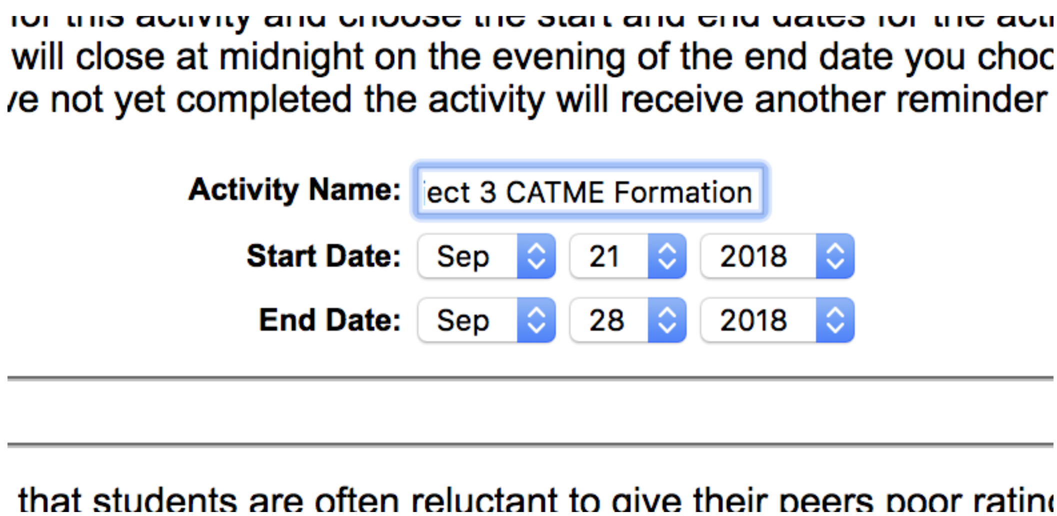
4 Select Next on the first screen. (There are 10 sections to complete)



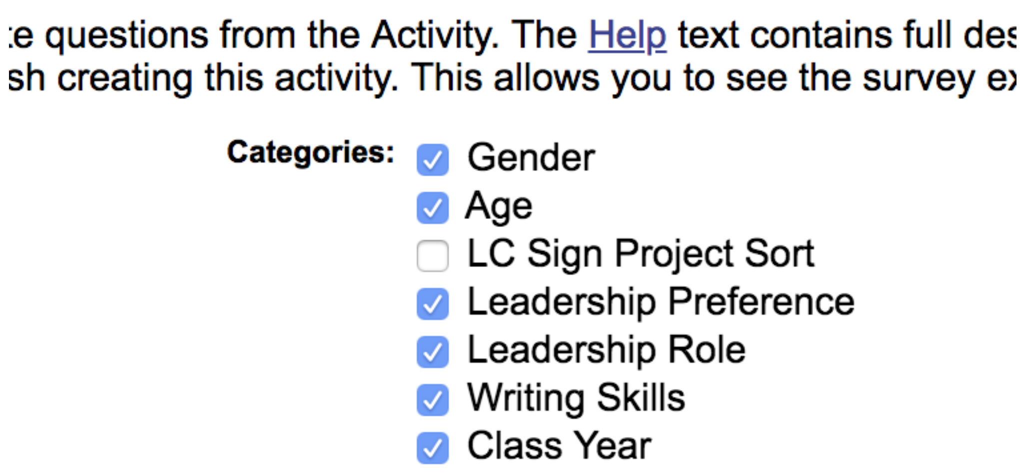
5 Select Team Maker, then Next on screen 2



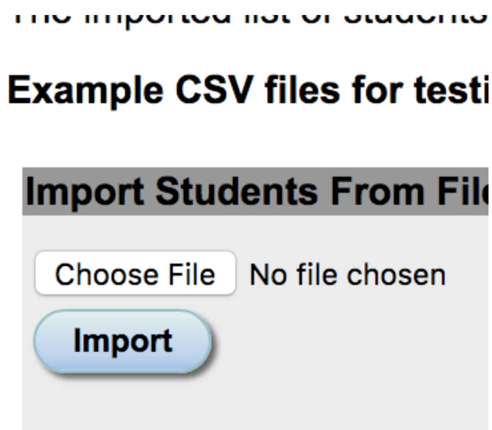
6 For Activity Name please use Project 3 CATME Formation. Refer to your individual sections to determine the start and end date window. When you have completed these parts, select Next. Change Rater Practice to No Practice, if needed, and make sure Limit Entry is not checked. Select Next.



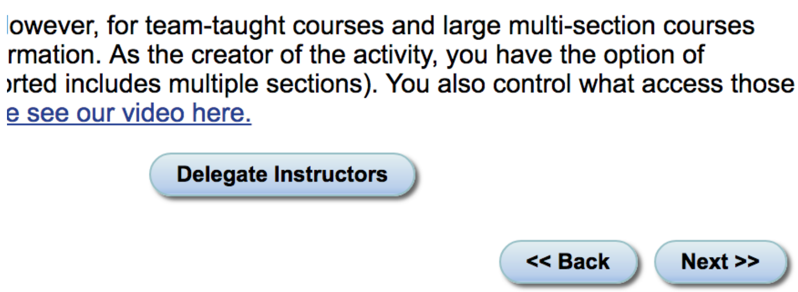
7 Verify that the following categories, and only the following categories are selected, then select Next.



8 Choose the file used in project 2 and Import, then select Next.

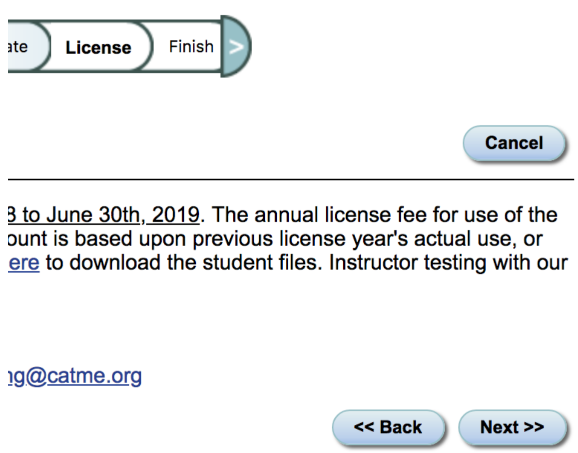


9 No changes are needed on Delegate screen, select Next.

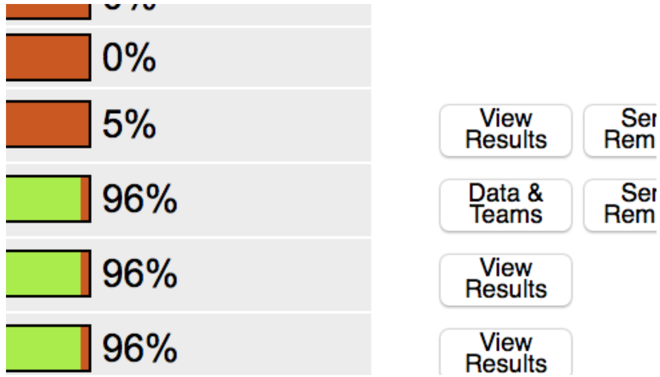


10 No changes are needed on the License screen, select Next.

11 Select Done.

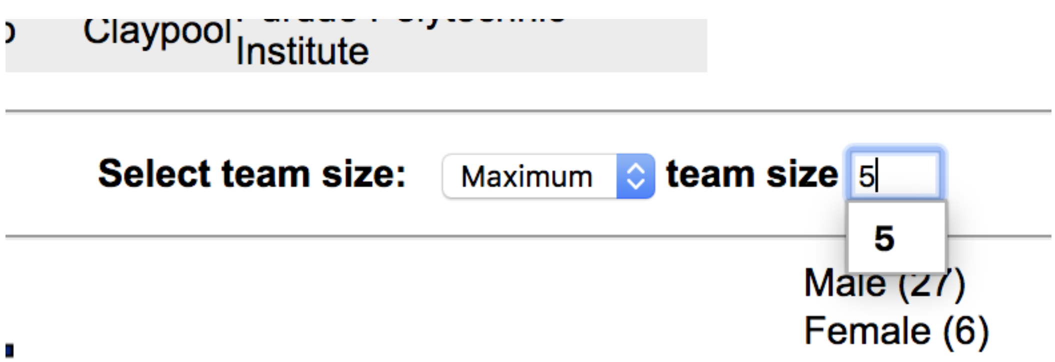


12 After the students have completed the survey, select Data & Teams.



13 Select Make Teams.

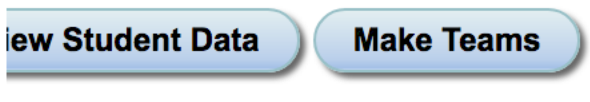
14 Set team size to Maximum, team size to 5 (if 40, or less, students in section, team size to 6 if more than 40 in section).



15 For the following categories select the far left option, Gender, Age, Leadership Style, Writing Skills, & Class Year.

16 For Leadership Preference, select the far right option.

17 Select Make Teams.



18 Save Teams.

19 Inform the students which group they are in during class and have them move into their respective groups and sign up for their group. Alternatively, you can assign the student to groups in Blackboard.