

Effective Building and Development of Student Teamwork Using Personality Types in Engineering Courses

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Abstract

Engineers have a high calling of contributing to the betterment of humanity. Engineering projects have become more complicated in recent years. One solution to solving complex problems and working on engineering projects is team building. Competent and effective team building requires time and effort in the workplace or school. To best prepare students to meet the engineering profession's demands and the needs of experienced professionals, teamwork and team building need to be taught in the educational system. Teamwork is also a necessary component of an engineering education. This paper presents ways educators can form student teams for class projects and assignments in order to develop better student teamwork skills.

Different ways of forming student groups are examined in this paper. Those include using Carl Jung's and Isabel Briggs Myers' personality test, using a random lottery system, and pairing motivated with less motivated students. These methods were used in civil and mechanical engineering courses where students had to work on course projects. The assessment of the effectiveness of those methods was conducted by using self and peer evaluations forms, peer group evaluation forms, instructor observations on team dynamics, conducting student interviews, and evaluating final project quality. The observations of this study are analyzed to explore how the different ways of pairing students for group course projects influence team building skills.

Introduction

Engineers have a high calling of contributing to the betterment of humanity. Engineering has become very competitive and projects more complicated in recent years.^{1,2,3} One solution to the competitive engineering environment is team building.^{4,5,6} Competent and effective team building requires time and effort in the workplace or school. To best prepare students to meet the engineering profession's demands and the needs of experienced professionals, it is important to teach teamwork and team building in the educational system. Teamwork is also a necessary component of an engineering education because it provides a collaborative environment around which students can understand and implement the class material. However, in order for students to build the necessary to engineering profession team skills, the team groups should be formed in a way to challenge students and contribute to their professional development.

Over the years, many different ways of forming groups in the workplace or school have been examined. Some of them include using Carl Jung's and Isabel Briggs Myers' personality test, the Factor-C test, pairing motivated with less motivated individuals, using the knowledge differential and level of team members, selecting members with diverse opinions and approaches, selecting and team leader and let him pick his/her team member, letting individuals select their group partners, and others. Shen et. al⁷ focus on different methods of forming groups in the school/ university environment. Out of the ten methods they presented, more than half are based on

random team members' selection while the rest depend on factors such as sex, age, nationality, specialization, previous class performance, and personality or learning style. Shen et. al mentioned that groups in the classroom are most often formed based on random selection. However, other literature^{8,9,10,11} indicates that forming groups in a more elaborate way could prove to be more effective. Even though, there is much research on team building and group forming, there is not a universally accepted best way to form groups to achieve the finest outcome.

This paper focuses on examining different ways of forming student groups to help students develop skills that will make them successful in the workplace. Since, based on the literature, there is not a universally accepted method to form groups as much superior to others, this study focuses on examining the following group formation methods: Carl Jung's and Isabel Briggs Myers' personality test, which is widely used in American companies to form teams, pairing motivated with less motivated students, method often used in academia, and forming groups randomly based on a lottery system because it is a very common way of assigning groups. These methods were used in civil and mechanical engineering courses that included student group course projects. The assessment of the effectiveness of those methods was conducted by using self and peer evaluations forms, peer group evaluation forms, instructor observations on team dynamics, student interviews, and evaluation of project quality.

Forming Student Groups

Carl Jung's and Isabel Briggs Myers' personality test. Carl Jung's and Isabel Briggs Myers' personality test assigns personality types to people based on their preferences on the following four different categories: favorite world, information, decisions, and structure.¹¹ Favorite world looks at the preference of people on focusing on the outer world or their own inner world and it is called Extraversion (E) or Introversion (I). Information has to do with how people process and interpret the information they receive. It is called Sensing (S) or Intuition (N). The third category is about the way one takes decisions. Does he/she base decision on logic and consistency (Thinking (T)) or on people and circumstances (Feeling (F))? The last category is about how people deal with the outside world. Do they prefer to get things decided (Judging (J)) or stay open to new information and options (Perceiving (P))? When the preference in each category is recorded, the personality type is expressed as a code with four letters, one from each of the four categories. That leads to sixteen different personality types. This test is widely used in American companies to form teams and it is used more than twenty years to form engineering design teams.¹² However, some studies have shown that the Myers-Briggs test does not accurately predict behavior and should not be trusted to form teams.¹³ In this study, the test was used to examine if student groups performed better and developed more team skills.

Students were assigned into teams based on the Carl Jung's and Isabel Briggs Myers' personality test results in three sections of the Engineering Management senior level course taught at The Citadel. The three sections had 16, 15, and 14 students, respectively. The course project was about studying the proposed traffic improvement strategies of a freeway corridor, prioritizing

those strategies based on factors students considered significant, providing clear and detailed reasoning for the priority list, and finally supporting their priority list against the list of the other student groups. The project required three deliverables including the final submission, two presentations, and a debate. In addition to the actual project work, teams had to record and submit the time spent by team members by project task during the entire project time. They also had to complete peer-group evaluation forms, i.e., evaluate the work of other groups judging from the presentations other teams did, and self and peer evaluation forms describing how they felt about the themselves and other team members' quality of work, communication, and contribution to the completion of the project (see form in the appendix).

In order to find students personality type, students were required to complete a free online “Jung Typology Test”¹⁴ during the first day of the class and email their results to the professor. The free online “Jung Typology Test”¹⁴ is based exactly on the concepts and categories of the Carl Jung’s and Isabel Briggs Myers’ personality test and consists of 72 yes-no questions. Students’ personality types were tabulated and grouped in four different categories (quadrants) based on a study from Keirsey¹⁵. Table 1 illustrates the personality type quadrants.

Table 1 Personality Type Quadrants.^{15,16}

Rationals (Quadrant 1)	Idealists (Quadrant 2)	Artisans (Quadrant 3)	Guardians (Quadrant 4)
ENTJ – INTJ	ENFJ – INFJ	ESTP – ISTP	ESTJ – ISTJ
ENTP – INTP	ENFP – INFP	ESFP – ISFP	ESFJ – ISFJ

A total of 45 students (38 civil and 7 electrical engineering) took the test and the results are summarized in Table 1 . The different quadrants are color-coded in Table 1 . Light blue, orange, green, and dark blue indicate Quadrants 1, 2, 3 and 4, respectively. The intent of this study was to form groups that consist of four students; one student from each quadrant. However, as it can be seen in Figure 1 and Table 1 , 60% of the students belonged to quadrant 1. This is actually not surprising because Keirsey¹⁵ mentions that the majority of engineers and coordinators belong to that quadrant. In order to justify that Keirsey’s¹⁵ finding and the engineering management student personality results were not too skewed, another survey with the same personality test was given to 41 freshman engineering students at Indiana University Purdue University (IUPU). The majority of students in the freshman class were majoring in mechanical engineering and the rest in electrical engineering. It should be noted that there were no civil engineering major students in that class. Apparently, as seen in Figure 2, the majority of the students belonged in ENTJ and INTJ categories, exactly as observed with the engineering management course results (Figure 1). Also, there is almost equal percentage of students in the other categories for both surveys.

Due to the fact that the majority of students fell in the ENTJ and INTJ categories, three teams with all students from quadrant 1, two teams with students from each quadrant, and seven teams

with at least two students from quadrant 1 and students from quadrant 2 and/or quadrant 4 were formed. The personality types of the students in each team along with the quadrant they belonged to are presented in Table 2.

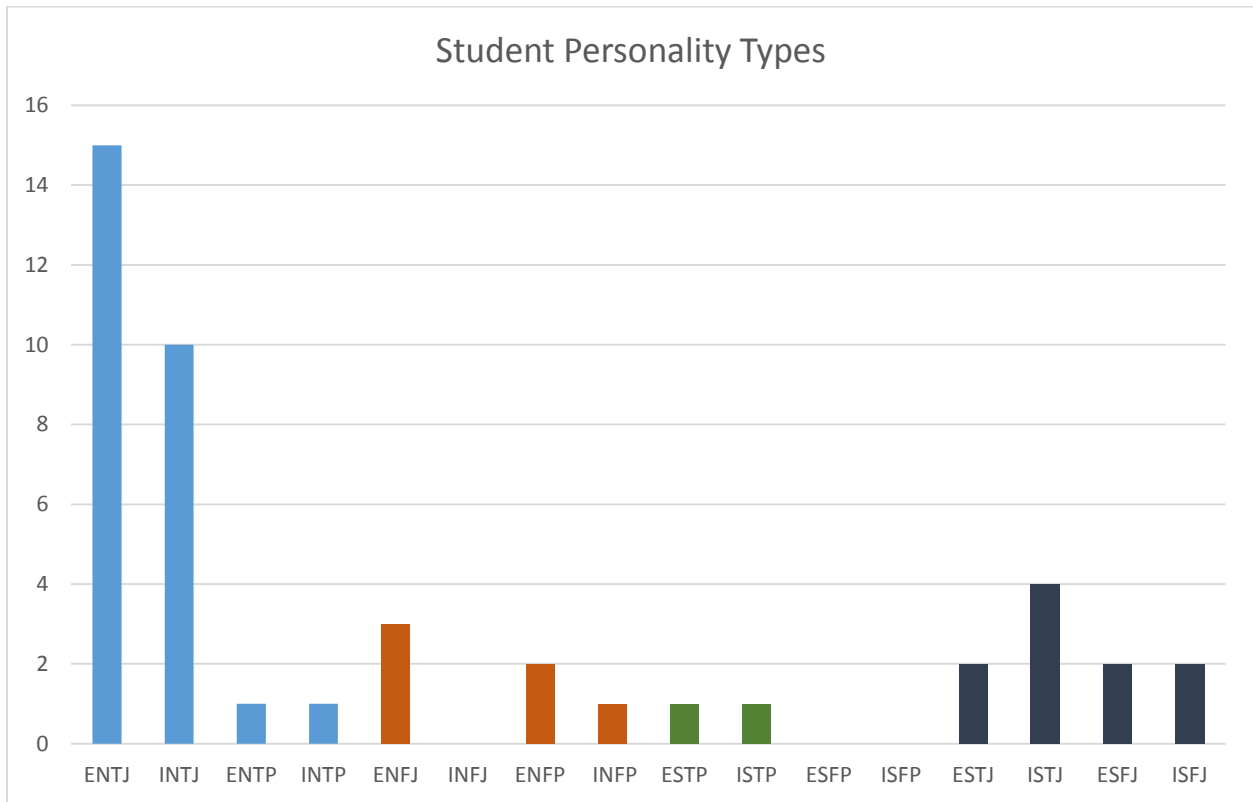


Figure 1 Student Personality Type Results_Civil (85%) and Electrical (15%) Engineering

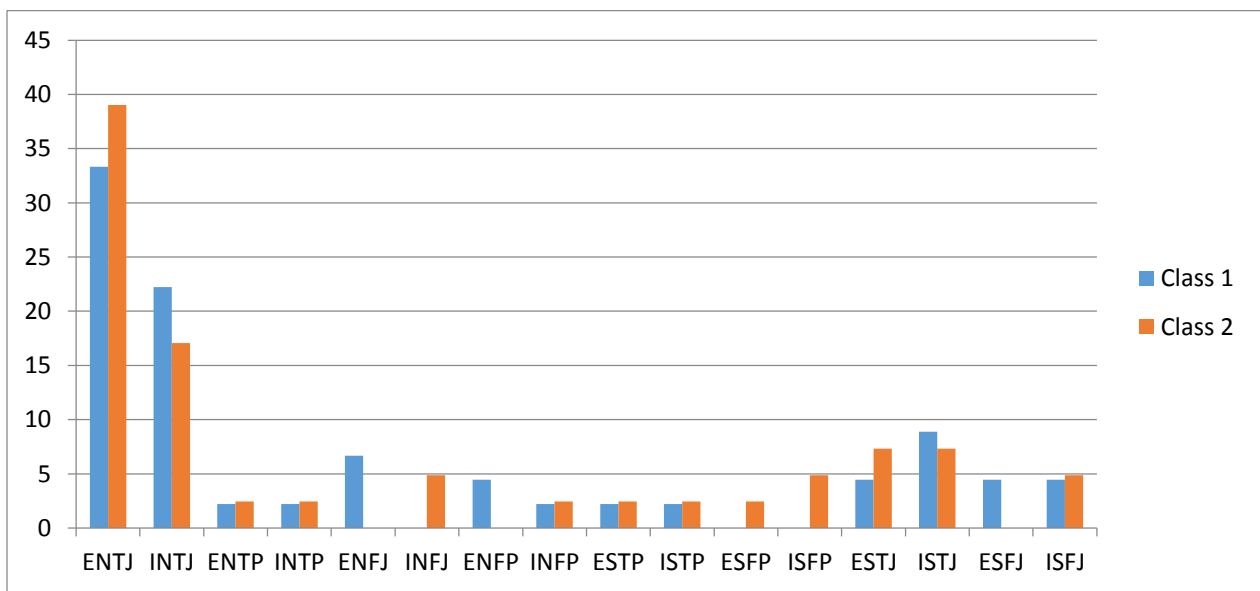


Figure 2 Student Personality Type Results_Mechanical and Electrical Engineering

Table 2 Student Teams

		Teams							
		1		2		3		4	
Section 1	Personality Type	Quadrant	Personality Type	Quadrant	Personality Type	Quadrant	Personality Type	Quadrant	
		ENTJ	1	ENTJ	1	INTJ	1	ENTJ	1
		ENTJ	1	INTJ	1	ENFJ	2	INFP	2
		INTJ	1	INTJ	1	ESTP	3	ISTP	3
		ENTJ	1	ISTJ	4	ESTJ	4	ISTJ	4
		Teams							
		5		6		7		8	
Section 2	Personality Type	Quadrant	Personality Type	Quadrant	Personality Type	Quadrant	Personality Type	Quadrant	
		ENTJ	1	ENTJ	1	INTJ	1	ENTJ	1
		INTJ	1	INTJ	1	ENTJ	1	ENTJ	1
		ENFP	2	ENFJ	2	ENFJ	2	ISFJ	4
		ESTJ	4	ESFJ	4	ISTJ	4		
		Teams							
		9		10		11		12	
Section 3	Personality Type	Quadrant	Personality Type	Quadrant	Personality Type	Quadrant	Personality Type	Quadrant	
		ENTJ	1	INTJ	1	ENTP	1	INTP	1
		ENTJ	1	INTJ	1	ENTJ	1	ENFP	2
		ENTJ	1	INTJ	1	ISFJ	4	ESFJ	4
		ENTJ	1			ISTJ	4		

In the end of the semester, all teams performed very well in their course project. Looking at the project grades, presentation performances, and interaction among team members, there was not any characteristic that stood out among teams with members from different quadrants and teams with members from the same quadrant. Looking at the peer group evaluations where groups had to evaluate the work of the other groups, students seemed able to critically judge and comment others' work. Again, there was not any significant difference among different teams. In addition, in the self and peer evaluation forms where students evaluated themselves and their teammates, there was only one team (team 2) that had one student who seemed to be disengaged in his project work for the entire semester. That student was not engaged in the rest class material and was also absent from many lectures.

In the end of the semester, a random sample of students was interviewed on their group work experience. Some interesting comments from the students include: "It was very hard to build good team dynamics in the beginning of the semester but after some time we were able to work very well together", student from team 1 with personality type INTJ; "I took personally that my

team had to do well in this project and I was able to motivate my teammates”, student from team 11 with personality type ENTJ; “I didn’t like the idea I had to work with people I would not have chosen myself as my teammates but in the end I consider working with them a valuable experience”. It is worth noting that only two students (out of the 45) complained about the professor assigning the teams. The fact that there was some reasoning behind assigning teammates, i.e., teams were formed based on the personality test results, seemed to make students positively receive the experience and discomfort of working with people they would not have chosen as teammates themselves.

Based on both the students’ comments on their group work experience and the professor’s observations on how groups performed throughout the semester, it was clear that students were challenged mainly with the fact that they had to work (in most cases) with individuals that they wouldn’t have selected themselves. That made most of the teams pass through a ‘storming’ period in the start of the semester. However, the best part was that teams did perform well overall and students seemed more willing to work with people that do not know well.

Student groups were formed randomly using lottery system. The same civil engineering students who were assigned in groups based on the Carl Jung’s and Isabel Briggs Myers’ personality test results to work in the engineering management course project, were also placed in groups randomly using a lottery system to work on a highway engineering course project (electrical engineering students who took the engineering management course do not have to take the highway engineering course since it is not part of their curriculum). The highway engineering project involved the design of a two-lane highway using CIVIL 3D, software that students were not very familiar with. The project required five deliverables including the final submission. There was also a competition for the best course project. The winning project received 2% extra at the final course grade. In addition to the actual project work, teams had to complete self and peer evaluation forms describing how they felt about themselves and the other team member quality of work, communication, and contribution to the completion of the project. In this case, each student group consisted of two students.

Student groups were assigned randomly by assigning numbers at student names and then drawing two numbers. The drawing happened during the first class period in front of the students so that students did not complain that the professor was biased while assigning group members. Due to the randomness introduced with the lottery, it was noted that three group types were formed: groups where both students had high GPA, groups where both students had low GPA, and groups with one student with high GPA and one student with low GPA.

In the end of the semester, all groups but one performed above passing grade. About 15% of the students complained because they were not allowed to select their own group partners but others recognized that the discomfort they faced working with classmates they had not interacted much in the past was very beneficial in their professional development. 39 out of 45 students recorded that their team and teammate were awesome/ the best at the peer-evaluation forms which means that, by the end of the semester, they were able to work well with their assigned group partners.

In this case, as in the assignment of groups using the Carl Jung's and Isabel Briggs Myers' personality test, most groups passed through an 'overcoming discomfort period' trying to get to know each other and build rapport between team members.

Based on motivation and class performance. In another semester of the highway engineering course, student groups were assigned based on their motivation levels and class performance at the transportation engineering class that was a prerequisite for the highway engineering class. Highly motivated students with Transportation Engineering course grade "A" or "B", were assigned in groups with less motivated students with grades "C", and "D". It should be stated that, here, highly motivated students were all the ones who expressed an interest in transportation engineering and wanted to do well in the related courses. Also, all motivated students earned A or B in the transportation engineering course. There were 22 teams studied. As stated above, students had to design a two-lane highway using CIVIL 3D. The project required five deliverables including the final submission and a competition for the best course project. Again, the winning project received 2% extra at the course final grade and teams had to complete self and peer evaluation forms describing how they felt about themselves and the other team member's quality of work, communication, and contribution to the completion of the project. In this case, it was greatly emphasized by the instructor that teams had to share the work and really collaborate with each other in order to get full credit.

After observing team members' interactions, project quality, and considering student-professor discussions, the following were observed:

1. Some students with high grades and good understanding of the course material were able to motivate students with worse grades and make them contribute almost equally to the project.
2. Some students with high grades got very frustrated when their group partners were not producing work on the project. In that case, some of them requested to change group partner and others did the majority of the work themselves.
3. Some students with low grades felt they could depend on their partner for all the work.
4. Some groups worked so well together that their grades in the previous course did not influence their performance.
5. Some groups turned in less material than required due to lack of communication.

Forming groups based on grades was not well accepted by the students. About 65% of the students complained about the way groups were assigned and there were many frustrations among team members during the semester. Students with high grades felt it was unfair to work with students who had not done well in previous courses. There were also instances where "A" students had to spend more time explaining and assigning tasks to their group mates than doing the task themselves. Nevertheless, even in this case, all projects submitted received a passing grade, yet 3 projects out of 22 had missing parts and 7 (out of 22) had parts that were very well prepared and parts that had not followed the instructions. Based on the professor's observations, even though forming groups based on class performance was still a valuable experience for the students, it is not recommended due to high number of complaints received. It was actually observed that some A students who were paired with C or D students were so biased that their

partner will not do good work on the project that they did not even try to involve them in the majority of the project tasks. They preferred doing all the tasks themselves rather than meeting with their partner. Situations like this were resolved by discussions among students and professor and proper guidance by the professor.

Conclusions and Recommendations

This paper examined how forming groups using Carl Jung's and Isabel Briggs Myers' personality test, using a random lottery system, and pairing motivated with less motivated students could affect student team building abilities and professional development.

Students seemed to accept well the first two methods used to form the groups because there was some reasoning other than class performance behind them. Their feedback in both cases was positive indicating they greatly benefited from having to work with people they were not familiar or comfortable with. However, assigning groups based on previous courses' performance was not well accepted and there were many frustrations during the semester. In the case of forming groups using Carl Jung's and Isabel Briggs Myers' personality test, no significant differences were observed among different teams. This could be a result of lacking much variety of personalities in the engineering classes. Generally, authors observed that students learned to adjust and develop fast if there was a reasoning behind splitting them into teams more than using grades in previous classes.

Based on all evaluation criteria studied here (group performance, peer evaluations, student interviews, and professor observations), it was evident that students were challenged because they had to work with individuals that they would not have selected themselves as group partners. About 95% of the teams had to overcome personal preferences and focus on producing the work. This was a very valuable experience for them because they had to overcome communication and work related difficulties. The great outcome from this experience was that most groups performed well in their project and also felt more comfortable with working with others that are not very close to them, a skill very valuable in the professional world.

In every case, the professor had a significant role in guiding students, making sure students are on track with the completion of their project and that all team members are involved in doing project work. Also, students need to be reminded that team dynamics, professional communication, and commitment among team members are essential.

Future Steps

In the future, a more robust team building assessment should be developed and used. Perhaps, at the end of the semester, an elaborate survey can be given to students asking them more questions on their experience of working with their group mates. Also, observing and assessing students' professional development in terms of working in teams throughout their 4-year studies could give some good insight on how different course projects and working with people they were not willing to work with in the first place, helped them gain team building skills required in order to be successful in the professional world. Furthermore, the authors would like to obtain data from

students that are majoring in other than engineering majors to study how team dynamics compare in different majors.

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APPENDIX – Self and Peer Evaluation Form

Engineering Management, Self & Peer Evaluation

Name: _____

1. In a scale of 1 to 100, what grade do you expect at your group's final project submission?: _____

2. List the project tasks for which **you** were responsible:

3. List the project tasks for which each of your **team members** were responsible:

a. Name: _____

Tasks: _____

b. Name: _____

Tasks: _____

c. Name: _____

Tasks: _____

d. Name: _____

Tasks: _____

e. Name: _____

Tasks: _____

f. Name: _____

Tasks: _____

4. In a scale from 1 to 10 (with 10 indicating the best in each case), evaluate **you** and your **team members** for the categories shown in the table below.

Questions	Myself	Team Member Initials					
		a. _____	b. _____	c. _____	d. _____	e. _____	f. _____
1. Easy to communicate with.							
2. Was always willing to perform tasks for the project.							
3. Contributed significantly to the project.							
4. We couldn't have completed the project without him/her.							
5. Was often taking initiatives to keep everyone on task.							
6. Came up with great ideas for our project.							
7. Was always available to discuss information about the project.							

5. In your opinion, did the way groups formed make working on the project easier or harder?

Why? _____

6. Other project/team member comments:

Engineering Management, Leadership Evaluation

Disclaimer: The information provided in this form may be used to improve student team and leadership skills' development in the engineering curriculum.

Name: _____

1. If you had to identify a leader in your team, who would that be? (You can identify more than one person and also yourself if applicable)

2. For each attribute listed in the table below, please rate your team leader with respect to teamwork. If more than one leader were identified above, ask for extra forms!!

		Poor	Fair	Average	Good	Excellent	N/A or Don't Know
1.	Created a positive team environment.						
2.	Stimulated group synergy.						
3.	Generated unified commitment by focusing on team vs. personal goals.						
4.	Communicated effectively and honestly.						
5.	Questioned and challenged teammates to achieve the best for the team.						
6.	Built trusting relationships.						
7.	Continually raised the bar for on-going improvement.						
8.	Respected and supported team members.						
9.	Understood and valued individual differences.						
10.	Understood struggles of team members that were not always obvious.						
11.	Formulated a collaborative climate through cooperation, team spirit and fun.						
12.	Actively participated to achieve an excellent project.						

3. In summary, what were the **positive** and **negative** qualities of your team leader?

Positive

Negative

4. Additional comments
