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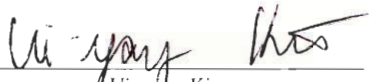IQP/MQP SCANNING PROJECT

THE IQP ON MQPs

An Interactive Qualifying Project Report

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

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ii

Abstract

The purpose of this project is to find the most effective cognitive distribution for a technologically-oriented team. This project will provide evidence that knowing the Myers-Briggs Type Indicator (MBTI) mix of a group can help predict the performance of these groups and that optimization of group composition using cognitive type data has a direct impact on project outcome. The data field was comprised of the Major Qualifying Projects (MQPs) from Worcester Polytechnic Institute (WPI) completed in 2003.

Table of Contents

Table of Figures

Table of Tables

1. Introduction

Throughout the growth of psycho-sociological science, methods of organization of teams to maximize innovation, creativity, productivity, and cohesion have been the subject of a myriad of studies in cognitive type research. These studies have focused extensively on categorizations provided by the Myers-Briggs Type Indicator (MBTI), the Keirsey Temperament Sorter, the Gordon Cognitive Styles Indicator (GCSI), and custom application psychometric associative surveys. When cross-correlated with outcome related variables such as team performance, excellence, and leadership, researchers have been able to uncover significant observations. These findings have refined the understanding of cognitive type theory and its intersection with team dynamics in a way previously unanticipated.

Within both industry and academia, there is a general consensus that psychological typologies factor significantly in the performance of teams and in the collaborative dynamic extant among team members. What remains poorly characterized within the professional literature is the nature of the coordinating nexus that drives project teams to meet and exceed expectations. Within this paper, the authors examine the traditional elements of psychometric classification through the use of the MBTI and the Keirsey classification methods.

This study was undertaken to catalog and analyze team dynamics observed in projects conducted in an undergraduate setting. The analyses would focus on the intersection of the MBTI typologies and the hybrid categorizations afforded by the Keirsey temperaments. Validation of the team dynamics research performed on

mechanical engineering design student teams as described by Douglass Wilde of Stanford University is a central element to the study performed by the authors.

The purpose of this project is to find the most effective cognitive distribution for a technologically-oriented team as well as to verify the Wilde study. This project will provide evidence that knowing the MBTI mix of a group can help predict the performance of these groups and that optimization of group composition using cognitive type data has a direct impact on project outcome. The data field was comprised of the Major Qualifying Projects (MQPs) from Worcester Polytechnic Institute (WPI) completed in 2003. The authors conducted the study by sending over 200 surveys to the MQP teams' advisors. About 42 advisors responded to the survey coupled with the fact that usually there are 2-3 members per team; they received data on 125 students.

2. Background

Worcester Polytechnic Institute (WPI) has since 1972 operated under a curricular environment the university refers to as "The Plan." Since its inception, the program has sought to provide undergraduates the opportunity to place their studies within their major fields of concentration into practice, true to the spirit of the school's motto, "Lehr und Kunst," to wit, "Learning & Skilled Arts." This objective is accomplished through the requisite completion of the Major Qualifying Project (MQP), and the Interactive Qualifying Project (IQP.) The MQP focuses the student's energies in the application of their learning to the "real-world" in a 9 credit-hour practicum which culminates in the delivery of a senior-level thesis paper and the presentation of the project during Project Presentation Day. The MQP is the project of primary focus for the authors in their analysis of team dynamics in the context of psychological type, and it is in this task

environment that the undergraduates demonstrate the collaborative strategies undertaken in their projects.

Project teams for the MQP are typically organized by either the faculty advisor or are self-organizing among the team members as selection occurs among friends and associates. Typically teams are comprised of 2-3 members, although teams do exist with 8-11 members in a specific mechanical engineering project team. The processes for project selection, formation, organization, execution, and resolution each add aspects for examination in the context of cognitive typology and team dynamics.

The sophistication demanded of the participants in an MQP is quite high, and with this requirement is concomitantly developed a level of professionalism in the MQP project team members. Standards for performance are specific and are resolutely set by the university's administration in an effort to standardize comparable grading policies. The language "fell short, met, and exceeded expectations" directly follows from the grading standards for final project grades of C, B, and A respectively as set by the Office of the Registrar & Project Administration. However, in practice those that meet expectations get an A. The result is 75% A grades MQP projects (based on the Class of 2002 dataset). The research undertaken by the authors was an effort to get back to the advisors, ignore the grades and ask which ones really exceeded expectations as opposed to meeting expectation – so as to identify the top 20-25% of project teams in terms of performance.

The number of difficulties to be overcome by the fielding of a comprehensive survey instrument such as the one employed by the authors is sizable, but the resulting mix of variables is worth the effort. In this case, variables were also assembled from

3

other studies for instance the MBTI data was collected as a corollary to other research projects. Therefore, the scope of the project is limited to specific analyses which focus directly on MQP outcomes and their intersection with cognitive type theory. Comparative models, the basis for our hypotheses, include the Wilde study, prior IQPs researching MQP outcomes, and examples of team dynamics afforded in industry. The case study literature includes accounts of the Helios Group at Polaroid, the legendary Skunkworks group at Lockheed, the Data General group that created the first 32-bit computer as immortalized by Tracy Kidder in "Soul of a New Machine," and R&D New Product Development (NPD) teams at Gillette. Other analyses which build upon and expand the reach of the theoretical constructs developed by the authors and their predecessors can be readily performed, and the dataset created by this study continues the foundation of team dynamics research iterations performed at WPI.

Cognitive theory focuses on leadership, conflict, roles taken by specific cognitive types, and identifying the right mix of people for a given task environment. Task environments differ in terms of open-ended and structured goals and whether innovative or productive outcomes are anticipated. There is also a debate under way about whether there exists a cognitive type called the "technologist" type that is needed for a design team to flourish, excel, and exceed expectations. This theory will be expanded upon later when the authors cover the Stanford study by Douglass Wilde who made the initial claim.

2.1 Project History

The study of MQP outcome data stratified by MBTI cognitive typology and Keirsey Temperaments has a more than twenty year history encompassing the experiences of thousands of graduating WPI undergraduates. The continual collection of

qualifying project outcome data in various forms over the years has yielded a dataset

supporting the cumulative research of Dr. John Wilkes, Associate Professor of Social

Science & Policy Studies at WPI. In their research, the authors intend to expand this

significant dataset, and to validate and compare the findings they have uncovered in the

analysis of MQP outcome data for the MQPs conducted during the 2003 academic year.

The research herein described as engaged by the authors have confirmed and

broadened the community's findings. In so doing, the present research has validated

several theoretical constructs important to advancing the formulation of team dynamics

models capable of ensuring greater team innovation, productivity, creativity, and

cohesion.

Back in the 1960s, Gordon and Morse performed a study on group dynamics in

industry. Their point was to try to replicate a previous study by Charanian which

indicated that remote association correlated to a positive outcome at the individual level.

The study engaged by Gordon added the differentiation measure to that of remote

association and identified a difference between people who were good at coming up with

promising research ideas – the differentiators – and those acquiring patents – the remote

associators. Then in the 1980s, almost 20 years later, there was a study performed of 50

MQP students at WPI concurrent with the Helios 8x10 Design Team activity at Polaroid.

Boynton et. al. found the MQP teams to be similar to the research and development teams

found in the workplace in terms of group dynamics. However, the cognitive mix in the

student pool included many fewer remote associators than the elite Polaroid R&D team,

so the correspondence was not exact since most engineers do not do research and

development. That is an elite specialty. But, all engineering graduates at WPI do an MQP – trying their hand at design work (in most cases for the first time outside of class).

A billion dollars was invested in the Polaroid Helios Project, arguably leading to the collapse of the former Fortune 500 Company when the product failed in the marketplace[1]. As the Helios 8x10, 11x17 and NB6 teams could be compared, the 11x17 team finished years beyond schedule, and this delay materially hurt Polaroid as that was the size image needed to try to take over the chest x-ray market. The Polaroid study had an interesting feature as it allowed one to study the troubleshooter / crisis management team that successfully coped with shifting the NB6 plant designed to make Helios film (only) to make it for other producing purposes. The effective team members who stayed on and overcame difficulty after difficulty with fewer and fewer people were primarily high differentiators. Many were also high remote associators, but the implementers and problem solvers fled presumably in search for a more stable and productive task environment. The integrators stayed, and amazingly, the problem finders / assessors elsewhere in the company occasionally volunteered for service in the plant and thus were reassigned there as the departures multiplied.

The WPI studies inspired Gordon to recruit the Vice President of R&D, John Bush, of Gillette to perform additional studies on industrial R&D teams. With Bush's contacts, they hoped to gather cognitive and performance data on about 50-60 groups or teams. Unfortunately only 5 Gillette teams were studied, as no other companies were successfully recruited by John Bush for the study. The results of the Gillette study were promising as one could predict who in a team of 3 members was most likely to solve the problem at hand and acquire a patent in successful groups. With the unsuccessful teams,

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[1] The film did not sell because the scanner was unavailable.

there was some difficulty discerning within the group the problem's source and how it was formulated. This lack of early focus was typically insurmountable despite the presence of considerable cognitive talent in the team that had enjoyed prior success on other teams. That it was impossible to overcome the handicap of a bad start was revealing. Occasionally the result in the "unsuccessful" teams would actually be a technical success, as the team would meet the established specification, but the company ultimately lost money on the ill conceived projects even when the engineers found a way to do what they were told to do.

In studying the Class of 2003 MQPs at WPI, the data the authors have collected includes returns from student questionnaires and advisor questionnaires. Within the dataset are over 40 advisor surveys that have been returned, out of a little over 200 distributed, of which about 70% of the students involved in those projects have taken the MBTI. By completing this project, the authors intend to discover a cognitive mix that consistently does well on projects of this type, under specified task environment conditions.

3. Literature Review

The first step before delving into the instruments used in this study and the results is to inform the reader on the concepts and indicators utilized. These concepts are that of the Jung typologies and the indicators of MBTI, Keirsey Temperament Sorter and GCSI. This section will also provide the general idea of the previous study conducted by Gauntt and Rivera and the study done by Douglass Wilde at Stanford University.

3.1 The MBTI

The MBTI is a test, which describes the cognitive preference of the test taker. For general research purposes, this test was administered to several classes at WPI throughout the years including the class of 2003. The resulting data set will be analyzed to determine what cognitive styles make up a successful MQP group. The instrument tests four different areas of cognition. The four areas are perception, judgment, source of energy, and lifestyle. Because there are four areas, every examinee is divided into one of 16 types.

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ	ESFJ	ENFJ	ENTJ

Table 1: The 16 MBTI types

3.1.1 Source of Energy

When one refers to the source of energy of an object, one is referring to the focus of their thoughts and attention. An extravert (E) judges and perceives the world based on the tangible such as people and objects while an introvert (I) is more directed toward the inner world and put their judgment and perception towards concepts and ideas. Extraverts tend to act before reflecting in a given situation and resort to trial and error to get feedback from the environment when unsure how to proceed. They also prefer large

8

groups of people rather than being alone or with a small number of people. Their source of energy comes from the environment while introverts, on the other hand, absorb the energy from their surroundings and "recharge" when they take a moment for themselves. They regain energy from what they are thinking. They also tend to reflect on a given situation before acting and dislike sharing incomplete ideas or projects. They also prefer to have quiet time to themselves or a small amount of people to being immersed in a large group of people.

3.1.2 Perception

Perception refers to the method of how one processes and acquires the information they receive. A sensing (S) individual tends to use their five senses to acquire the information while an intuitive (N) individual tends to apply another layer of meaning or try to interpret it more than what is sensed by the 5 senses. Sensing people are usually identified as practical and down to earth. As they process information, they tend to direct their attention to the tangible data and thus devalue ambiguous, subjective information. They also tend to miss or disregard information if it is not clear and obvious. They are mostly interested in facts and just want to take in the details. Through these facts and details, they come to understand their surroundings. Intuitive people rely on their subjective and ambiguous information to make decisions. They take the subjective information and process the information as it is acquired. They emphasize the possibilities and implications of the information processed. They can sometimes miss important practical details. Intuitives tend to recognize patterns and relationships among their surroundings where others might see randomness. For example, imagine two groups, one of which consists of sensing type and the other of the intuitive type. They

9

are put in separate rooms and told to "behold a maple leaf." The sensing group describes the leaf in great detail: listing all the parts of the leaf and their functions. Alternatively, the intuitive group sees the leaf and does not go further into details about the function and description. Instead, the group lists everything that comes to mind with the word leaf in mind such as "table leaf" and "leaf from a notebook". They are not working from the same body of information.

3.1.3 Judgment

In other words, how people make their decisions using the information perceived via sensing or intuition. The T-F dimension refers to their preference for logical abstract as opposed to case by case decision making. Some people like to think (T) through their decisions logically based on abstract principles while others like to make decisions based on empathetic feelings (F) and trust their subjective judgments.

Individuals who are thinking types prefer to make decisions with logic and thorough analysis; they distrust subjectivity as a source of bias and feel they make their best decisions when they are being totally objective and impersonal. They tend to value fairness and sometimes play the odds but always have "good reasons" to justify their decisions. Individuals who are feeling types tend to trust their emotions and make decisions with human values in mind hence they think they make their best decisions when they can empathize with those affected by those decisions. Feelings types tend to value harmony over equity. They also have a knack for persuasion and seeing things from the other person's point of view. For example, in evaluating candidates for a job, a thinker would choose final candidate from reviewing their credentials while a feeler

would review the situation of each candidate and hire the candidate that benefits both the company and the employee as they see it, based on a personal interview.

3.1.4 Lifestyles

The lifestyle of an individual is based on a dimension that Isabel Myers developed to determine which is the dominant and auxiliary between the perception dimension and decision making (judgment) dimension for each individual. This category is divided into judging (J) orientated and perceiving (P) orientated individuals. However, over time it has come to be considered more of a "Lifestyle" indicator. People who lean toward the judging end of the spectrum of the MBTI tend to be organized and structured. They like to plan things ahead of time and thrive on deadlines. They like things to come to closure and tend to have a decisive nature. They need to get things done and finished to feel they have accomplished something. A judging person will gather enough information to make a decision and tends to commit to it because of his need for closure and structure.

People who are oriented toward perceiving tend to be flexible and spontaneous. They also thrive on discoveries rather than deadlines and tend to go with the flow as opposed to having a set plan as well as content with open-endedness as opposed to having closure. A perceiving person's dominant is information gathering and they prefer more information to less information when making decisions. They tend to defer judgment as long as possible to acquire as much information as possible and keep their options open. The trait that is shown to the external world is affected by the EI and JP dimensions. For example, if someone is ESTJ, then their dominant as seen by the outside world is thinking (T). However, if someone is ISTP their auxiliary, which is thinking, is shown to the outside world, but on the inside the Dominant trait is actually their

11

preference for sensing. See Appendix 2 for the description by our unknown seminar author that was the basis for our questionnaire.

3.2   Keirsey Temperament Sorter

Before the authors explain this temperament sorter, they would like to make it clear that the original terminology used by Keirsey was Dionysian (SP), Epimethian (SJ), Apolloian (NF), and Promethean (NT). However, for the use of this study, the authors will use the terminology of some unknown presentation[2]. In this reference, the author calls the SJ type traditionalist/stabilizers, the SP type troubleshooter/negotiator, the NT types visionaries, and finally the NF types catalysts. These types, like the MBTI, is based on the Jung terminology. In the online general description of these types at Keirsey.com, the Artisan is the troubleshooter, Guardian is the stabilizer, Idealist is the catalyst, and the Rational is the visionary.

3.2.1 Troubleshooter/negotiator

The troubleshooter is of the SP type. "This is the "Sensation Seeking Personality" -- trusting in spontaneity and hungering for impact on others. They are usually hedonic about the present, optimistic about the future, cynical about the past, and their preferred time and place is the here and now. Educationally they go for arts and crafts, avocationally for techniques, and vocationally for operations work. They tend to be permissive as parents, playmates as spouses, and play oriented as children" (4).

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[2] Professor Wilkes was present at a conference seminar and got a written handout from a presenter who was basing their work (on innovation) on Keirsey's. However, he changed the names of the types, and we used these names coined by the now unidentified presenter (and his definitions) in developing our questionnaire. However, this seminar handout document no longer has a cover page and his identity has been lost, but not his references.

3.2.2 Traditionalist/stabilizers

The stabilizer is of the SJ type. They are said to be, "CONCRETE in communicating and COOPERATIVE in implementing goals, can become highly skilled in LOGISTICS. Thus their most practiced and developed intelligent operations are often supervising and inspecting (SJT administering), or supplying and protecting (SJF conserving). And they would if they could be magistrates watching over these forms of social facilitation. They are proud of themselves in the degree they are reliable in action, respect themselves in the degree they do good deeds, and feel confident of themselves in the degree they are respectable" (4).

3.2.3 Catalysts

The catalysts is of the NF type. They are said to be, "ABSTRACT in communicating and COOPERATIVE in implementing goals, can become highly skilled in DIPLOMATIC INTEGRATION. Thus their most practiced and developed intelligent operations are usually teaching and counseling (NFJ mentoring), or conferring and tutoring (NFP advocating). And they would if they could be sages in one of these forms of social development" (4).

3.2.4 Visionaries

The visionaries is of the NT type. They are said to be, "ABSTRACT in communicating and UTILITARIAN in implementing goals, can become highly skilled in STRATEGIC ANALYSIS. Thus their most practiced and developed intelligent operations tend to be marshalling and planning (NTJ organizing), or inventing and configuring (NTP engineering). And they would if they could be wizards in one of these

13

forms of rational operation. They are proud of themselves in the degree they are competent in action, respect themselves in the degree they are autonomous, and feel confident of themselves in the degree they are strong willed" (4).

3.3   Gordon's Cognitive Style Instrument

fasdfasdf

3.4   Stanford study

The main idea of the Stanford study conducted by Douglass Wilde was that there was a certain type called the "technologist" present in many groups that led to unusually strong performance. To measure performance, he flagged the groups that won Lincoln Design Competition awards. These groups were initially formed using the Gough Creativity Index (GCI). The GCI is a measure of creativity and "empirically determined linear transformation on the four scores generated by the MBTI" (Wilde, December 1996). The question that arose from this index was if it was possible to predict success of a design team and if it could serve as a guide to build more effective teams.

Wilde claims that by using this indicator, he was able to construct teams that succeeded more often. "In 1995, Stanford teams won eleven out of the twelve Lincoln awards given. A more detailed account of the performance over the five years during which these ideas have been applied is given later in the article, which also compares these years with the thirteen preceding" (Wilde, December 1996). This table is shown below, and indicates that Stanford's success rate went from 29-30% to a success rate of 60%.

14

		HIGH GCI TEAMS			OTHER TEAMS			ALL TEAMS	
Period	Years	Number	Prizes	%	Number	Prizes	%	Number	Prizes
1:'77-8/'89-90	13	N/A	N/A	-	N/A	N/A	-	138	40
2:'90-1/'94-5	5	49	31	63%	14	7	50%	63	38

Table 2: Summary Lincoln Prize Awards to Stanford Teams

Another aspect of group dynamics that Wilde studied was the satisfaction of the team experience. He found that the groups that were most satisfied always had at least one EN "brainstormer/synthesizer" member or EF "teamwork/harmonizer" member. The other finding was that of the "technologist" type. Wilde found that if two ISTJs were in the same group, the group had an unsatisfying experience, but each successful team had at least one.

Next, Wilde used a Preference Questionnaire (PQ). This test is a simpler version of the MBTI by "de-emphasiz[ing] the counseling aspects, inappropriate for an engineering course" (Wilde, December 1996). This test is used to categorize the types of each person and place them in a group of four. His ideal group of four consists of "a manager [ESTJ] moderating between a quiet technologist [ISTJ] and a gregarious brainstormer [ENF], with a fourth person of temperament different from all three of the others" (Wilde, December 1996).

The authors' main criticism of this study was that in the using the PQ data, Wilde specifically goes against the official MBTI literature. The MBTI is not a continuous measure in which people are more or less Extraverted or Introverted. It is a hard classification and the numbers refer only to the consistency of the data and hence the odds of misclassification.

3.5 Gauntt/Rivera study

Before this study, Stephen Gauntt and Paul Rivera had done a similar study based on the results of the MBTI. They focused on the conflict potential of a homogeneous group and non-homogeneous group. They defined the homogenous group as "when the team members are similar to one another in terms of the cognitive qualities factors found within the group." They go on to hypothesize that this kind of group will have less clashes and high productivity but as the saying goes, "If two partners always agree, one of them is unneeded." The lowered conflict potential also has a negative correlation to performance on innovative projects. On the other hand, the non-homogeneous group has a higher conflict potential and is more likely to quarrel among its members. The supposed advantage of this kind of group is that they will produce more innovative projects. They also found that the synthesizer led productive teams better than innovative teams.

Steve Gauntt and Paul Rivera investigated Wilde's claims, and they found that the successful MQPs had an ISTJ or INTJ. However, they also found that there was no evidence that the combination of the "technologist" type and synthesizer/harmonizer was necessary for successful projects. Furthermore, the "technologist" type seems to only be effective in projects where innovation was called for.

4 Methodology

This section explains the surveys conducted as well as reasoning behind the changes made to the survey used by our predecessors. This section will also examine the process by which the authors gathered and organized the data for analysis.

4.1   Advisor Survey

The surveys given to the professors contain a series of questions to determine several components. The authors shall analyze each question. The professor survey was split into three parts. Part one is questions relating to the project as a task. This included the degree of definition, the perceived difficulty and the educational potential for the students. The second section inquires about the team's actual performance and includes questions on independence from the advisor, success of the project and roles taken up between the students and the advisor. The third section is a feedback variable. Not many professors filled it out, but the ones that did usually had strong emotions about what they wanted to say. Comments received were both positive and negative.

4.1.1 Questions: Part 1

In question one, the authors asked the professor to rate the degree of difficulty the project entailed. The purpose of this question was to determine how difficult the project was according to the professor who advised it and probably the one who proposed it. This information allows the study to include another variable to determine the effectiveness of a certain cognitive mix in a group.

In question 2,

```
2a. At the outset this project was...
    (1)————————(2)————————(3)————————(4)
    Very Well Defined                              Very Ill Defined

2b. At the outset this project was...
    (1)————————(2)————————(3)————————(4)
    Constrained                                    Open-Ended
```

This question was asked to determine the open-endedness of the MQP. This way, the authors can determine if a certain cognitive mix is better for open-ended projects or constrained projects. These two questions seem to be asking the same thing, but the authors cannot drop one until it is demonstrated to correlate with the other.

> *3a. Did this project break some new ground or incrementally improve an existing concept or design?*
> ☐ *Broke New Ground*   ☐ *Incremental Innovation*   ☐ *Neither (innovation was not called for)*

The question is designed to evaluate the creativity and originality of the group. If they broke new ground, and the authors can consistently show that a kind of certain group mix does that, the authors can make some inferences about that certain group.

> *4b. The material needed to complete this project was distributed across how many classes?*
> ☐ *1*   ☐ *2*   ☐ *3*   ☐ *4*   ☐ *5*   ☐ *6+*

The purpose of this question is to determine the level of explicit and formal preparation for the project.

4.1.2 Questions: Part 2

> *1a. What was the given origin of this project? Was it initially their idea, yours, come from an external sponsor or what? If it was part of your pre-existing research agenda, what stage of the cycle from pilot study or proof of concept to full-scale demonstration or rigorous verification does it represent? Is it a replication or a variation on a theme largely worked out by a prior group?*
> _____
> _____
> _____
>
> *1b. Given the circumstances, the students in this project team were _____ of/on the advisor(s)*
> *(1)————————(2)————————(3)————————(4)*
> *Very Independent*   *Very Dependent*

The purpose of this question is to determine if a certain group excels in an open-ended project or a more structured and defined project.

Most MQPs are part of the design education of the college but some projects are not design projects and are simply production projects where one reproduces an object or design. This is to determine which types of student are most effective with design projects and which types are effective with research projects.

In considering performance, the first question to consider is whether the resulting design was workable and indeed, whether a working model was produced. In short, were the specifications met and did the outcome meet expectations or not? The possibility of a partial success is very real.

3a. The outcome of this project…
(1)	(2)	(3)	(4)
Did not meet Expectations	Barely met Minimum Expectations	Met reasonable Expectations	Exceeded Reasonable Expectations

This is one of the most important questions in the entire survey. It is to determine, in the advisor's opinion, which projects excelled and which projects were a disappointment. This is the most important question on the survey simply because it asks to rate the performance of a particular group. From these responses, the projects can be categorized by the degree of their performance.

4. Level of Creative Ability Exhibited

Projects vary in the extent to which the students doing them come up with novel and useful approaches to a class of problems (given their background and experience). This could be in terms of concepts, methods, process or product design. Projects that are departures from the established procedures or approaches are called "innovative" outcomes.

4a. Would you say that this project produced some results or solutions that were indicative of an ability to be "innovative" on the part of the students?
(1)	(2)	(3)	(4)
No evidence of Innovative Ability			Much evidence of Innovative Ability

The purpose of this question is to what types are the most creative and innovative when put into a group. Theory suggests that the NP Type and ST Type are the most "creative". However, this question is not very useful because the authors do not know how much impact each member had in the group.

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5. Student Leadership and Roles

According to some 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.

5a. According to these definitions, which team member best fulfilled each of these roles? Check the number assigned to each student in the group on the first page (We suggest that you jot down the students initials in the top row to make things easy).

	1	2	3	4	5	6
Visionary						
Catalyst						
Stabilizer						
Troubleshooter						

This question was put into the survey to see if a correlation could be made between the advisor's observation and predicted MBTI results.

5b. How good a fit is this set of roles to the division of labor that developed in your group?
☐ *Very Good* ☐ *Reasonably Good* ☐ *Not Very Good* ☐ *Not Good*

5c. Were there any roles you had to step into to make the group work as a team because the students could not themselves fill those roles?
☐ *Yes* ☐ *No*

If so, which one(s)?
_____
_____
_____

This was to verify if the advisor had confidence in his decisions and if the advisor disrupted the team dynamics of the team by becoming a group member rather than an advisor.

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6. Did you step in and take over a stage of the project for the students?
☐ *Yes* ☐ *No*

If yes, in what stage did you intervene?
☐ *Formulation of Design* ☐ *Execution of Design* ☐ *None of the Listed*

This question was designed to find out if a certain type was possibly missing from the group and the advisor had fulfilled their role.

4.2   Constructing and Organizing the Data

The aforementioned survey concluded in a large amount of data, which needed to be organized. To organize the data the authors entered all the data from the surveys in to Statistical Package for the Social Sciences (SPSS), which also can be used to analyze the data as well as draw up graphs and charts.

4.2.1 Gathering the Data

Once the survey was complete the authors sent out a copy to every professor the authors could find a mailbox for who was listed as having advised (or co-advised) an MQP in 2003. The authors started getting replies after several days and began data entry several days later (once a bit of a pile was created). After about 2 weeks no more seemed to be coming in so the authors took a look at the overall reply rate. Much to the authors'

dismay, the return was less than our predecessors as the authors had a total of 69 replies

and only 48 usable groups to look at. Only about 20% of the surveys were returned.

4.2.2 Organizing the Data

When the authors started this project the authors had not expected to be merging

datasets with our predecessor IQP, but instead comparing outcomes after analysis.

Because of this the authors created our own variables in SPSS which fit our needs and the

new survey instrument. These variables were as follows:

Variable	Description
GroupID	*Contains a unique identifier describing which project the person belongs to*
Name	*The name of the student (Family_Name, First_Name)*
Award	*Whether or not they had received any personal awards upon graduation*
Grade	*Their grade on the project (A, B, C)*
Major	*Their Major*
EI	*A number representing whether they are Extroverted or Introverted on the MBTI scale*
EI_cont	*The mid-value-zero scale of their E/I MBTI Type*
SN	*A number representing whether they are Sensing or iNtuitive on the MBTI scale*
SN_cont	*The mid-value-zero scale of their S/N MBTI type*
TF	*A number representing whether they are Thinking or Feeling on the MBTI scale*
TF_cont	*The mid-value-zero scale of their T/F MBTI type*
JP	*A number representing whether they are Judging or Percieving on the MBTI scale*
JP_cont	*The mid-value-zero scale of their J/P MBTI type*
Diff	*Whether they are a Differentiator on the GCSI scale*
RA	*Whether they are a Remote Associator on the GCSI scale*
GCSItype	*A 4-digit code for their complete GCSI type*
Vis	*From the survey (Q 2.5a) If the professor thought they were a Visualizer*
Cat	*From the survey (Q 2.5a) If the professor thought they were a Catalyst*
Sta	*From the survey (Q 2.5a) If the professor thought they were a Stabilizer*
Tro	*From the survey (Q 2.5a) If the professor thought they were a Troubleshooter*

Table 3: Individual Data Variables

The following table consists of the variables used in the group data set. The

variables mentioned here apply to the group and project as a whole.

Variable	Description
GroupID	*Contains a unique identifier describing the project's name*
MemNum	*The number of members in a group*
Grade	*The grade the project received*
MConf	*MBTI Conflict level (discussed earlier)*
SNSP	*SN/SP count over the number of members*
Polar	*The degree of polarization*

22

Wilde	"Wilde's Technologist & Synthesizer", a 4-value variable of which traits are available in a team
MInno	MBTI Innovation Potential
GConf	GCSI Conflict Potential
GInno	GCSI Innovation Potential
Q1.1A	Scale of project being straight forward to complicated
Q1.2A	Scale of project being well defined to ill defined
Q1.2B	Scale of project being constrained to open-ended
Q1.3A	Trichotomy of opportunity for innovation
Q1.4A	Number of prior classes required for base project knowledge
Q2.1B	Scale of team members being independent to dependent
Q2.2A	Scale or project being educationally successful to not successful
Q2.3A	Binary of whether the project was a design project
Q2.3B	Scale of the project having not met expectations to exceeding expectations
Q2.4A	Scale of the members having no innovative ability to much innovative ability
Q2.5B	How well the student roles described fit the students (this information stored in the Student dataset)
Q2.5C	Binary whether or not the advisor had to fill roles not covered by students
Q2.6A	Binary whether or not the advisor had to take over any stage of the project
Q2.6B	Three-value of which stage the advisor had to step in
NOTES	Notes about the project - This became the place to note if MQP awards were given to the project

Table 4: Group Data Variables

The reason for two data sets was to allow modification of project-based data independent of individual data. That way if a new variable was added, additional data came in or the authors had to update an entry, it would be done on one record in one location. Once analysis began, however, the data files would be merged using GroupID as the primary key.

5 Analysis

When it came time to analyze using the same metrics as the Gauntt/Rivera paper we realized that our new survey had several variables that did not quite mesh with theirs. The problem was two-fold; first, we would not be able to perform all the same analyses on our data and would not be able to see the same overall picture as they presented. Second, future research along the same thread would have to make a decision which survey instrument to use and which set of analyses they wished to perform. The analyses that follow are not numbered sequentially; instead they have been set up for comparison

to the analyses in the Gauntt/Rivera paper. Please refer to appendix 1 for the full listing of analyses performed in their paper.

5.1   Analysis 1: Team Size Effects on Project Outcome

Our first test was to compare the size of the project group with the success of the project as seen by the advisor. As you can see below, groups of three people exceed the advisors' expectations slightly more often than groups of other sizes.
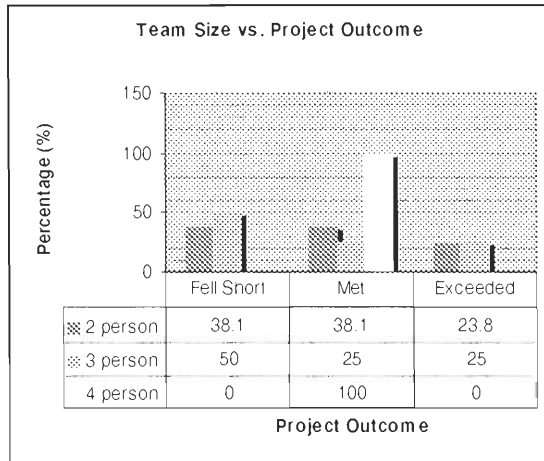

Team Size vs. Project Outcome

	Fell Short	Met	Exceeded
2 person	38.1	38.1	23.8
3 person	50	25	25
4 person	0	100	0

Project Outcome

Figure 1: Team Size Effects on Outcome graph

This varies from our predecessors' findings since they reported that groups of two people had been most likely to exceed expectation. In our case there is no difference in percentage terms, but there are more three person groups than two person groups, exceeding expectations simply because there are more of them. Also, Gauntt found the difference between group performances versus size to be in the upper ranges of performance. Their two person groups would out perform the three person groups when exceeding expectations. Year 2003 data, on the other hand, has nearly identical performance between two and three person groups (23.8% and 25% respectively) when

24

exceeding expectations and a more clear difference in the lower ends. This change from 2002 may be due to a number of different factors. It will not be clear why on the whole the two person groups are a bit stronger until further research is done. There is substantial sound theory on triads that suggest that three person groups should out perform two person groups, so this is a surprise. As in the Gauntt/Rivera paper we must inform the reader that the figures above are the number of *students* in the study and not the total number of groups.

5.2   Analysis 4: E/I vs. Productivity & Innovation

Due to changes in our survey instrument when dealing with innovation versus productivity, when performing this analysis we had to take a different tactic. In our survey we asked if the project broke new ground, was an incremental innovation over the state of the art or was neither. In figure 2 we compare that question with the introversion or extraversion of the members. One of the most striking things about the figures below is it does not matter if you are an introvert or an extravert, if the project was seen as having neither broken new ground nor to have produced an incremental innovation the project never exceeds expectations.
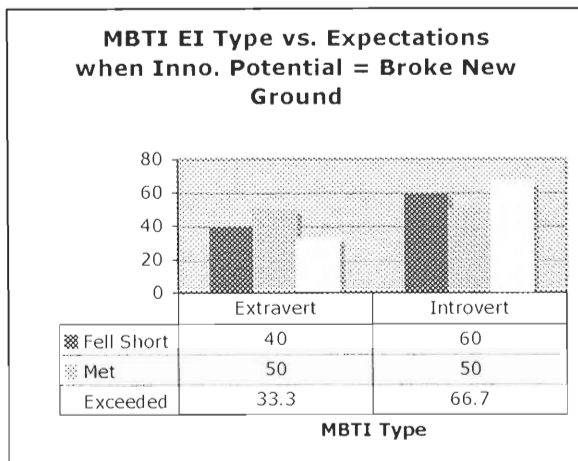
MBTI EI Type vs. Expectations when Inno. Potential = Broke New Ground

	Extravert	Introvert
Fell Short	40	60
Met	50	50
Exceeded	33.3	66.7

MBTI Type

Figure 2: MBTI EI Type vs. Expectations when Innovative Potential = Broke New Ground

MBTI EI Type vs. Expectations when Inno. Potential = Incremental Inno.

	Extravert	Introvert
Fell Short	52.9	47.1
Met	6.7	93.3
Exceeded	30	70

MBTI Type

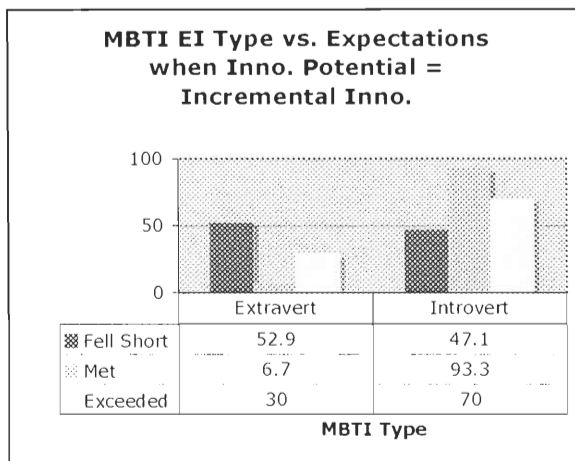Figure 3: MBTI EI Type vs. Expectations when Innovative Potential = Incremental Innovation

Success, as we have measured it, trying to identify the top 20-25% of projects requires that the advisor see evidence of innovation. Therefore, from here on in we will be concentrating on the productive and innovative measures, only bringing up projects that have little to no innovative potential if they break the trend discussed above.

5.3 Analysis 5: E/I & J/P Hybrid vs. Productivity vs. Innovation

Next we performed a cross of the E/I and J/P scales to see if there was a more complex relationship of types. In the figure below there is an increase in group success when an EJ is present. No conclusions can be drawn on that as there is only one data point, however, clustering the data does yield interesting results.

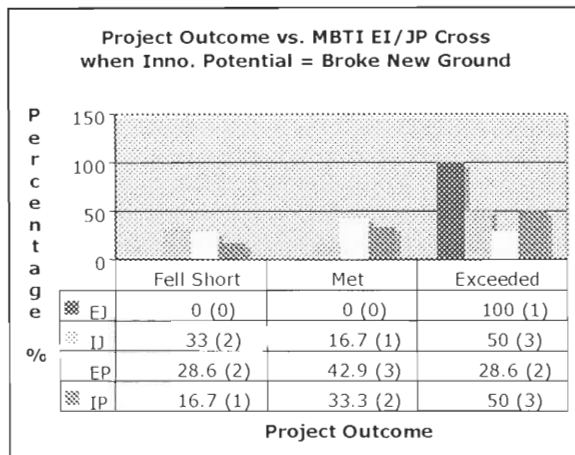| Project Outcome vs. MBTI EI/JP Cross when Inno. Potential = Broke New Ground			
	Fell Short	Met	Exceeded
EJ	0 (0)	0 (0)	100 (1)
IJ	33 (2)	16.7 (1)	50 (3)
EP	28.6 (2)	42.9 (3)	28.6 (2)
IP	16.7 (1)	33.3 (2)	50 (3)

Figure 4: Project Outcome versus MBTI EI/JP Cross when Innovative Potential = Broke New Ground

Collapsing the JP dimension leaving sets of extraverts and introverts shows us that when the project is considered to be innovative there is a clear advantage to having introverts on the team. The data shows a 50% success rate for the introverts and only a 33% success rate for extraverts. Following the same procedure for productive projects we find that both introverts and extraverts perform equally with 20% and 23% respectively.
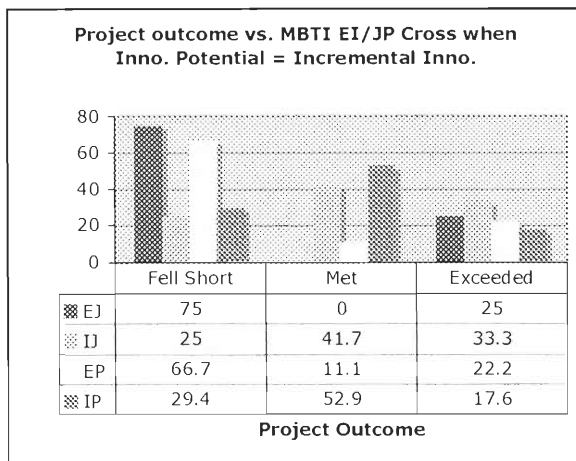
Project outcome vs. MBTI EI/JP Cross when Inno. Potential = Incremental Inno.

	Fell Short	Met	Exceeded
EJ	75	0	25
IJ	25	41.7	33.3
EP	66.7	11.1	22.2
IP	29.4	52.9	17.6

Project Outcome

Figure 5: Project outcome versus MBTI EI/JP Cross when Innovative Potential = Incremental Innovation

The next figure shows the same process where the professor sees the project as an incremental innovation beyond the state of the art. Here the EJ type actually does worse and tends towards falling short of expectations. This might be due to constraints in the project not allowing that type to show their talents. Instead the IJ type comes to the front and performs well, especially compared to the IP's.

Unfortunately, in the last set of data there were not many survey returns. However, the data seem to suggest that when there is little correlation between the E/I J/P MBTI type and project success when there is no innovative potential seen. Further study in how to collect data on the outcome of these projects would greatly help future projects.

5.4   Analysis 6: S/N & J/P Cross vs. Productivity vs. Innovation

The first theme we noticed when conducting this analysis was that WPI has a disproportionate proportion of NP students in these projects. Also, take note that the SJ (some of which fall into the technologist type category) did very well by having half of

28

them exceed expectations. The NPs also showed a propensity to exceed expectations

shown in the figure below.

Project Outcome vs MBTI SN/JP Cross when Inno. Potential = Broke New Ground

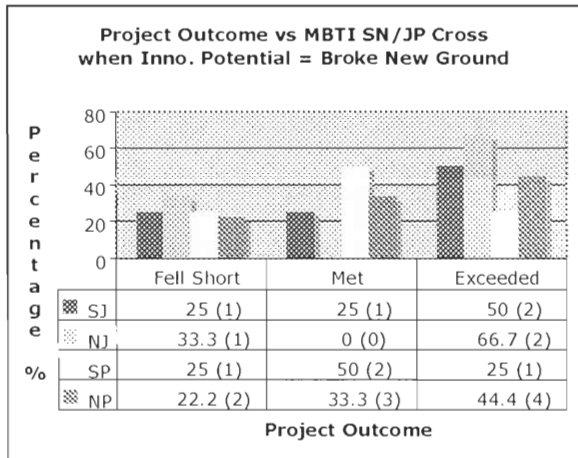|	Fell Short	Met	Exceeded
SJ	25 (1)	25 (1)	50 (2)
NJ	33.3 (1)	0 (0)	66.7 (2)
SP	25 (1)	50 (2)	25 (1)
NP	22.2 (2)	33.3 (3)	44.4 (4)

Project Outcome

Figure 6: Project Outcome vs. MBTI SN/JP Cross when Innovative Potential = Incremental Innovation

In the next figure, the incremental setting, one can see that the NPs are no longer

exceptional and simply average with productive projects. The SJs again continue to show

their prowess for engineering projects in general.

Project Outcome vs MBTI SN/JP Cross when Inno. Potential = Incremental Inno.

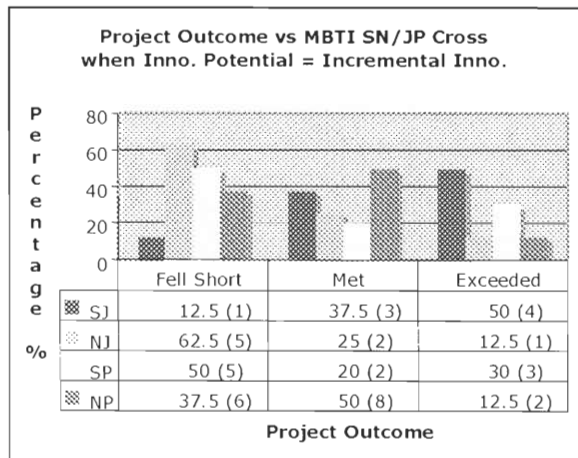|	Fell Short	Met	Exceeded
SJ	12.5 (1)	37.5 (3)	50 (4)
NJ	62.5 (5)	25 (2)	12.5 (1)
SP	50 (5)	20 (2)	30 (3)
NP	37.5 (6)	50 (8)	12.5 (2)

Project Outcome

Figure 7: Project Outcome vs. MBTI SN/JP Cross when Innovative Potential = Incremental Innovation

29

The conclusion of this analysis supports the results found in the Stanford study completely.

5.5 Analysis 12: Wilde Theory vs. Productive or Innovative

From the next figure, one should notice that the technologist better correlates to success more so than the synthesizer alone.
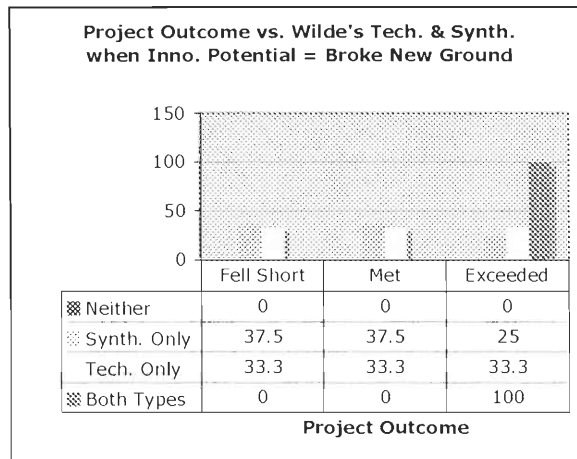

Project Outcome vs. Wilde's Tech. & Synth. when Inno. Potential = Broke New Ground			
	Fell Short	Met	Exceeded
Neither	0	0	0
Synth. Only	37.5	37.5	25
Tech. Only	33.3	33.3	33.3
Both Types	0	0	100
	Project Outcome		

Figure 8: Project Outcome versus Wilde's Technologist & Synthesizer when Innovative Potential = Broke New Ground

In this next figure, notice the trend when both types are present in the group, they are more likely to meet or exceed expectations.

Project Outcome vs. Wilde's Tech. & Synth. when Inno. Potential = Incremental Inno.

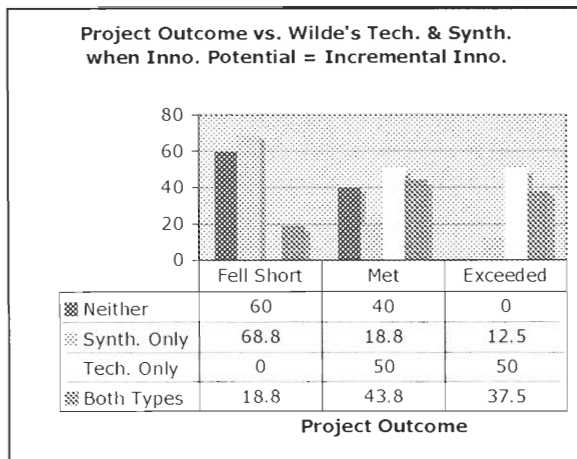|	Fell Short	Met	Exceeded
Neither	60	40	0
Synth. Only	68.8	18.8	12.5
Tech. Only	0	50	50
Both Types	18.8	43.8	37.5

Project Outcome

Figure 9: Project Outcome versus Wilde's Technologist & Synthesizer when Innovative Potential = Incremental Innovation

In this next figure, a synthesizer alone does not help the group perform at all and may even have adverse effects on the group.

Project Outcome vs. Wilde's Tech. & Synth. when Inno. Potential = Neither

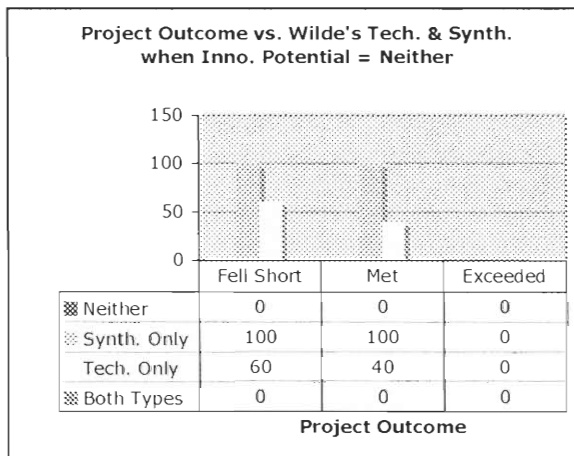|	Fell Short	Met	Exceeded
Neither	0	0	0
Synth. Only	100	100	0
Tech. Only	60	40	0
Both Types	0	0	0

Project Outcome

Figure 10: Project Outcome versus Wilde's Technologist & Synthesizer when Innovative Potential = Neither

In conclusion, the presence of the technologist type in a group increased the chance of exceeded expectation quite a bit over simply having only a synthesizer in the group. And the presence of both a synthesizer and technologist increases chances of success even more.

31

6 Discussion of Results

In this section the authors will discuss the findings which resulted from the administered survey. They will offer different perspectives and theories on why and how each conclusion was reached.

The Class of 2002 data differed from the Class of 2003 data in several important areas. Take note of the numbers of members in a MQP group, because in 2002 most of the projects were two-person groups and were more successful than the three-person groups while in 2003, most of the groups were three-person groups and were more successful than the two-person groups. The authors believe that this is due to the fact that out of the surveys received, they discarded any two-person group with which they did not have MBTI data on both members.

From the data shown, the authors have found the introverts to be more likely to exceed expectations than the extroverts. They believe this is due to the nature of introverts. Because they are more likely to devise a plan before taking action, which is advisable to engineers, they will not suffer the negative effects of progressing too quickly, making large mistakes and beginning once again from scratch which an extrovert is more likely to do.

7 Conclusions

In conclusion, our results did not coincide with that of the other group. This was due to the fact that our data sets could not be combined. In the future, the authors suggest that certain items be changed to benefit the next group conducting this study. First, the authors would like to mention that the survey the authors sent out did not include questions which addressed the leadership issue. The leadership position in a group is important because the cognitive mix of the leader greatly influences the overall results and actions of the group.

Secondly, the authors would like to emphasize the questions on the survey that provided the most substantial information, such as performance measurement and project innovativeness. The performance measurement was important because a project outcome variable is required to evaluate the effectiveness of each group. The level of innovation for each project is important because there is a clear difference between performances of productive projects and innovative projects.

Finally, the last recommendation the authors have is doing a thorough follow-up of the surveys. If the authors had sent out the surveys and made the advisors accountable if their surveys were not returned, the authors could have had a substantial increase in the amount of cases and ultimately, perform a more extensive study.

8 Appendix 1

Listing Metrics Used in Stephen Gauntt and Paul Rivera's paper:

Analysis	Description
Analysis 1	*Team Size Effects on Project Outcome*
Analysis 2	*MBTI Based Conflict Potential Effects on Project Outcome*
Analysis 3	*GCSI Based Diversity Effects on Project Outcome*
Analysis 4	*E/I MBTI Dimension Observations on Project Outcome Factored by Productivity vs. Innovation Project Emphasis*
Analysis 5	*E/I & J/P MBTI Dimension Hybrid Cross Variable Observations on Project Outcome Factored by Productivity vs. Innovation Project Emphasis*
Analysis 6	*S/N & J/P MBTI Dimension Hybrid Cross Variable Observations on Project Outcome Factored by Productivity vs. Innovation Project Emphasis*
Analysis 7	*MBTI Based Conflict Potential Verification*
Analysis 8	*SN & JP Dimensional Polarization Observations vs. Reported Group Conflict Individual Reporting*
Analysis 9	*SN & JP Dimensional Polarization Observations vs. Reported Group Conflict Individual Reporting Represented as a Dichotomy*
Analysis 10	*Group Conflict Individual Reporting vs. Project Outcome*
Analysis 11	*Wilde Theory Verification*
Analysis 12	*Theory Verification Factored by Innovative vs. Productive Groups*
Analysis 13	*Individual Grade MQP Distributions*
Analysis 14	*Individual Grade vs. Project Outcome*
Analysis 15	*Individual Grade vs. Project Outcome Factored by Productivity vs. Innovation Project Emphasis*

9 References

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