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# Harmony and Conflict Prediction of Space IQP Teams Using MBTI® Personality Descriptors

An Interactive Qualifying Project Report
Submitted to the Faculty
of the
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by


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# 1 Abstract

This study looks at the relationship between cognitive diversity among team members, as measured by the MBTI and group performance. There were 44 WPI students formed into 14 IQP teams working concurrently on space-related topics. Group dynamics (leadership, conflict, division of labor and performance) were covered by a student questionnaire administered in the first third of the project and again toward the end. The results indicated that diversity was related to the student but not the advisor rating of how things went. The advisor ratings were most affected by whether there were certain “anchor” types of students on the team.

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# 3 Introduction

## *3.1 The Myers-Briggs Type Indicator® and our Study*

Numerous studies of group dynamics have been performed using the Myers Briggs Type Indicator (MBTI). MBTI research has been used to advance the study leadership, interpersonal and family relationships, learning styles, as well as charting a suitable career path. Our particular study presents a natural experiment opportunity to test several hypotheses due, in large part, to the circumstances surrounding the groups being studied.

We were presented with the opportunity to study fifteen separate project teams completing projects on similar topics that ran concurrently. The majority of these teams consist of three members. This is a natural experiment, in that the groups were not specifically created for the purpose of this study yet are subject to manipulation to some degree. As a result we are presented with the opportunity to focus on group dynamics and creating a set of hypothesis rather than setting up the experimental conditions.

Another difference between the project teams that we will be focusing on and the project teams focused on in most prior studies is that the current project teams have very broad IQP topics to work with rather then a specifically defined MQP topic that is managed more narrowly. Additionally, most current team members lack prior knowledge regarding the projects that are being undertaken. Few of the students on the teams are working on projects that relate to their respective major and those that are Aerospace majors are dealing with the social implications of work in their technical area. Some group members chose to work together on their projects, while other groups were assigned randomly or based on similar interests. It is important to understand that all of the project teams are starting at the same point; no one group having an advantage over the other.

No study is without variables, and our independent variable focus is on the cognitive diversity of the groups. The dependent variables will be the groups' division of labor, the level of conflict expressed by the groups, and the qualitative outcome of each group's project report. We hypothesize that initial or early conflict can be beneficial to the level of excellence in a team's final product. We predict that such conflict tends to be constructive, yielding both a consensus or means and improved communication and hence greater productivity later on as is reflected in a higher quality outcome. However, there is a limit to the amount of conflict that a group can experience before the outcome of the project is jeopardized.

While we hypothesize that having cognitive diversity within each team will produce a resilient balance of people because there will be a more natural assignment of roles and there will always be someone comfortable with the task environment that comes up in a changing situation. For example, if someone who is more of a task manager works with someone who is more of a theoretical innovator, their roles within the group dynamics will naturally become defined in line with their preferences. In the past, studies comparable to ours, such as one conducted by Wilde at Stanford University, have shown that group diversity often leads to innovation. However, in those studies the groups being examined were conducting projects to be rated based on innovation standards in a mechanical engineering design competition. By contrast, the teams we will focus on are completing projects most of which require less innovation than persistence and the concerted application of time and effort.

We were able to monitor the progress of these project teams through questionnaires that were handed out at various points of the groups' progression towards their deadlines. These questionnaires were distributed to both the groups and their respective advisors. At the

conclusion of the projects the advisors were asked to assess the degree of success of their team. Based on the advisor feedback we were able to test our hypotheses.

# 4 Background / Literature Review

The Myers-Briggs Type Indicator (MBTI) is the personality specification device most commonly used around the world today. Conceived by Isabel Briggs Myers and her mother Katherine Briggs, the MBTI aims to produce a model for understanding individual personality difference and development. The concepts of the MBTI were modeled after the personality theory of Carl Jung. Jung affirms there are several ways to perceive a given situation. The psychological capacity of all individuals is comprised of a unique set of feelings towards varied stimuli. As a result, human beings react to and judge these stimuli in different manners (Myers 3). One's "mental functions" pertain to his or her perception and judgment while one's "attitude" reflects his or her direction of energy and point of reference to the peripheral world. The different ways of reacting to a variation of situations, combined with individual attitude, leads to a description of the individual (Myers 3). Myers developed and specified these ideas in her version of the MBTI system, and commented on what she had learned in her book Gifts Differing (latest version edited and published in 1995).

In recent years, more and more articles have been published about this empirically based cognitive style typology that produces sixteen psychological types. Figure 1.1 (Myers 10) shows the number of articles published that mention the MBTI, and the trend appears to be that more and more people are doing research on the different psychological types. According to the graph in 1957, a few years after Myers First edition of her "MBTI Manual" fewer than 15 articles had been written about the MBTI. By 1994 approximately 400 articles were devoted to the indicator. This significant increase in interest has helped progress the field of studying psychological types significantly to the point where there are now three editions of Myers' MBTI Manual. There

have been at least 11 revisions of the MBTI. Some revisions have to do with the actual indicator item, while others have to do with the fashion in which the test is administered and scored.

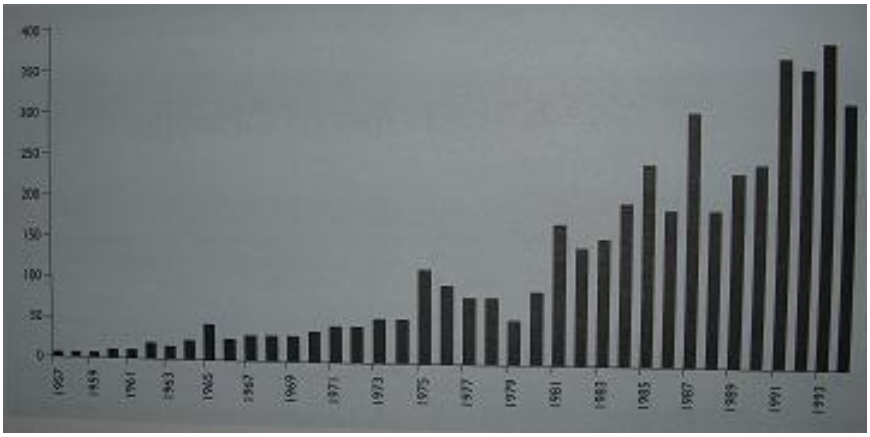

**Figure 1: Number of Articles about the MBTI published from the years 1957 – 1994**
Originally published in "MBTI applications: A decade of research on the Myers Briggs type indicator" (p.2) A.L. Hammers ed. 1996 Palo Alto CA. Consulting psychologists press. © 1996 by Consulting Psychologists press.

There are 16 possible cognitive types that the MBTI can fit a person into. These types are determined after evaluating a person on four different dichotomous dimensions. Each is independent of the other three and all four are represented by placing the respondent in one of two possible categories. The four different dichotomies, each of which is represented by one of two possible letters which help make the results of these dichotomies easier to convey to others. The first dichotomy is the extravert vs. the introvert (E-I). Jung hypothesized that people who are "extraverts" focus more on their surroundings and the people around them and derive energy (or stimulation) from them, while people who are "introverts" focus more on the internal world(and are stimulated) more by their own ideas and what concepts and images they are thinking about in their heads privately. A lot of time the introverts tend to focus better than extraverts amid distraction, but they tend to be more comfortable in less populated and noisy environments. This concept is developed further later in the paper.

The second dichotomy is the sensing-intuition (S-N) dichotomy, sometimes called the perception, (information processing) factor. The key psychological difference shown between

these two types is that the sensing types tend to use their five senses, and take the facts that they obtain with them most seriously when making decisions. By contrast the intuitive types tend to use the information that they have developed by reading between the lines, which is more subtle and less tangible, just as seriously as sensed data when making their decisions.

The third dichotomy that Jung spoke of and that Myers elaborated on was the thinking vs. the feeling (T-F). This dichotomy is designed to measure the way in which a person comes to decision. The thinking type is more likely to decide on matters as impersonally as possible, while the feeling type will make these judgments on the basis of their sense of what is best for all parties concerned, often with the goal of preserving harmony. Personal values are said to play a larger role in the decisions of feeling types, but the real difference is in allowing subjective feelings of empathy for those affected to enter into the decision making. Thinking types try to avoid all subjective influences that they consider sources of bias that will lead to flawed judgment and undercut reason and lead to inequity. Feeling types are trying to connect with those affected, see things from their standpoint and preserve social relationships. They are not dealing strictly with the facts in search of justice. This dichotomy can be summarized as the people who think with their “heads” versus the people who think with their “hearts”. This last statement while not an accurate account of people’s behavior all of the time can be used to describe the general difference in the preferences of the thinking-feeling types in terms of their style of decision making.

The last dichotomy is an indicator of which of the two previous dichotomies a person will prefer to use when dealing with the outside world. This is called the judgment-perception (J-P) dichotomy. If a person falls into the J (Judgment) group then their T-F qualities will be exhibited, whereas if a person falls into the P (Perception) group then their (S-N) qualities are what

outsiders see. The important thing to reemphasize is that this category points to how a person deals with the outside world, not their true dominant personality quality. Thus ENTP's show their intuitive side (their true dominant) to the world, but INTP's look the same on the outside, but their intuitive side is "auxiliary". The true dominant on the inside is Thinking. For our purpose, the important thing is that J's want just enough information to make a grounded decision, P's gather information for there own sake, and are endlessly curious sponges who often pretend to make a decision in dealing with others but are really keeping their options open in case new information comes in to suggest that that would be an error. Regarding plans, rules, and deadlines, P's consider them all "tentative" and subject to change. The J's are concerned with structure, certainty, and closure. They are committed to a plan, whatever idea occurs to them rules. P's on the other hand will change course late in the game putting the ability to finish on time at risk.

When the four letters of the four dichotomies that a person falls into are combined one of the 16 MBTI psychological types is created. What is important to note is that while the MBTI is an "indicator" to determine which type a person is, it is subject to error. Estimates of 85% accuracy (and there are reliability scores for each dimension to let one know if the usual level of reliability is obtainable in a given case). Myers believed that a person should be able to verify their type. Qualified users of the indicator are taught how to present a description of what the types are supposed to be getting at. As a result the verification of type is to simply sit down with an individual and ask them to verify their type, one dichotomy at a time and decide what type they are. Thus, the 15% misclassifications are dealt with in an ethical manner, and one learns a lot about oneself in the process for verification.

As previously mentioned, there are sixteen different type categories that a person can fall into. Appendix A contains a description of each of the individual types. It is presented on the Center for applications of psychological type (CAPT) website located at http://www.capt.org/mbti-assessment/mbti-overview.htm.

One reason that the MBTI has been given so much attention in the past decade and a half is due to the fact that the lessons learned from the MBTI serve as a vehicle for understanding different patterns of human activity and perception as well as the consequent interactions between people in a real world environment. This would be especially valuable on a team expected to innovate. Myers points out, “Every individual is unique. Each of us is a product of heredity and environment and, as a result, is different from everyone else. “The doctrine of uniqueness, however, gives no practical help in understanding the people whom we must educate, counsel, work with, or interact with in our personal lives” (Myers 21). While there is a basic world-wide recognition that all individuals are different, whether they were raised differently, taught differently, and had to make different life choices, many people fail to understand these differences and have difficulty working with people of varied personalities. The goal of the MBTI is to make the diversity manageable and systematic, and to teach people their own personality type, how to deal with people of a range of personality types, and how to help them learn how to work with these differences in a positive and constructive manner (Myers 21).

A second goal of the MBTI was to validate Jung’s theory of psychological types and save these ideas for real world application. Type indicators are now in common use in various facets of people’s lives such as selecting a career, dealing with stress, selecting among methods of education and the dynamics of groups ranging from a family to a research and development team. In addition, leadership style and small group dynamics are major areas of application.

The Center for Applications of Psychological Type (CAPT) have published books that hypothesis that if we look at the MBTI results of an individual and then also examine the individual's career choices, as well as there future career plans we will begin to notice a trend based on the preferences that produce a cluster of similar types that have entered these fields or careers. This is particularly evident if the individual is allowed to self select a career for themselves. Dr. Charles Martin, in his book *Looking at Type and Careers* , lists descriptions of what cognitive types tend to look for in a career. According to Dr. Martin's description of the ENTP cognitive type

> "ENTPs are most likely to find interesting and satisfying those careers that make use of their breadth of interests, their grasp of possibilities, their use of logic and analysis, and their adaptability. ENTPs are found in a variety of careers that reflect their diversity of interests, but the fields in which they work typically allow them to engage their inventive and analytical minds."

CAPT lists the possible jobs that an ENTP would most likely choose as photography, marketing, public relations, journalism/writing, engineering, computer sciences, life and physical sciences, construction, consulting, acting, arts and entertainment, and law. When looking for a career an understanding of ones MBTI type can be used to help them avoid the problems of failing to choose a career that they can potentially excel at as well as enjoy. In his writings Dr. Martin continues to speak of the problems that each type has in the job hunt itself. This is valuable knowledge that can make this process considerably less stressful and more successful.

Stress and the things that stress certain people are also hypothesized to be related to people's cognitive types. CAPT has put together a list of situations that bring anxiety to the lives of certain types. The example that is shown in figure 3 is a general list of things that make introverts most anxious, while the list shown in figure 4 is a more specific list based on all of the

four different dichotomies of an INFJ. Based on the figures it is clear that people of the introvert type do not do well in noisy areas and where there is a lot going on around them. It is also clear that the INFJ type not only is not known for doing well in noisy areas but also is particularly not suited for confrontation or in very restricted situations. Also it appears that the INFJ type does not like to deal with distractions that they consider unimportant.

**I**

noisy environments
constant supervision
leading discussions
public speaking or large group presentations
large groups or social gatherings for too long a time
frequent interruptions
too much time outside myself

**Figure 3: List of Stressful situations for an extravert**
This list was created by CAPT and can be found at the CAPT website at the following URL:
http://www.capt.org/using-type/mind-body-spirit.htm

**INFJ**

hostile, critical atmosphere
confrontation, conflict situations
politics on the job
leadership situations
working where not accepted
working where innovation is not possible
not knowing what is expected
working with those who do not honor their obligations or meet promised deadlines
highly competitive environments
insignificant interruptions
meeting new people
being in a situation where one has little or no control
noise
constant supervision

**Figure 4: List of stressful situations for an INFP**
This list was created by CAPT and can be found at the CAPT website at the following URL:
http://www.capt.org/using-type/mind-body-spirit.htm

The Myers Briggs Type Indicator is also well known for being a valuable teaching tool for students of all ages and backgrounds within reason. Obviously a person must be able to read

and understand the questions of the MBTI, also the minimum age for which detection of type is said to be accurate is a student in at least the ninth grade (or reads at that level). There are many approaches to teaching; some of which are especially appealing to a set of related MBTI profiles.

In order to establish an understanding of when to use these various approaches it is imperative to understand specific learning styles, best assessed by the one hundred and twenty six item MBTI, Form G as it is the basis for most of the existing research and a reliable determinant. The Consulting Psychologists Press has shifted to the new 100 item form M as the main product, but the problems with Form M is that inexpensive hand scoring is no longer possible and it produces a different distribution on the T-F dimension than Form G. Three quarters of females are F's on the Form M. The Form G produced a 60%-40% distribution for females and a reverse distribution for males, resulting in a 50% - 50% T-F distribution overall. On the Form M the population as a whole is 60% Feeling. The results of an MBTI instrument will establish which personality type a person is, or in other words, will reveal one's specific learning style, subject to a 15% error rate. The *GSU Master Teacher Program: On Learning Styles* presents concrete distinctions between the types in addition to suggesting which teaching approach best fits each learning style (GSU 1). One example they offer is the approach to teaching Sensing (S) students versus teaching Intuitive (N) students. Students who are "sensing" are very orientated toward detail, they want to have all the facts first, and they trust only tangible and verifiable facts. Students who are "intuitive" analyze the facts by hunting for patterns and relationships between them. They trust their gut feelings, or intuition, in order to establish the bigger abstract picture first. Then they fill in the factual details in the end. Albert Einstein is a good example of an intuitive learner where most people saw chaos he saw patterns (GSU 2).

The methods one would use teaching Sensing students and Intuitive students differ greatly. The GSU Master Teacher Program asserts that (S) sensing students prefer lectures that are organized and have a definite structure. To teach (S) sensing students it is necessary to address two main concerns while planning a lesson: the general level of information already known by the student relevant to the subject being taught, and how a connection can be drawn between what is already known and what is about to be learned. Conversely, students that are (N) intuitive prefer fewer details and rather, the main idea first at an abstract conceptual level. Presenting the subject's foremost purpose rather than systematic details will display, to intuitive learners, how various parts of the subject are interrelated; intuitive students must be presented with the "big picture" in order to formulate an understanding of the subject matter. This is very different from how a (S) sensing student needs to be taught (GSU 3).

Fortunately there is a way to teach both learning types simultaneously: the "why method" (GSU 4). The GSU report asserts that S and N students can be combined into learning groups under the "why method", because they conclude, "the intuitive student can help the sensing student to discover the theory; the sensing student can help identify and marshal the facts of the exercise" (GSU 4). The ability of sensing and intuitive profile types to work together is one of the many important connections that relate to the findings of our study.

The "why method" discussed earlier is just one example in which a mixture of different cognitive types working together can lead to greater advancement than either could achieve alone. In June 1984, Kathy Brittain White published an article in the MIS Quarterly Journal entitled *MIS Project Teams: An investigation of Cognitive Style Implications.* This article discusses a study conducted to investigate the findings of K.M Kaiser and R.P. Bostrom that assert, "A successful design team was identified as having 43% feelers" (White 97). The

“feelers” that Kaiser and Bostrom refer to are the Sensing and Feeling (SF) types and the Intuiting and Feeling (NF). A Table describing both the Feeling cognitive type as well as the Thinking cognitive type is shown in figure 5. The case study that White focuses on only contains two separate project teams and the comparative study takes place in industry.

Each of these teams contains ten members and each study takes place over a two-year interval. The first of these project teams (project team one) is composed of all thinking types. Seven of the members are of the ST type and the remaining three are of the NT type. This team shows very little diversity in its make up which Isabel Myers speculated would mean that while the group members would have little trouble in communicating with one another there would also be a very limited range of viewpoints. It was more likely that all of the group members would make the same mistakes (Myers, 1967). This turned out to be exactly what happened as the project team made an invalid assumption and after two years had to abandon the project and start from the beginning. The second project team, project team two, was made up of four ST’s, 2 NT’s, 2 SF’s, and 2 NF’s. This team was able to complete the project and “positive evaluations of project team two centered around three main topics: communication skills, user satisfaction, and overall work accomplishments (White 98). The hypothesis that proved to be correct in this study was that when creating project teams it is important to not only have known innovators (the thinkers) on a team but to have a mix of both thinkers and feelers so that different view points can be seen and the lines of communication can be opened. According to White’s article, this is the optimum approach to achieve the most progress in this field of design where someone has to be able to see things from the view point of the user.

Table I. Summary of Problem-Solving Styles

| | ST Sensing/ Thinking | NT Intuiting/ Thinking | SF Sensing/ Feeling | NF Intuiting/ Feeling |
|---|---|---|---|---|
| Focus of Attention | facts | possibilities | facts | possibilities |
| Method of Handling Things | impersonal analysis | impersonal analysis | personal warmth | personal warmth |
| Tendency to Become | practical and matter-of fact | logical and ingenious | sympathetic and friendly | enthusiastic and insightful |
| Expression of Abilities | technical skills with facts and objects | theoretical and technical development | practical help and services to people | understanding and communicating with people |

**Figure 6: Summary of problem solving styles**

It is clear at this point that the MBTI is a valuable tool that can describe the dynamics of groups through the preferences of the people making them up and can help in the classroom as well as in creating a team atmosphere in industry. Since its creation in the early 1950's however, the MBTI has been adapted for specific purposes in order to measure individual personality traits. An example of this is the MBTI- creativity index (MBTI-CI) which can be used to measure how creative a person is. Greg Stevens, the president of Win Ovations inc, explained that only approximately 60% of the projects that get off the ground succeeded at a minimal self supporting level. Considerably fewer actually grow and thrive. He explained that a key to the success of these top tier groups was that "the type of individuals usually selected for both early stage project management and market research are risk averse, patient and persistent individuals, whereas market research for new product development requires personnel with high risk acceptance, creativity, and openness to the "irrational" process of new product development" (Stevens 3). Most projects will stagnate and decline but a few people have a good success rate as new product managers "pick" and "nurture" winners. The study that he conducted took place over a ten-year span from 1987 to 1997 over which his research team monitored the success of

managers assigned to identify and develop promising new products for a Fortune 500 company. True to form, 60% of the products (from launching) that were studied did indeed succeed but very few get to that point. Stevens used the MBTI creativity index formula (figure 7) to find that at Dow Chemical the most successful project leaders had scored in the top half of Gough's MBTI-CI.

**Figure 7:** MBTI Creativity Index = 3SN + JP – EI – 0.5TF

ENTP's score the highest based on the formula in Figure 7.

Another MBTI related measure that Stevens used to find a correlation between those products that failed and those that succeeded was the Keirsey temperaments of the individual responsible during the early stages of the venture. Keirsey separates the sixteen possible MBTI types into four separate groups based on just two of there four dichotomies. The groups are known as the "rationalists" (NT's), the "idealists (NF), the Guardians (SJ) and the Artisans (SP). The rationalists (NT's) had a considerably higher success rate than any of the other types. Eventually Stevens came up with something that he called the "rainmaker index" which simply combined elements of Gough's creativity index with the Keirsey Temperaments insights to create his own "Rainmaker" that he claimed was the best model for predicting who could pick winners in his particular study. It was based on just the S-N and T-F scalars and identified the NT's, while stressing the N factor scores.

Perhaps the most conclusive and the most controversial study that has been performed recently were done at Stanford University. Here Stanford Professor Doug Wilde helped to create a method of organizing teams by mixing very specific MBTI types. His theory was that each type played a specific role in a maximally innovative project outcome. The most important of these roles was hypothesized to be the technologist on the team. The type that he felt could best

play this role is the ISTJ. However, it was very important that only one of the members of the team be an ISTJ as they are known to conflict with one another due to the fact that they both attempt to play a similar role on the team.

The EN type is the next most important member of the team. The role of the EN is to facilitate progress and generate possibilities, push the team to the edge of what is possible in contrast to the play it safe, stick to the facts "technologist" and have the opposite ideas to the technologist type. The EN requirement can best be fulfilled by the ENFP, their cognitive opposites, which Wilde considers the "facilitator" type. However, the ENTP (innovators) and the ENFJ (harmonizer) types are also thought to be able to fill this role. Ideally, according to Wilde's theory, the last spot on a project team should go to the ES(F) type (F is needed if the brainstorm is ENTP rather than ENFP). The best mix of cognitive types and roles is to have "a quiet technologist, a gregarious barnstormer, and a moderator. (Wilde 8)." When these teams were assembled in a mechanical engineering design class at Stanford and competed in the nationwide Lincoln competition, focusing on mechanical innovation, Stanford dominated the event. There was a dramatic difference in the amount of prizes won by the Stanford teams versus the amount of prizes won by teams from other universities. Even compared to the amount of prizes usually won by Stanford teams of past year the performance of the 1995 class was extraordinary. They nearly swept the events getting almost all of the prizes awarded.

It is important to note that while the Stanford teams did well in competition it was later found in a study of Worcester Polytechnic Institute MQP projects that the particular types that Stanford put into their groups would excel at innovation, but not necessarily in projects with other goals. WPI found that Wilde was wrong about the ISTJ being the only able "technologist". At WPI teams with an SJ or NJ on them did just as well in terms of innovation. However, having

an SJ or an NJ on the team was no help if the team goal was production rather than innovation. On a project team, having a facilitator was associated with success.

It is impossible to ignore the amount of prizes that these Stanford teams were able to capture. The Stanford ME and WPI MQP study findings but Wilde was wrong about two things. One was that the task environment mattered and the other was that at WPI the teams with all three of his types in the proper mix did not out perform those without the three of his types in the proper mix. What mattered was having the anchor SJ or NJ on an innovation team. This relates to the WPI space IQP teams because both sets of teams are of a similar size and both are doing technically challenging projects. The difference is that the not all of the WPI teams needed, or wanted to be innovative. Wilde developed four divisions called Preference Groups. Figure 8 shows the categorizations he created.

| Technologist mode | Synthesizer mode | Left-brain extrovert direction | Teamwork mode | Organization mode |
|---|---|---|---|---|
| ISTJ | EN | Enf | EF | ET |

**Figure 8: Wilde's Preference Group Classifications**

We combined the middle three columns for simplification in our study, to create three main classifications: Technologist (ISTJ), Facilitator (ENF), and Organizer (ET).

The Worcester Polytechnic Institute's study of MQP teams that was previously discussed also produced some very interesting findings with regards to leadership. Steve Gaunt and Paul Rivera found in their study that having a clearly defined leader on a team significantly increased the chance that the outcome of a project would be extraordinary enough to exceed the advisors expectations. It was just as likely (50 – 50 probability) that teams that only met expectations had a leader.

On the whole, the literature review provides us with a mixed bag. While a lot of the literature points to the fact that diversity will help a team's performance, there are yet other studies which say that a team that is too diverse pays a price in terms of communication issues and conflict and will not work harmoniously. The Stanford study supports the value of diversity (for innovation) but only by selecting specific psychological types to form specific roles in all of the groups. While Stanford enjoyed a tremendous amount of success in what they won, we really have no idea of how many teams it took to claim all of their prizes. At WPI we can account for all of the groups, stellar and mediocre. Further at WPI we have a full range of cognitive mixes as they were not all formed to fit a theoretical ideal. Thus when we say that we were not able to replicate Stanford's results at WPI we don't know what happened to the non-prize winning groups at Stanford so it is difficult for us to be sure that our results are different. It is clear that our hypothesis that the diversity on a team will lead to a better result appears to be backed up by a substantial literature and appears to be Myers position as well.

Also our hypothesis regarding the division of labor and the clarity of roles on a team appears to have support in the literature. WPI has shown in the Gaunt and Rivera study that a clearly defined leader on a team will increase the chances of a project that will surpass the expectations of the project advisor. This is opposed to the teams that do not have a leader which have a considerably more likely not to meet or just meet the advisors expectations. To some extent our hypothesis will be based on the logic of the theory regarding the MBTI, rather than strictly upon prior empirical findings. There are discrepancies in the empirical record in any case, such as Stevens exalting the ENTP's as the most creative and Wilde stressing the need for one ISTJ on the innovative mechanical engineering design teams.

# 5 Procedure

## *5.1 Our Hypotheses*

The first step in our process of investigation was to create a defined idea of where to go. We set out initially with an open mind as to what we should search for, and we brainstormed possible questions we would want to answer. Combining questions like “Do we think one type is what makes a group great, or is it more any type of diversity than a specific type?” and the literature that we had available, we decided that we could test several hypotheses with one simple survey questionnaire.

We immediately knew that leadership was of vital importance in our theory of group dynamics and set that as our first test hypothesis. WPI has had a history of studying leadership and our advisor informed us that it should at least be included in our paper, if not one of the main focal points.

We also look at the development of division of labor in the groups and its effect on group progress. We felt this was an important element of a positive group dynamic, where the division of labor would lead to more efficiency and productivity.

Finally, we decided to further test the validity of the Stanford Study to support their hypothesis with more experimental data, but in a different initial setup. The Stanford Study was done on students that were grouped by their MBTI style with a certain hypothesis in mind. We had a set of groups pre-assembled before our study with no experimental theory behind it, and we could observe these groups over time, find out their relative level of success, how they interacted and how they perceived one another. If our findings matched those of Stanford, the validity of their finding would be much less debatable.

### 5.1.1 Leadership Hypothesis

There have been WPI project teams in the past that have performed studies on MQP group aimed at determining if having a leader on a small project team is helpful or detrimental to the overall success of the team. The Gauntt and Rivera Study was mentioned in the literature review. Steve and Paul reported that teams having a leader were significantly more likely to exceed their advisor's expectations than teams that had no leader. However, in teams that fell short of this there was no significance in having a leader. This shows that while a team can be productive regardless of the presence of a leader, it is much harder to excel as a group if there is no defined leadership role. Though we were studying less well-defined IQP's, we adopted this hypothesis as reasonable, and predicted that we would replicate their finding.

### 5.1.2 Division of Labor Hypothesis

We hypothesized that a "good" division of labor in a team would lead to progress, and a good division of labor would be based on the natural inclinations preferred by the group members, not arbitrarily assigned roles. This was due to the fact that through numerous examples in the literature review we saw that diverse groups performed better than groups that were less diverse, such as in the article published by Kathy Brittain White in the MIS Quarterly Journal entitled *MIS Project Teams: An investigation of Cognitive Style Implications*. This depicts how the more diverse people were able to perform different tasks for the project team and as a result the team performed considerably better than the less diverse project teams. We had a questionnaire that would also allow us to find out if certain MBTI types gravitated toward specific roles on the team such as stabilizer, visionary, or troubleshooter. However, we were less interested in that than the general diversity question, convinced that there were many possible complementary mixes that would work. The Stanford emphasis on specific roles having to be filled sort of put us off.

### 5.1.3 Stanford Study Analysis

Stanford University has completed a well known study of how cognitive diversity can be used to form more innovative project teams. It is discussed in the literature review, but to recap what was done in this study, Professor Wilde created what he believed to be the ideal teams of students based on a specific mixture of cognitive types. When he formed three person groups in a Mechanical Engineering class and used these groups to compete in the nationwide Lincoln Competition he found that his groups performed considerably better than Stanford groups of the past, and essentially dominated the competition for several years running, but especially in 1995.

When Gauntt and Rivera, a WPI IQP team, attempted to replicate this experiment using the Class of 2002 MQP data, it was found that while the groups that Professor Wilde had put together using SJ's as the anchor were extremely good at innovation, they were not as good with production goals. Further, they could expand on Wilde's ideal group by not demanding that each team member be just one specific cognitive type as was previously suggested, but by allowing NJ's to play the anchor role. Wilde seems to have had classes that were one-third ISTJ, so he put one on each group. At WPI, similar classes – about a third STJ – have been studied (Shaler, 2003) in fields of engineering.

We were able to once again test Professor Wilde's theories with this study as it turned out completely by chance that roughly half of the groups contained at least one member that either Wilde believed, or that Gauntt and Rivera later found, would be on an "ideal" project team as the anchor person.

## *5.2 Determining Degrees of Difference*

The "degree of difference" is a classification technique introduced to us by our advisor, John Wilkes. It was used in a prior study carried out with Gerald Gordon and John Bush and later adopted by Steven Gauntt in his study of the WPI MQP teams of the Class of 2002. It is used to obtain a quantifiable, and thus a comparable, value for the amount of differences there are in a group's mix of personality types.

It compares every individual in the group to every other individual. The number of different letters between the two types is the degree of difference between those two individuals. This is done for every combination of pairs in each group, as shown in Figure 8. After every difference is determined the degrees are added together, resulting in a total degree of difference for the group. This total is a number that can be used to relate one group's level of personality type differences to another and thus useful in the analysis of our data.

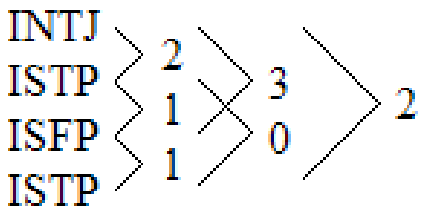


**Figure 8: Example of Degree of Difference**. Group 1's members are shown with each degree of difference listed. The individual differences are then summed to give a total degree of difference for the group, in this case 2+1+1+3+0+2=9.

## *5.3 MBTI® Data Collection*

Our data collection process was two-fold: first, we needed every student on the Space Initiative IQP teams to complete an MBTI® questionnaire and record their results; second, we tried to administer group dynamics surveys (see Appendix C) to all students at two different points during the project, with near 100% success the first time, and approximately 85% success the second time. There were 45 students participating in Space IQPs on campus during the 2005-06 school year and all but one of the 45 students completed an MBTI® questionnaire and were administered two surveys. The MBTI® form that was used was Form M, and a detailed profile was generated for each student using www.SkillsOne.org on-line system.

The MBTI® questionnaire was completed online by almost all students who had not previously taken it in a class with our advisor. We obtained an account, with the help of our advisor John Wilkes, with www.SkillsOne.org to administer the questionnaires and allow us availability to the data and results. After all members had completed this, we compiled the data given to us and divided the list into students whose scores needed to be verified, and those who did not. The split came to 38 students whose data was ambiguous on at least one of the four dimensions and 6 that we could use right away, so we decided to verify those who needed to be verified all at once. Students were given a 20 minute presentation by our advisor, John Wilkes, about each descriptor and what they meant. Each student was given a copy of their MBTI® results, and a small booklet describing all types in detail. The talk was then opened to discussion and questions, after which each student filled out a verification form finalizing our data. The students with scheduling conflicts who were not present were given the written material, but not the oral presentation.

## *5.4 Group Dynamics Survey*

Soon after verifications were completed, we began creating a group dynamics survey to administer to the students. We were given a previous survey by our advisor, John Wilkes, which was created by a previous IQP team in 2003 and revised by Don Foster in 2003. That survey had been developed to generate self report data from Major Qualifying Project teams at WPI, but the data collection team was never able to get a high enough response rate from the students to use it effectively. They had about 200 responses, but not all the team members on a team would respond; so Steve and Paul defaulted to using advisor estimates. We really wanted student data on the inner workings of the team, and decided we could do better. The advisor might be able to tell you if there was a leader and how good the quality is overall, but they are often unaware of internal conflict and division of labor.

So, Gauntt's study was done based on the advisor's perceptions as gathered by a different survey. We had access to the items from both the student and advisor versions of our survey. The student version as revised by Don Foster impressed us the most because it really got into the division of labor for a group in terms that tied back to the four Temperaments of Kiersey, among other things.

The idea was to have a simple survey that could be given to students during their IQP meetings without taking up much of their meeting time. We needed questions geared towards group harmony, interaction, division of labor, dynamics, leadership, and each student's views on the current state and likely future success of their project. Using these guidelines and the survey template we created the survey listed in Appendix B.

With the help of our advisor and several other project advisors, we distributed these surveys to Space IQP students roughly one-third of the way to project completion. Each group

had scheduled meeting times with their advisors, so we tried to attend these meetings or have the group's advisor distribute the surveys during each meeting. The students would then take five minutes to fill out the survey, and we would collect them after completion.

In order to preserve confidentiality no students were allowed to see any other student's survey, and for anonymity they were not allowed to keep a copy of the survey. The turnaround time from distribution to collection was approximately two weeks.

There was difficulty in collecting the surveys the second time around. We could not attend as many group meetings, and some groups had finished their projects early or were taking breaks. In response, we created an online version (www.hostedsurveylite.com/takesurvey.asp?c=ISISIQ131854) which we alerted everyone to through email. This allowed us to nearly complete the second round of data collection, but not all students responded and it took much longer than we had originally planned to gather data in this fashion.

### 5.4.1 Breakdown of Each Survey Question

The survey was developed to operationalize the following variables. First, to provide a unique ID for each respondent and group, we had each person supply their name, their advisor's name, and the names of all their group members with a symbol assigned to each group member for purposes of the questionnaire.

*Your Name: A)_____ Main Advisor(s): _____*

*Your Project Partners' Names: B)_____ C)_____ D)_____*

The name was used to identify the survey with the person's MBTI type which became the survey reference point. The advisor's name was used to have a reference for each group's advisor when we were given the advisor's final rating of each group. We would then be able to compare the "expectation" of each of the advisors. The labeling was used in the first question instead of names, since the first question was rather lengthy; we thought that labels would reduce some of the text further down.

*According to Psychological Type theorists, the following terms describe the four major functions performed by members of a successful team.*

*Visionary -- The person who conceives ideas with ingenuity and logic, contributes strategies and analyses, and is the main source for setting up the problems.*

*Catalyst -- The person who works by interacting with others about values and inspirations and contributes something personal or a special vision of possibilities. Through this interaction, this person can help "bring out" the answers from other people.*

*Stabilizer -- The person who works from a sense of responsibility. Through steady and timely work, this person is prepared for current and future problems and is able to keep the group on track.*

*Troubleshooter -- The person who finds timely solutions to meet urgent needs. This person is adept at solving the unexpected problems that often arise.*

1. *According to these definitions, which team member best fulfills each of these roles? Check the column for each group member named above – B, C, D, and yourself, A.*

| | *A (self)* | *B* | *C* | *D* |
|---|---|---|---|---|
| ***Visionary*** | | | | |
| ***Catalyst*** | | | | |
| ***Stabilizer*** | | | | |
| ***Troubleshooter*** | | | | |
| ***Other**** | | | | |

*** Please specify a brief description at the end of the survey.*

*-----on last page------*

*** Please specify a brief description if you included any member of your team in the other section on page 1.*

*-----on last page------*

The first question is the longest and most involved. It begins with definitions of four functions that studies have found essential to successful teams. Each function is a separate entity, even though a person can have more than one function in a group. We had the students categorize each person in their group with these functions. If they did not agree with any of the definitions for someone, then there was a space for adding what they felt a person contributed to the group. This table was used to find out what MBTI styles are most likely to contribute what function to a group over the 14 teams. We were testing a theory in this case, one that if verified should make it easier to design more efficient teams that can be created to fit a task or research setting.

*2. How good a fit is the set of roles that developed in your group? (Check one.)*

1. *Very Good*
2. *Reasonably Good*
3. *Not Very Good*
4. *Not Even Roughly Approximate*

This question was to give the student a chance to tell us if the functions they saw emerging in their group was at all like the set of roles described above. Each answer was given a numerical value, in descending order; the more accurate a description the hypothesized division of labor was the more weight given to this question.

*3. Were you friends with any of your project partners prior to this project?*

*Yes No If so, which one(s)*

In designing this survey, previous relationships with other group members was one of the more important factors to take into account. The idea was that relationships have stages of development that normally occur, and these would ideally occur during the time of the project. However, some people had previous knowledge and relationships with others in their group which can effect the development of the group in several ways. We wanted to have this piece of information from everyone to find out if established relationships truly do have a positive effect on group dynamics or not. If it is not that simple, what that effect might be would have to be described.

*4. How did the leadership of your group emerge? (Check one.)*

1. *No leader in the group.*
2. *Leader chosen by group consensus.*
3. *Leader emerged from within the group.*
4. *Other - please explain*

When considering group dynamics, it is essential to know if there is a group leader. This question was geared only at finding out how the leadership emerged in the group if it did. It does give some extra information though, based on whether or not group members agree with each other on if and how the leader emerged. If there is disagreement, the legitimacy of the leader is probably in question.

*5. How closely has your IQP advisor worked with your group? (Check one.)*

1. *Our project advisor acted like a "hands off" manager who came up with the initial problem but let us make the decisions on how to proceed.*
2. *Our project advisor worked with us but avoided micro managing the operational details.*
3. *Our project advisor worked with us closely and was involved in making all the major decisions.*
4. *Our project advisor was essentially one of the team members -- a full partner.*

This was included as a third initial hypothesis, but as the project progressed and we discovered the difficulty of getting surveys back in a timely manner. This delay and the limited amount of time given to our project kept us from successfully creating a survey key for the

advisor survey and adjusting our student survey key to correspond with that. The data development and analysis would have not been up to par with what we were expecting. So we had to discard this hypothesis, and thus the question became irrelevant to our data collection because we felt that it was the least important of our three original hypotheses. Its purpose was to find how the advisor worked with the group, and how that affected the group dynamics.

*6. How much new knowledge do you think your project required? (Check one.)*

1. *None -- Everything needed was known to team members or easily found in our textbooks.*
2. *A little -- We found materials during our literature searches and/or discussions with others.*
3. *Some -- We needed to ask for help and guidance from local experts as well as our adviser.*
4. *A substantial amount -- We performed extensive research and contacted outside experts.*
5. *We broke new ground -- Little of what we needed was available in the literature; experts on campus and outside had only vague ideas. Our project has a lot to do with the feasibility of an idea.*

We used this question as a way to find out how conceptually challenging the project ended up being for each group. This lends itself to more group work as the problem is more complex and requires more discussion. Projects with little conceptual difficulty can more easily be split into sub-projects and distributed to members, limiting group interaction and the development of interactive group dynamics.

*7. How often has your group experienced conflict while working on your IQP? (Circle one.)*

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

*Very Rarely Rarely Sometimes Often Continuously*

This is the key question to getting a straight-forward answer about the level of conflict that occurs in the group. The most weight was given to *Sometimes*, as we feel that conflict occurring any more than 50% of the time will create an overall atmosphere of conflict and F's would have difficulty functioning in such a setting, and it might degrade the quality of work in all teams, no matter what the conflict is. This also means that there was not a resolution between conflicting parties over time, which is essential to a high level of success according to our hypothesis.

*8. How much progress do you think your group has made thus far? (Circle one.)*

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

*Very Poorly  Poorly  Adequately  Well  Exceptionally*

This begins a series of questions geared to find out the students opinion on the state of the project outcomes, given that data was collected before it was finished. We asked this question to find out how the student thought the team was doing overall mostly in terms of what their expectations were about the final report and its quality. This is not directly what we were studying, but the opinion the student has about their project will affect their outlook on it and possibly how they interact with their other team members.

*9. Overall, how has your IQP progressed in terms of teamwork?*
*In terms of effective use of time, how has your IQP progressed in terms of productivity?*

This was a two-part open-ended question that allowed the student to elaborate in his own words how he felt the team was performing. We asked two individual questions to get separate information on the teamwork and productivity. We used the word progressed to gear the answers to be about the improvements that have been made over time with the project. We had questions that gave us information about initial conflict, now we are trying to get a description of what has come about as a result of it.

*10. Please rate how you feel about the eventual success of your project team and your project report. (Check one.)*

| ***Team Work*** | ***Written Report*** |
|---|---|
| *Optimistic* | *Optimistic* |
| *Pessimistic* | *Pessimistic* |

This was used to get "perceptions about the future" from the student, and to really try and find out how they felt about their group and project. Optimism is important to have when doing group work. If the students were optimistic about the future they will be motivated to try to get along and strive for a good grade – feeling that they deserve it. We then compared it with the

amount of conflict present in the group to see how the level of conflict affected the optimistic or pessimistic tone of the group members' mindset.

*11. How many hours per week have you put into actual "time on task" work on your project thus far?*

This was not a very important question to our study; we just wanted to have an idea of the amount of time each student dedicated to their project, since there is usually a correlation between the amount of time put into a group project and the project outcome. We also needed to know if there was anyone in the group that had essentially quit participating beyond going to a weekly meeting called by the advisor.

*12. How do you think this time commitment will have to change if the project is to be successful? (Circle one.)*

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

| *Decreasing Greatly* | *Decreasing Slightly* | *Remaining the same* | *Increasing Slightly* | *Increasing Greatly* |
|---|---|---|---|---|

This is another question geared at finding the mindset of the student in regards to the success of the project. After giving us a numerical account of the hours per week they work, they are then asked to decide whether they are doing what they need to do in terms of time commitment in order to succeed.

The key question to get at through this question is whether there is consensus in the group on what level of effort is needed, and whether they are all acting on it. If not, conflict, hard feelings, and inequity will erupt at the end – and in terms of our theory that would be destructive conflict due to timing. Only early conflict can be beneficial in the long term.

## *5.5 Advisor Ratings of the Groups*

### 5.5.1 The Letter to Advisors

The final step in our process was to obtain advisor ratings of each group and interpret them in a way that would allow us to compare it to the numerical predictions obtained from the surveys. Discussion with Professor Wilkes led us to the conclusion that it would be easier for him to get a hold of advisor opinions than us. I then drew up a template letter that he edited and sent to each advisor. The letter read:

> *Advisor*,
>
> The Oversight Group and I are trying to see how many of our teams were successful in meeting the expectations of the advisor this year. If you could, please reply to me stating whether the "Nuclear Power on the Moon" and "Cooperation in Space" teams did not meet your expectations, met your expectations, or exceeded your expectations and by how much they fell short or impressed you.
>
> Would you also note whether you considered it a challenging topic that they were undertaking and whether or not you noticed that the group(s) had a leader or not, and that person's name. We are curious about whether those who stepped up to leadership roles have the same MBTI type or not. We have the MBTI data for all but one of the 45 students on the 14 teams active this year.
>
> Oh, if the team did anything innovative, in your opinion, either an incremental advance or something more striking, that would be of interest as well.
>
> John

This email, combined with reviews given to us by Professor Wilkes for his other IQP groups, gave us a total of 11 available results.

### 5.5.2 Advisor Review Key

Next we needed to create a key to allow us to take these reviews and quantify them. There were four parts to the email:

i) Whether or not the team met the expectations that the advisor had,

ii) Whether the problem that the team was faced with was challenging or not,

iii) If there was any innovation in their process of solving it,

iv) If the team had a defined leader

Some were more important to our hypotheses than others, so we needed to come up with a way to take that into account. We decided to use a numerical scale to weight each answer and give it a numerical value. We used integers only to make calculation and data entry less complicated. For expectations, we had the heaviest weights. The scale was divided into five parts to allow for some flexibility in the wording of answers. The scale was as follows:

| (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|
| Nothing that was expected | Some of what was expected | Completed what was expected, nothing more | Exceeded some expectations | Exceeded all expectations |

Next was the question of challenge and innovation. This was not as important, but we wanted to make sure that varying difficulty had some sort of possible "control" variable if needed. We used a three part scale, with lower values than the expectations scale. The scale was as follows:

| (0) | (1) | (2) |
|---|---|---|
| No challenge No Innovation | Either Challenge or Innovation | Both Challenge and Innovation |

Finally we gave an additional point to those teams who were described as having a clear leader. Those teams that had no leader, a hard division of labor, or division among the group got no additional point.

## *5.6 Data Input*

With distribution and collection of the initial surveys underway, we then developed a key to code the surveys into Microsoft Excel, and then transfer it to Statistical Package for the Social Sciences (SPSS) for analysis. Professor Wilkes showed us how to quantify each person's MBTI result, and guided us through the survey question-by-question with our hypotheses and gave numerical values to each possible answer according to how well it supported the hypothesis related to that question.

### 5.6.1 MBTI Data

The MBTI results were split into four columns: E/I, S/N, T/F, and J/P. The first of each title was assigned a 1, and the second was a 2. For example, if a person was an ISTJ, they would be coded as a 2-1-1-1. Next we coded different combinations of letterings that the Stanford spin-off by Gauntt and Rivera had developed: SN/JP. Pairings were listed out and assigned values, given as SJ=1, SP=2, NJ=3, NP=4. Finally, we coded a Stanford variable to cover the different roles Wilde had created. The categorization used Figure 9 to determine what roles each group contained (see description in Section 4).

| | Technologist | Organizer | Facilitator |
|---|---|---|---|
| **0** | **1** | **2** | **3** |
| INFP | ISTJ | ENTJ | ENFJ |
| INFJ | | ENTP | ENFP |
| INTJ | | ESTJ | |
| INTP | | ESTP | |
| ISFJ | | | |
| ISFP | | | |
| ISTP | | | |

**Figure 9: The Stanford Variable used in the Data Set**

There are only fourteen types in Figure 9 because we only had fourteen types found among the 44 students in our 14 groups.

### 5.6.2 Survey Data

After MBTI data was coded, the surveys were added. The questions on the survey had different possible answers, and each was assigned a numerical value. Question 1 was the only one that did not follow this exactly. Below is a description of each question's values individually in more detail.

Question #1 was split into two parts for coding. The completeness of the chart was coded as one part, and the actual values in the chart were simply logged at the very end of the data set. Incomplete charts for both labeling members and functional roles were given a negative one (-1), charts that had either all roles labeled or all members labeled but not both were given a zero (0), and those that were completely labeled for both roles and team members received a one (1).

For questions with multiple choice answers, the assigned values for each possible answer were as follows:

2. (2) Very Good
   (1) Reasonably Good
   (0) Not Very Good
   (-1) Not Even Roughly Approximate
3. (-1) Yes
   (0) No
4. (0) No Leader
   (2) Leader Chosen
   (1) Leader Emerged
6. (-2) None
   (-1) Little
   (0) Some
   (1) Substantial
   (2) Broke New Ground
7. (-1) Very Rarely
   (0) Rarely
   (1) Sometimes
   (0) Often
   (-1) Continuously
8. (-2) Very poorly
   (-1) Poorly
   (0) Adequately
   (-2) Well
   (-1) Exceptionally
10. **Teamwork**
    (1) Optimistic
    (-1) Pessimistic
    ---
    **Written Report**
    (1) Optimistic
    (0) Pessimistic
12. (-1) Decrease Greatly
    (0) Decrease Slightly
    (1) Remain the Same
    (0) Increase Slightly
    (-1) Increase Greatly

Question #9 was an open-ended question, so we decided to review each answer and categorize it based on its wording. Positive answers were assigned a one (1), negative answers were assigned a negative one (-1), and if there was no answer given it was coded as a zero (0). This was done separately for both parts of #9, splitting it into #9a, and #9b.

Question #11 was coded by sets of numbers given numerical designations. The hours worked ranged from low single digit times per week up to 20 hours per week. We divided this into four sets of 5 hours, the lowest 1-5 hours being zero (0), 6-10 hours being one (1), 11-15 hours being two (2), and finally (1) for 16-20 hours because we felt that too much time per week would cause the student problems in the overall scheme.

We did not code question #5 because of an initial miscommunication in our survey idea, and time would not permit us to add it in nearer to the end when our ideas had altered.

### 5.6.3 Advisor Rating Data

The last part that needed to be coded was the advisor ratings, which were collected by our advisor as described earlier. Professor Wilkes then reviewed these ratings and determined a scale to give numerical values to these ratings. The scale's range was 0.0 - 4.0, with incremental steps of 0.5. The lowest score that was given to a team was 2.5, and the highest was 4.0. These values were then coded into our data set, and our analysis could begin.

# 6 Results and Conclusions

## *6.1 Leadership Hypothesis Results*

Upon first glance we did not notice any definite trends in our results either. Almost the exact same proportions of teams with a leader did well as the proportion of teams without a leader. When we examine the data more closely however we notice that there are indeed trends that begin to develop. While it is true that having a leader does not automatically make a team better we can see in Figure 11, which is the cross tabulation of having or not having a leader versus the final Advisor ratings for a group, that having a leader is associated with having an exceptional project. [1] We notice that of the 5 people that were in groups that scored the highest rating of 4.0 only 1 person was in a team without a leader. This means that while having a leader does not necessarily make a project great, it can help turn a good project into a great project. We also notice that virtually the same number of people that received a score in the 3.0 to 3.5 range had leaders as those that did not. A last trend that we noticed was that of the six people that received that lowest scores, five were on teams with leaders. This shows that not only can a leader make a project great, but he or she can also keep a project from meeting expectations. We hypothesize that teams without leaders are just as capable of competing adequate projects as teams without leaders; however, a leader is capable of making or breaking a project and so the teams with the best leaders often turn out to be the most productive teams, where the teams with the worst leaders often turn out to be the least productive teams. Because this data is so spread out based on the quality of leadership there is no clear cut correlation between having a leader and being successful. Thus the Guantt and Rivera finding has been replicated using IQP data.

[1] 0 means that there is no leader, 1 means that there is a leader.

| | | | Advisor Group rating | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.5 | 3.0 | 3.5 | 4.0 | Total |
| 2_4 | 0 | Count | 1 | 6 | 5 | 1 | 13 |
| | | % within 2_4 | 7.7% | 46.2% | 38.5% | 7.7% | 100.0% |
| | | % within Advisor Group rating | 16.7% | 37.5% | 62.5% | 20.0% | 37.1% |
| | 1 | Count | 5 | 10 | 3 | 4 | 22 |
| | | % within 2_4 | 22.7% | 45.5% | 13.6% | 18.2% | 100.0% |
| | | % within Advisor Group rating | 83.3% | 62.5% | 37.5% | 80.0% | 62.9% |
| Total | | Count | 6 | 16 | 8 | 5 | 35 |
| | | % within 2_4 | 17.1% | 45.7% | 22.9% | 14.3% | 100.0% |
| | | % within Advisor Group rating | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 3.911[a] | 3 | .271 |
| Likelihood Ratio | 4.014 | 3 | .260 |
| Linear-by-Linear Association | .331 | 1 | .565 |
| N of Valid Cases | 35 | | |

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is 1.86.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | -.218 | .252 | -.851 | .395 |
| N of Valid Cases | | 35 | | | |

**Figure 11: Chart of having a leader versus final outcome as rated by advisors. (4.0 is the highest possible advisor rating)**

## *6.2 Division of Labor Hypothesis Results*

When we cross tabulated the way in which the roles in groups were filled that were successful based on the advisor ratings of the groups we found that if labor was divided among a lot of people the groups tended to do slightly worse than if a single person or a smaller group filled a majority of the roles. When we examined the results a little more closely we discovered that while there were numerous groups that just met expectations where the division of labor was not as great there were also a considerable number of groups that received a 4.0 which is the best that a group could do. We also noticed that in groups where the division of labor was great there were more people that did very poorly. There was still the same number of people that just met expectations in both types of groups but the probability of being in an exceptional group completely disappeared when the division of labor was what he hypothesized it needed to be to do well. One possible reason that may have led to these results is for this is that when group members are all doing different tasks they often fail to communicate with each other so that there individual portions of the project can fit together well. These results are shown in Figure 12 below. The actual trend appears to have an approximate gamma correlation of -.40 which is not enough to be sure that these results will also hold true, but is high enough to say that we do see a very clear trend develop that the less division of labor a group has the better its final results.

| | | | Advisor Group rating | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.5 | 3.0 | 3.5 | | |
| dichot Role Divisions | not all roles filled by diff people | Count | 2 | 8 | 3 | 5 | 18 |
| | | % within dichot Role Divisions | 11.1% | 44.4% | 16.7% | 27.8% | 100.0% |
| | | % within Advisor Group rating | 33.3% | 50.0% | 37.5% | 100.0% | 51.4% |
| | all roles filled by diff people | Count | 4 | 8 | 5 | 0 | 17 |
| | | % within dichot Role Divisions | 23.5% | 47.1% | 29.4% | .0% | 100.0% |
| | | % within Advisor Group rating | 66.7% | 50.0% | 62.5% | .0% | 48.6% |
| Total | | Count | 6 | 16 | 8 | 5 | 35 |
| | | % within dichot Role Divisions | 17.1% | 45.7% | 22.9% | 14.3% | 100.0% |
| | | % within Advisor Group rating | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 6.143[a] | 3 | .105 |
| Likelihood Ratio | 8.088 | 3 | .044 |
| Linear-by-Linear Association | 3.034 | 1 | .082 |
| N of Valid Cases | 35 | | |

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is 2.43.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | -.397 | .229 | -1.646 | .100 |
| N of Valid Cases | | 35 | | | |

**Figure 12: Division of Labor vs. Advisor Rating**

## *6.3 Stanford Study Results*

In order to test our theory that the WPI study finding was correct we cross tabulated the groups that had an "ideal team member" as we will refer to these people, with the advisors rating of the final project. As was previously explained the advisor rankings are done on a number system, where a 4.0 rating is the best that a group can do. This correlates to achieving beyond what the advisor had expected; while a 2.5 rating correlates to falling slightly short of advisor expectations. As we can see from Figure 13 shown below there is a very clear correlation. We observe that none of the groups with an "ideal member" scored less than a 3.0 which means that they all at least met their advisors expectations. Perhaps even more conclusive than this was the fact that twelve of the seventeen members that were in a group that contained an ideal member scored either a 3.5 or a perfect 4.0. This is in contrast to only a single two person groups that did not contain an ideal team member. As for the groups that did not contain an ideal group member 7 people were on teams that received a rating of 2.5 and 19 of the 21 people were on groups that received a rating of 3.0 or lower which is just barely meeting the advisors expectations. The numeric correlation for these findings is an extremely high .82 significance at the .001 level which means that there is very little chance of error in the findings and that we have definitely found a very strong correlation between having an ideal team member and performing well, i.e. meeting or exceeding the advisor's expectations.

**Crosstab**

| | | | Advisor Group rating | | | Advisor | |
|---|---|---|---|---|---|---|---|
| | | | 2.5 | 3.0 | 3.5 | 4.0 | Total |
| Stanford broad SJ or NJ | no NJ or SJ | Count | 7 | 12 | 0 | 2 | 21 |
| | | % within Stanford broad SJ or NJ | 33.3% | 57.1% | .0% | 9.5% | 100.0% |
| | | % within Advisor Group rating | 100.0% | 70.6% | .0% | 33.3% | 55.3% |
| | at least one ISTJ,INTJ, ESTJ or ENTJ on team | Count | 0 | 5 | 8 | 4 | 17 |
| | | % within Stanford broad SJ or NJ | .0% | 29.4% | 47.1% | 23.5% | 100.0% |
| | | % within Advisor Group rating | .0% | 29.4% | 100.0% | 66.7% | 44.7% |
| Total | | Count | 7 | 17 | 8 | 6 | 38 |
| | | % within Stanford broad SJ or NJ | 18.4% | 44.7% | 21.1% | 15.8% | 100.0% |
| | | % within Advisor Group rating | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Figure 13: Advisor Ratings vs. Stanford Groups**

## *6.4 Other Interesting Findings*

### 6.4.1 J/P vs. Advisor Rating

First, there was the J-P Finding compared with Advisor rating. This cross-tabulated the J/P difference with the rating that the group received from their advisor. The SPSS data is given in Figure 14. There was a gamma correlation of -0.46 with an approximate significance of 0.04. The Pearson Chi-Square asymptotic significance was 0.005. This shows that there is a statistically significant possibility that J's will outperform P's.

| | | | Advisor Group rating | | | | Total |
|---|---|---|---|---|---|---|---|
| | | | 2.5 | 3.0 | 3.5 | 4.0 | |
| J/P | 1 | Count | 1 | 7 | 8 | 2 | 18 |
| | | % within J/P | 5.6% | 38.9% | 44.4% | 11.1% | 100.0% |
| | | % within Advisor Group rating | 14.3% | 41.2% | 100.0% | 33.3% | 47.4% |
| | 2 | Count | 6 | 10 | 0 | 4 | 20 |
| | | % within J/P | 30.0% | 50.0% | .0% | 20.0% | 100.0% |
| | | % within Advisor Group rating | 85.7% | 58.8% | .0% | 66.7% | 52.6% |
| Total | | Count | 7 | 17 | 8 | 6 | 38 |
| | | % within J/P | 18.4% | 44.7% | 21.1% | 15.8% | 100.0% |
| | | % within Advisor Group rating | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 12.697[a] | 3 | .005 |
| Likelihood Ratio | 16.159 | 3 | .001 |
| Linear-by-Linear Association | 2.650 | 1 | .104 |
| N of Valid Cases | 38 | | |

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is 2.84.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | -.464 | .215 | -2.095 | .036 |
| N of Valid Cases | | 38 | | | |

**Figure 14: J-P Finding with Advisor rating**

### 6.4.2 Diversity vs. Student and Advisor Ratings

Second is the diversity of the group compared with the Composite Student rating of the student's own project (Figure 15a), and the diversity compared with the Advisor's Rating of the group (Figure 15b). There is a negative correlation (-0.46 at 0.04) shown in the first figure, but not in the second (-0.1 at 0.64). To describe what is revealed to us by these two figures is to say that cognitive diversity is negatively associated with the student assessments of how the project is going, but unrelated to the overall faculty assessment.

**Crosstab**

| | | | Composite Student rating | | | Total |
|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | |
| Diversity in 3 categories | Diversity score 1 or less | Count | 2 | 0 | 6 | 8 |
| | | % within Diversity in 3 categories | 25.0% | .0% | 75.0% | 100.0% |
| | | % within Composite Student rating | 22.2% | .0% | 66.7% | 21.1% |
| | Mediium over 1 under 2 | Count | 3 | 6 | 3 | 12 |
| | | % within Diversity in 3 categories | 25.0% | 50.0% | 25.0% | 100.0% |
| | | % within Composite Student rating | 33.3% | 30.0% | 33.3% | 31.6% |
| | High score over 2 | Count | 4 | 14 | 0 | 18 |
| | | % within Diversity in 3 categories | 22.2% | 77.8% | .0% | 100.0% |
| | | % within Composite Student rating | 44.4% | 70.0% | .0% | 47.4% |
| Total | | Count | 9 | 20 | 9 | 38 |
| | | % within Diversity in 3 categories | 23.7% | 52.6% | 23.7% | 100.0% |
| | | % within Composite Student rating | 100.0% | 100.0% | 100.0% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 19.586[a] | 4 | .001 |
| Likelihood Ratio | 24.507 | 4 | .000 |
| Linear-by-Linear Association | 5.630 | 1 | .018 |
| N of Valid Cases | 38 | | |

a. 7 cells (77.8%) have expected count less than 5. The minimum expected count is 1.89.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | -.463 | .214 | -2.056 | .040 |
| N of Valid Cases | | 38 | | | |

**Figure 15a: Diversity compared with Student Rating**

| | | | Advisor Group rating | | | Advisor | |
|---|---|---|---|---|---|---|---|
| | | | 2.5 | 3.0 | 3.5 | 4.0 | Total |
| Diversity in 3 categories | Diversity score 1 or less | Count | 0 | 3 | 5 | 0 | 8 |
| | | % within Diversity in 3 categories | .0% | 37.5% | 62.5% | .0% | 100.0% |
| | | % within Advisor Group rating | .0% | 17.6% | 62.5% | .0% | 21.1% |
| | Medium over 1 under 2 | Count | 3 | 6 | 3 | 0 | 12 |
| | | % within Diversity in 3 categories | 25.0% | 50.0% | 25.0% | .0% | 100.0% |
| | | % within Advisor Group rating | 42.9% | 35.3% | 37.5% | .0% | 31.6% |
| | High score over 2 | Count | 4 | 8 | 0 | 6 | 18 |
| | | % within Diversity in 3 categories | 22.2% | 44.4% | .0% | 33.3% | 100.0% |
| | | % within Advisor Group rating | 57.1% | 47.1% | .0% | 100.0% | 47.4% |
| Total | | Count | 7 | 17 | 8 | 6 | 38 |
| | | % within Diversity in 3 categories | 18.4% | 44.7% | 21.1% | 15.8% | 100.0% |
| | | % within Advisor Group rating | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 19.138[a] | 6 | .004 |
| Likelihood Ratio | 24.383 | 6 | .000 |
| Linear-by-Linear Association | .008 | 1 | .928 |
| N of Valid Cases | 38 | | |

a. 10 cells (83.3%) have expected count less than 5. The minimum expected count is 1.26.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | -.097 | .208 | -.468 | .640 |
| N of Valid Cases | | 38 | | | |

**Figure 15b: Diversity Compared with Advisor Rating**

### 6.4.3 Student Rating vs. Advisor Rating

Next, we compared how the individual students rated their project in the questionnaire with how the advisor rated their finished product. Figure 16 shows that with a correlation of 0.142 at 0.556 significance, the students did not have the same ideas about their project as the advisor. The largest differences are at the top and bottom of the spectrum, showing that teams that did both the best and the worst did not agree with their advisor's rating.

| | | | perfomance- group view | | | | |
|---|---|---|---|---|---|---|---|
| | | | -1 | 0 | 1 | 2 | Total |
| Advisor Group rating | 2.5 | Count | 2 | 2 | 0 | 2 | 6 |
| | | % within Advisor Group rating | 33.3% | 33.3% | .0% | 33.3% | 100.0% |
| | | % within perfomance-group view | 66.7% | 20.0% | .0% | 11.1% | 17.1% |
| | 3.0 | Count | 0 | 5 | 2 | 9 | 16 |
| | | % within Advisor Group rating | .0% | 31.3% | 12.5% | 56.3% | 100.0% |
| | | % within perfomance-group view | .0% | 50.0% | 50.0% | 50.0% | 45.7% |
| | 3.5 | Count | 0 | 2 | 0 | 6 | 8 |
| | | % within Advisor Group rating | .0% | 25.0% | .0% | 75.0% | 100.0% |
| | | % within perfomance-group view | .0% | 20.0% | .0% | 33.3% | 22.9% |
| | 4.0 | Count | 1 | 1 | 2 | 1 | 5 |
| | | % within Advisor Group rating | 20.0% | 20.0% | 40.0% | 20.0% | 100.0% |
| | | % within perfomance-group view | 33.3% | 10.0% | 50.0% | 5.6% | 14.3% |
| Total | | Count | 3 | 10 | 4 | 18 | 35 |
| | | % within Advisor Group rating | 8.6% | 28.6% | 11.4% | 51.4% | 100.0% |
| | | % within perfomance-group view | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 14.830[a] | 9 | .096 |
| Likelihood Ratio | 15.279 | 9 | .084 |
| Linear-by-Linear Association | .313 | 1 | .576 |
| N of Valid Cases | 35 | | |

a. 15 cells (93.8%) have expected count less than 5. The minimum expected count is .43.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | .142 | .240 | .588 | .556 |
| N of Valid Cases | | 35 | | | |

**Figure 16: Student Rating vs. Advisor Rating**

### 6.4.4 Group Rating vs. Advisor Rating

This is a similar analysis to the previous section, but with composite student ratings instead of individual student ratings. The ratings were averaged for all of the members of each group to give a single group rating. This was then compared with the advisor rating to see if the group was more in line with the advisor than the individuals were. Figure 17 shows that a correlation of 0.433, while better than the individual correlation of 0.142, only 16% of the variance is explained by this relationship.

In short, the group rating is not related to the advisor rating with any viable significance, and thus there is no correlation between them.

| | | | Composite Student rating | | | Total |
|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | |
| Advisor Group rating | 2.5 | Count | 4 | 3 | 0 | 7 |
| | | % within Advisor Group rating | 57.1% | 42.9% | .0% | 100.0% |
| | | % within Composite Student rating | 44.4% | 15.0% | .0% | 18.4% |
| | 3.0 | Count | 3 | 11 | 3 | 17 |
| | | % within Advisor Group rating | 17.6% | 64.7% | 17.6% | 100.0% |
| | | % within Composite Student rating | 33.3% | 55.0% | 33.3% | 44.7% |
| | 3.5 | Count | 2 | 0 | 6 | 8 |
| | | % within Advisor Group rating | 25.0% | .0% | 75.0% | 100.0% |
| | | % within Composite Student rating | 22.2% | .0% | 66.7% | 21.1% |
| | 4.0 | Count | 0 | 6 | 0 | 6 |
| | | % within Advisor Group rating | .0% | 100.0% | .0% | 100.0% |
| | | % within Composite Student rating | .0% | 30.0% | .0% | 15.8% |
| Total | | Count | 9 | 20 | 9 | 38 |
| | | % within Advisor Group rating | 23.7% | 52.6% | 23.7% | 100.0% |
| | | % within Composite Student rating | 100.0% | 100.0% | 100.0% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 24.599[a] | 6 | .000 |
| Likelihood Ratio | 28.577 | 6 | .000 |
| Linear-by-Linear Association | 3.807 | 1 | .051 |
| N of Valid Cases | 38 | | |

a. 11 cells (91.7%) have expected count less than 5. The minimum expected count is 1.42.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | .433 | .145 | 2.707 | .007 |
| N of Valid Cases | | 38 | | | |

**Figure 17: Group Rating vs. Advisor Rating**

### 6.4.5 Initial vs. Final Conflict

Next, there is initial conflict as compared with final conflict. This looks at the answer to question 7 in the first survey, compared with the same question on the second survey. What is shown in Figure 18 is that initial conflict for our groups was never resolved, always reappearing in the second survey. This lends itself away from our initial belief, because initial conflict cannot be beneficial if it is never resolved.

| | | | 2--7 | | | |
|---|---|---|---|---|---|---|
| | | | -1 | 0 | 1 | Total |
| 1--7 | -1 | Count | 9 | 1 | 0 | 10 |
| | | % within 1--7 | 90.0% | 10.0% | .0% | 100.0% |
| | | % within 2--7 | 100.0% | 5.6% | .0% | 27.8% |
| | 0 | Count | 0 | 17 | 2 | 19 |
| | | % within 1--7 | .0% | 89.5% | 10.5% | 100.0% |
| | | % within 2--7 | .0% | 94.4% | 22.2% | 52.8% |
| | 1 | Count | 0 | 0 | 7 | 7 |
| | | % within 1--7 | .0% | .0% | 100.0% | 100.0% |
| | | % within 2--7 | .0% | .0% | 77.8% | 19.4% |
| Total | | Count | 9 | 18 | 9 | 36 |
| | | % within 1--7 | 25.0% | 50.0% | 25.0% | 100.0% |
| | | % within 2--7 | 100.0% | 100.0% | 100.0% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 55.863[a] | 4 | .000 |
| Likelihood Ratio | 55.571 | 4 | .000 |
| Linear-by-Linear Association | 29.718 | 1 | .000 |
| N of Valid Cases | 36 | | |

a. 7 cells (77.8%) have expected count less than 5. The minimum expected count is 1.75.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | 1.000 | .000 | 10.200 | .000 |
| N of Valid Cases | | 36 | | | |

**Figure18 : Initial vs. Final Conflict**

### 6.4.6 Initial Conflict vs. Final Progress

Finally, there is initial conflict compared with final progress. Below is the crosstab of this comparison and its corresponding correlation. There is a negative correlation of -0.42 shown between initial conflict and final progress, with a significance of 0.061. This suggests that initial conflict is a negative factor in the way the group sees itself progressing.

| | | | 2--8 | | | | |
|---|---|---|---|---|---|---|---|
| | | | -1 | 0 | 1 | 2 | Total |
| 1--7 | -1 | Count | 0 | 3 | 1 | 6 | 10 |
| | | % within 1--7 | .0% | 30.0% | 10.0% | 60.0% | 100.0% |
| | | % within 2--8 | .0% | 30.0% | 25.0% | 31.6% | 27.8% |
| | 0 | Count | 1 | 4 | 2 | 12 | 19 |
| | | % within 1--7 | 5.3% | 21.1% | 10.5% | 63.2% | 100.0% |
| | | % within 2--8 | 33.3% | 40.0% | 50.0% | 63.2% | 52.8% |
| | 1 | Count | 2 | 3 | 1 | 1 | 7 |
| | | % within 1--7 | 28.6% | 42.9% | 14.3% | 14.3% | 100.0% |
| | | % within 2--8 | 66.7% | 30.0% | 25.0% | 5.3% | 19.4% |
| Total | | Count | 3 | 10 | 4 | 19 | 36 |
| | | % within 1--7 | 8.3% | 27.8% | 11.1% | 52.8% | 100.0% |
| | | % within 2--8 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 7.921[a] | 6 | .244 |
| Likelihood Ratio | 8.166 | 6 | .226 |
| Linear-by-Linear Association | 3.926 | 1 | .048 |
| N of Valid Cases | 36 | | |

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .58.

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Ordinal by Ordinal | Gamma | -.422 | .209 | -1.872 | .061 |
| N of Valid Cases | | 36 | | | |

**Figure 19: Initial Conflict vs. Final Progress**

# 7 Recommendations for Further Research

Our study has shown several interesting correlations and relationships, some of which have both been previously discovered, and now that they have been replicated can be publicized. We believe that using this same system, there can be quite a few hypotheses beyond ours that can be tested.

All of the findings that were listed in section 6.4 could be expanded upon and researched further. Things of key note are the J/P vs. Advisor rating, which would be very useful to those who wish to design groups that exceed expectations, and should be extensively researched. Also the division of labor findings needs more follow-up: including what types gravitate toward which roles in the group, and how each member of the group views the division of labor.

Our data set was a decent size, but there were some anomalies, such as the perfect correlation between initial and final conflict that should be tested more with a larger data set to understand the true correlation of those two variables. Certainly, in theory, conflict can subside, and in practice there must be some cases of it on WPI projects. There are also other ways of coding group diversity, like focusing on certain key oppositions (i.e. S/N or J/P) rather than assuming all are equally important.

There was considerable discussion of Gauntt and Rivera's study of the "Rainmaker" Index and picking winners in our literature review, but we did no have the time in our project to look at his hypotheses. This is quite an interesting study because it looks at a different aspect of group work than the Stanford Study. Wilde was more interested in productivity, while Gauntt and Rivera did not care about what was made, but what was achieved in projects that had no final product. Their "excelling" type was ENTP, almost a cognitive opposite of Wilde's ISTJ.

This is definitely an interesting topic and should be looked at when more data is supplied and more time can be done for analysis of such variables.

In all, a continuation of our research would provide more data for all the variables and hypotheses that we studied in this paper. We recommend continuing this study as long as the space project continues, and improving the quality of the findings that have been discovered by adding about a dozen projects to the data set each year.

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# 9 Appendices

## *9.1 Appendix A – MBTI® Type Descriptions*

ISTJ

For ISTJs the dominant quality in their lives is an abiding sense of responsibility for doing what needs to be done in the here-and-now. Their realism, organizing abilities, and command of the facts lead to their completing tasks thoroughly and with great attention to detail. Logical pragmatists at heart, ISTJs make decisions based on their experience and with an eye to efficiency in all things. ISTJs are intensely committed to people and to the organizations of which they are a part; they take their work seriously and believe others should do so as well.

ISFJ

For ISFJs the dominant quality in their lives is an abiding respect and sense of personal responsibility for doing what needs to be done in the here-and-now. Actions that are of practical help to others are of particular importance to ISFJs. Their realism, organizing abilities, and command of the facts lead to their thorough attention in completing tasks. ISFJs bring an aura of quiet warmth, caring, and dependability to all that they do; they take their work seriously and believe others should do so as well.

INFJ

For INFJs the dominant quality in their lives is their attention to the inner world of possibilities, ideas, and symbols. Knowing by way of insight is paramount for INFJs, and they often manifest a deep concern for people and relationships as well. INFJs often have deep interests in creative expression as well as issues of spirituality and human development. While the energy and attention of INFJs are naturally drawn to the inner world of ideas and insights, what people often first encounter with INFJs is their drive for closure and for the application of their ideas to people's concerns.

INTJ

For INTJs the dominant force in their lives is their attention to the inner world of possibilities, symbols, abstractions, images, and thoughts. Insight in conjunction with logical analysis is the essence of their approach to the world; they think systemically. Ideas are the substance of life for INTJs and they have a driving need to understand, to know, and to demonstrate competence in their areas of interest. INTJs inherently trust their insights, and with their task-orientation will work intensely to make their visions into realities.

ISTP

For ISTPs the driving force in their lives is to understand how things and phenomena in the real world work so they can make the best and most effective use of them. ISTPs are logical and realistic people, and they are natural troubleshooters. When not actively solving a problem, ISTPs are quiet and analytical observers of their environment, and they naturally look for the underlying sense to any facts they have gathered. ISTPs do often pursue variety and even excitement in their hands-on experiences. Although they do have a spontaneous, even playful side, what people often first encounter with them is their detached pragmatism.

ISFP

For ISFPs the dominant quality in their lives is a deep-felt caring for living things, combined with a quietly playful and sometimes adventurous approach to life and all its experiences. ISFPs typically show their caring in very practical ways, since they often prefer action to words. Their warmth and concern are generally not expressed openly, and what people often first encounter with ISFPs is their quiet adaptability, realism, and "free spirit" spontaneity.

INFP

For INFPs the dominant quality in their lives is a deep-felt caring and idealism about people. They experience this intense caring most often in their relationships with others, but they may also experience it around ideas, projects, or any involvement they see as important. INFPs are often skilled communicators, and they are naturally drawn to ideas that embody a concern for human potential. INFPs live in the inner world of values and ideals, but what people often first encounter with the INFP in the outer world is their adaptability and concern for possibilities.

INTP

For INTPs the driving force in their lives is to understand whatever phenomenon is the focus of their attention. They want to make sense of the world -- as a concept -- and they often enjoy opportunities to be creative. INTPs are logical, analytical, and detached in their approach to the world; they naturally question and critique ideas and events as they strive for understanding. INTPs usually have little need to control the outer world, or to bring order to it, and they often appear very flexible and adaptable in their lifestyle.

ESTP

For ESTPs the dominant quality in their lives is their enthusiastic attention to the outer world of hands-on and real-life experiences. ESTPs are excited by continuous involvement in new activities and in the pursuit of new challenges. ESTPs tend to be logical and analytical in their approach to life, and they have an acute sense of how objects, events, and people in the world work. ESTPs are typically energetic and adaptable realists, who prefer to experience and accept life rather than to judge or organize it.

ESFP

For ESFPs the dominant quality in their lives is their enthusiastic attention to the outer world of hands-on and real-life experiences. ESFPs are excited by continuous involvement in new activities and new relationships. ESFPs also have a deep concern for people, and they show their caring in warm and pragmatic gestures of helping. ESFPs are typically energetic and adaptable realists, who prefer to experience and accept life rather than to judge or organize it.

ENFP

For ENFPs the dominant quality in their lives is their attention to the outer world of possibilities; they are excited by continuous involvement in anything new, whether it be new ideas, new people, or new activities. Though ENFPs thrive on what is possible and what is new, they also experience a deep concern for people as well. Thus, they are especially interested in possibilities for people. ENFPs are typically energetic, enthusiastic people who lead spontaneous and adaptable lives.

ENTP

For ENTPs the driving quality in their lives is their attention to the outer world of possibilities; they are excited by continuous involvement in anything new, whether it be new ideas, new people, or new activities. They look for patterns and meaning in the world, and they often have a deep need to analyze, to understand, and to know the nature of things. ENTPs are typically energetic, enthusiastic people who lead spontaneous and adaptable lives.

ESTJ

For ESTJs the driving force in their lives is their need to analyze and bring into logical order the outer world of events, people, and things. ESTJs like to organize anything that comes into their domain, and they will work energetically to complete tasks so they can quickly move from one to the next. Sensing orients their thinking to current facts and realities, and thus gives their thinking a pragmatic quality. ESTJs take their responsibilities seriously and believe others should do so as well.

ESFJ

For ESFJs the dominant quality in their lives is an active and intense caring about people and a strong desire to bring harmony into their relationships. ESFJs bring an aura of warmth to all that they do, and they naturally move into action to help others, to organize the world around them, and to get things done. Sensing orients their feeling to current facts and realities, and thus gives their feeling a hands-on pragmatic quality. ESFJs take their work seriously and believe others should as well.

ENFJ

For ENFJs the dominant quality in their lives is an active and intense caring about people and a strong desire to bring harmony into their relationships. ENFJs are openly expressive and empathic people who bring an aura of warmth to all that they do. Intuition orients their feeling to the new and to the possible, thus ENFJs often enjoy working to manifest a humanitarian vision, or helping others develop their potential. ENFJs naturally and conscientiously move into action to care for others, to organize the world around them, and to get things done.

ENTJ

For ENTJs the driving force in their lives is their need to analyze and bring into logical order the outer world of events, people, and things. ENTJs are natural leaders who build conceptual models that serve as plans for strategic action. Intuition orients their thinking to the future, and gives their thinking an abstract quality. ENTJs will actively pursue and direct others in the pursuit of goals they have set, and they prefer a world that is structured and organized.

## *9.2 Appendix B – Final MBTI® Results for Space IQP Students*

| Group | E/I | N/S | T/F | J/P |
|---|---|---|---|---|
| 1 | I | N | T | J |
| | I | S | T | P |
| | I | S | F | P |
| | I | S | T | P |
| 2 | I | N | T | J |
| | I | S | T | J |
| | E | S | F | P |
| 3 | E | S | T | P |
| | I | S | T | P |
| | E | S | T | P |
| 5 | I | N | T | J |
| | E | S | T | J |
| | E | N | T | J |
| 6 | I | S | F | J |
| | I | N | T | J |
| | E | S | T | P |
| 7 | I | N | F | J |
| | I | S | F | J |
| | I | N | F | P |
| 9 | I | S | T | P |
| | E | N | F | J |
| | E | S | T | J |
| 11 | I | N | T | P |
| | E | S | T | P |
| | I | N | T | P |
| 12 | E | S | T | P |
| | I | N | T | P |
| | I | N | T | P |
| | I | S | T | J |
| 14 | I | N | T | J |
| | I | S | T | J |
| | I | N | T | J |

| | | | | |
|---|---|---|---|---|
| 15 | I | S | T | J |
| | I | S | T | P |
| | I | S | T | J |
| | | | | |
| 16 | E | S | T | P |
| | E | N | T | P |
| | E | N | F | P |
| | | | | |
| 17 | E | N | T | P |
| | E | S | T | P |
| | I | N | F | J |
| | | | | |
| 19 | E | N | F | J |
| | I | N | T | J |

## *9.3 Appendix C – The Survey Administered To Group Members*

Your Name: A)_____ Main Advisor(s): _____

Your Project Partners' Names:

B)_____ C)_____ D)_____

According to Psychological Type theorists, the following terms describe the four major functions performed by members of a successful team.

Visionary -- The person who conceives ideas with ingenuity and logic, contributes strategies and analyses, and is the main source for setting up the problems.

Catalyst -- The person who works by interacting with others about values and inspirations and contributes something personal or a special vision of possibilities. Through this interaction, this person can help "bring out" the answers from other people.

Stabilizer -- The person who works from a sense of responsibility. Through steady and timely work, this person is prepared for current and future problems and is able to keep the group on track.

Troubleshooter -- The person who finds timely solutions to meet urgent needs. This person is adept at solving the unexpected problems that often arise.

1. According to these definitions, which team member best fulfills each of these roles? Check the column for each group member named above – B, C, D, and yourself, A.

| | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| **Visionary** | | | | |
| **Catalyst** | | | | |
| **Stabilizer** | | | | |
| **Troubleshooter** | | | | |
| **Other**** | | | | |

** Please specify a brief description at the end of the survey.

2. How good a fit is the set of roles that developed in your group? (Check one.)

5. ____ Very Good
6. ____ Reasonably Good
7. ____ Not Very Good
8. ____ Not Even Roughly Approximate

3. Were you friends with any of your project partners prior to this project?

Yes____ No____ If so, which one(s)_____

4. How did the leadership of your group emerge? (Check one.)

5. ____ No leader in the group.
6. ____ Leader chosen by group consensus.
7. ____ Leader emerged from within the group.
8. ____ Other - please explain _____

…continued on back →

5. How closely has your IQP advisor work with your group? (Check one.)

5. ____ Our project advisor acted like a "hands off" manager who came up with the initial problem but let us make the decisions on how to proceed.
6. ____ Our project advisor worked with us but avoided micro managing the operational details.
7. ____ Our project advisor worked with us closely and was involved in making all the major decisions.
8. ____ Our project advisor was essentially one of the team members -- a full partner.

6. How much new knowledge do you think your project required? (Check one.)

6. ____ None -- Everything needed was known to team members or easily found in our textbooks.
7. ____ A little -- We found materials during our literature searches and/or discussions with others.
8. ____ Some -- We needed to ask for help and guidance from local experts as well as our adviser.
9. ____ A substantial amount -- We performed extensive research and contacted outside experts.
10. ____ We broke new ground -- Little of what we needed was available in the literature; experts on campus and outside had only vague ideas. Our project has a lot to do with the feasibility of an idea.

7. How often has your group experienced conflict while working on your IQP? (Circle one.)

|----------|----------|----------|----------|
Very Rarely Rarely Sometimes Often Continuously

8. How much progress do you think your group has made thus far? (Circle one.)

|----------|----------|----------|----------|
Very Poorly Poorly Adequately Well Exceptionally

9. Overall, how has your IQP progressed in terms of *teamwork*?

_____

_____

In terms of effective use of time, how has your IQP progressed in terms of *productivity*?

_____

_____

10. Please rate how you feel about the eventual success of your project team and your project report. (Check one.)

**Team Work**
____ Optimistic
____ Pessimistic

**Written Report**
____ Optimistic
____ Pessimistic

11. How many hours per week have you put into actual “time on task” work on your project thus far?

_____

12. How do you think this time commitment will change if the project is to be successful? (Circle one.)

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

| Decreasing Greatly | Decreasing Slightly | Remaining the same | Increasing Slightly | Increasing Greatly |
|---|---|---|---|---|

** Please specify a brief description if you included any member of your team in the other section on page 1.

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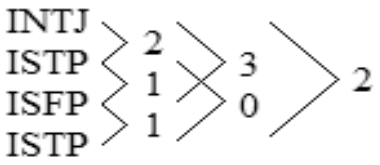
## *9.4 Appendix E - Degrees of Difference List*

Group 1:

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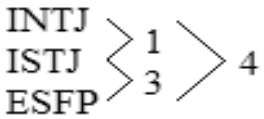


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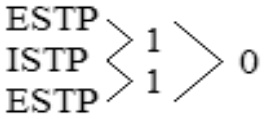


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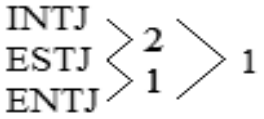


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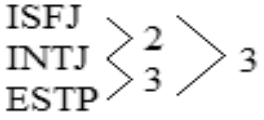


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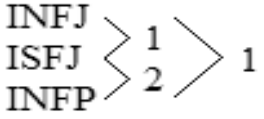


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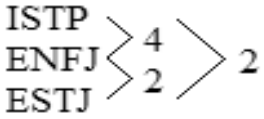


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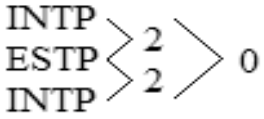


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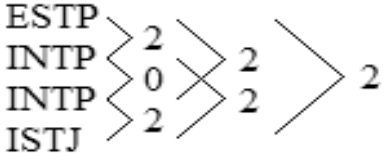

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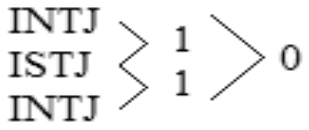


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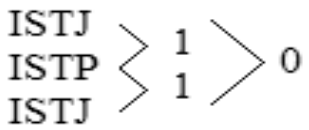


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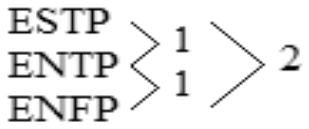


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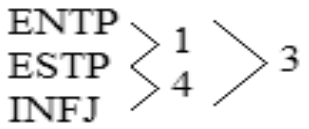


Group 19: