

Building Teammates: Bringing Better Team Skills to Design Courses

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INTRODUCTION

In the past ten years there has been a large push from industry to improve the quality of engineering graduates entering the profession. One of the key deficiencies identified by industry is the tremendous lack of team working skills commanded by new engineers.¹ Last year the National Academy of Engineering recommended that engineering schools “make engineering leadership a principal focus” and develop graduates “who can lead real and virtual teams.”² To address this need there has been a vast amount of research pursued regarding what makes a good engineering design team, typically focused on factors other than skill-set. The researchers have then proposed various recipes for creating the ideal design team based on various personality or thinking style indicators. Unfortunately corporations in industry do not always have the freedom to assemble the ideal design team based on these personality assessments. In most business settings, teams are formed based on skills sets required for the tasks and which human resources happen to be available at the time. Though insightful, the current research into design team recipes has not taken into account those constraints.

The approach taken by professors at the United States Air Force Academy was to look at the basic unit of the team, the individual, and equip the individual with the skills and tools necessary to work in any combination of personality styles. If the military trained only for the best of conditions, they would not be very effective at defending the nation. The same analogy can be applied to engineering students. By equipping students to cope with any situation, they not only excel in the perfectly formed teams but also in the teams where challenges arise. The latter is more likely to occur outside the university environment than the former. These new lessons

focus on first the student understanding themselves and how they interact in team situations, then working to understand the context in which the team is working including the context of the other team members and the customer, skills to resolve conflict within the team, and finally in the management of expectations. This recipe results in an engineer with the ability to work well in any team. To analyze the impacts of this shift in the curriculum, a survey of design team performance and satisfaction before the changes and after has been undertaken. The current hypothesis is that the students with the teammate training will not only perform at least at the same level of the “perfect teams” but also have a more satisfying team experience as well as meeting the industry requirement for developing better team members.

CONTEXT:

It is well known that one of the driving requirements from industry for our new engineering graduates is to be able to perform in teams. Given the increased complexity of today's products, no one engineer can perform all the tasks necessary for project success. John Donne once said "No man is an island entire of itself; every man is a piece of the Continent, a part of the main.... Any man's death diminishes me because I am involved in Mankind; and therefore never send to know for whom the bell tolls; it tolls for thee."³ It was never truer for engineers than today. Unfortunately the academic environment is conditioned on rewarding individual achievement. It is typically not until students have excelled in the individual reward structure for 12 years that we force them to work in teams. When we do this we tend not to provide them with the tools or the language to support this new work practice. Much has been done to attempt to address this. Under a program sponsored by Ford, Michigan State University developed a one-lesson teamwork minicourse for a senior-level Mechanical Engineering class.⁴ Tennessee Technological University uses the Army's Leadership Reaction Course to teach teamwork and leadership.⁵ UCCI has adopted the Emotional Intelligence model to create a course that develops teaming skills in engineering students.⁶ All of these programs build teaming skills in an artificial context for teamwork instruction separate from the engineering task students will face in the real world. The programs do have an impact on building teaming skills in engineering students. It is my experience that lump that knowledge into a separate bin that is not used when they solve engineering problems in teams.

Much of the research into student teams in engineering education has focused on optimizing team formation. Professor Doug Wilde at Stanford has evolved his interpretation of Meyers Briggs Temperament Indicator to build model teams based on using engineering analytical techniques to extract deeper Jungian modes.⁷ Jensen, Feland, et al, have used a simple version of MBTI formation strategies combined with an assessment of creative thinking styles based on DeBono's⁸ efforts to form teams in undergraduate design courses.⁹ This work has proved to impact design team performance in a positive manner. Unfortunately industry tends to form teams based on the domains of experience required for a particular project. These types of individual assessment methods, such as MBTI, are not used form teams. Corporations typically do not have the resources or the diversity of individuals required for form perfect teams in all of their projects. To address this shortfall of undergraduate team-wise education, a new approach is required. Developing the skills within the students to work within any teaming situation addresses this shortfall. The BESTEAMS program has adopted this approach and uses the lens of Kolb's learning skills as a method to improve the teaming environment within the engineering curriculums of the member schools.¹⁰ The approach taken at the Air Force Academy in the sophomore level Introduction to Design Course, ME290 differs in several important aspects detailed below.

IMPLEMENTATION ENVIRONMENT

The United States Air Force Academy is an accredited undergraduate institution. Rated as one of the best undergraduate experiences in the United States by U.S. News and World Report, students serve as officers in the Air Force after graduation. It is difficult to think of another career in which teamwork skills would be more important than that of the military officer. With this in mind, Academy cadets are thrust into teaming situations starting day one of their Basic Cadet Training, affectionately known as Beast. The three domains of the USAFA curriculum, academic, athletic, and military, all heavily rely on team-based education in their respective curricula. Unfortunately cadets do not receive any formal team building training until their junior year of instruction. By this time, cadets have deeply accepted the powerful "cooperate and graduate" teaming model, which relies on trading off heroic efforts rather than coordinating and working with team members in concert. This ingrained method of teaming tends to cause

multiple team meltdowns as team members mooch on each other as they limp their project across the finish line. In the author's own experience there have been on average four complete team meltdowns per twenty teams per semester. Team meltdowns are situations where project work has stopped; typically two sides have been formed; both sides are advocating the assignment of a failing grade to the other faction; and several unpleasant encounters have occurred. This inhibits the pedagogical goals of the project as well as degrades their learning experience.

There is a teamwork course integrated into the core curriculum at USAFA. We believe that the teamwork class taught during the junior year fails to develop teamwork skills due to a lack of real-world context in the course. The course is based on creating artificial situations in which to learn and apply teaming and leadership skills. Cadets are highly aware of artificial constructs and learn to win the game rather than learn the material. In our approach in the sophomore design course we bring teamwork into the context of improving design team performance. Grades tend to be the motivating factor for students. The other main motivator is competition, such as that created between student teams in the final design contest. By casting the team building skills in the context of improving their grades and design contest performance, the level of acceptance and enthusiasm grew significantly.

The team building content was integrated into the sophomore level design course, ME290. Students participate in three design contests throughout the semester long course. The first is an individual project focused on getting the students' feet wet in design and prototyping. The second is a team exercise involving potentially dangerous modifications to NerfTM Guns. The last project is an open ended head-to-head competition involving the typical kit of parts. The training occurred before the teams finished the redesign contest with interventions during the final context.

CONTENT

Initially, four hours of class time was devoted to developing the teaming skills of students. Subsequent implementations have consisted of three hours. In all semesters one hour was devoted to instructor mediated team interventions. The remaining hours were used to cover the following topics: understanding yourself, another session on respecting each other, and the last on what a good team feels like. After these sessions, each team had interviews with the

instructor to discuss teaming issues either viewed by the instructor or revealed through peer reviews.

Understanding yourself

Students were assigned to undergo a battery of personal assessments and create a composite profile to share with their teams. Three assessments were used, Meyers-Briggs Temperament Indicator, a homegrown DeBono 6 Hats of Creative Thinking Styles, and the Johnson Conflict Survey. MBTI has been used by industry and academia alike to assess students and student teams. Most notable is the work by Doug Wilde at Stanford and his modified MBTI analysis used for form teams in a graduate design course.¹¹ The 6 Hats instrument was developed by Dan Jensen at USAFA based on Richard DeBono's book on creative thinking styles. While MBTI allows the students the gain personality insights, 6 Hats reveals information about the creative thinking styles of team members. The following table describes the Six Hats:

| White | Red | Yellow | Black | Green | Blue |
|---|--------------------|--------------------|--|--|---|
| Neutral and objective, concerned with facts and figures | The emotional view | Sunny and positive | Careful and cautious, the "devil's advocate" hat | Associate with fertile growth, creativity, and new ideas | Cool, the color of the sky, above everything else, the organizing hat |

Table 1: Description of the Six Color Hats used in Richard DeBono's Creative Thinking Styles⁸

The Johnson Conflict Survey assesses how students cope with conflict in teaming situations. It provides students with an assessment of their typical response to conflict in five paramount areas, Accommodation, Collaboration, Compromise, Avoid/Withdraw, and Force. Examining the balance of these factors, students can anticipate how their team and they themselves will react to the inevitable conflicts that arise.

The students aggregated their results into a one-page summary. This was done before the results were explained in an effort to limit the "gaming" of the assessments. In class the three assessments were explained and the students were encouraged to share their results with team members. Then, as a reflective exercise, the students were required to comment on the perceived validity of their results as well as summarize the make-up of their team using the shared results. Then students were asked to predict team successes as well as potential conflicts and possible

solutions to these future problems. The students found this to be a useful and entertaining exercise. They were all very eager to learn more about themselves as well as each other. The insights gained proved to be invaluable in the coming weeks as the students moved forward with their projects.

Profile for John Feland

Portrait of the Champion (eNFp)

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The Champion [Idealists](#) are abstract in thought and speech, cooperative in accomplishing their aims, and informative and extraverted when relating with others. For Champions, nothing occurs which does not have some deep ethical significance, and this, coupled with their uncanny sense of the motivations of others, gives them a talent for seeing life as an exciting drama, pregnant with possibilities for both good and evil. This type is found in only about 3 percent of the general population, but they have great influence because of their extraordinary impact on others. Champions are inclined to go everywhere and look into everything that has to do with the advance of good and the retreat of evil in the world. They can't bear to miss out on what is going on around them; they must experience, first hand, all the significant social events that affect our lives. And then they are eager to relate the stories they've uncovered, hoping to disclose the "truth" of people and issues, and to advocate causes. This strong drive to unveil current events can make them tireless in conversing with others, like fountains that bubble and splash, spilling over their own words to get it all out.

Champions consider intense emotional experiences as being vital to a full life, although they can never quite shake the feeling that a part of themselves is split off, uninvolved in the experience. Thus, while they strive for emotional congruency, they often see themselves in some danger of losing touch with their real feelings, which eNFps possess in a wide range and variety. In the same vein, eNFps strive toward a kind of spontaneous personal authenticity, and this intention always to "be themselves" is usually communicated nonverbally to others, who find it quite attractive. All too often, however, eNFps fall short in their efforts to be authentic, and they tend to heap coals of fire on themselves, berating themselves for the slightest self-conscious role-playing.

6 Hats RESULTS!!!!

| score | std dev | +/- std dev | +/- * 100 |
|--------|---------|-------------|-----------|
| white | 2.2 | -1.34893 | -134.893 |
| red | 3.8 | 0 | 0 |
| black | 3.2 | -0.50585 | -50.5848 |
| yellow | 4.4 | 0.505848 | 50.58482 |
| green | 5 | 1.011696 | 101.1696 |
| blue | 4.2 | 0.337232 | 33.72321 |

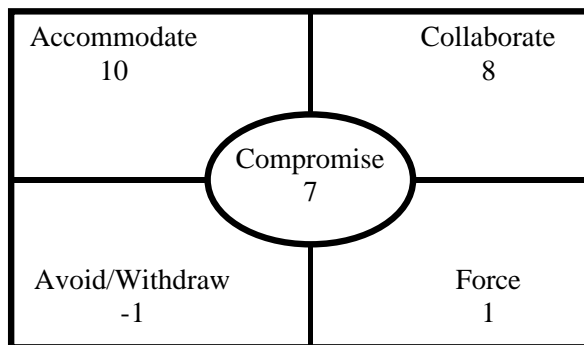


Figure 1: Sample Student Profile prepared for the self-awareness class and used to share with the student teams. This whole assessment only took 30 minutes to complete.

Respecting Each Other

Student teams were exposed to the Seven Fundamental Personal RIGHTS, the concept of expectation management, and four Team Killing behaviors to be aware of. The Seven Fundamental Personal Rights are explained in Table 1 below:

| |
|---|
| To be R espected |
| To I nform/Have own opinions |
| To have G oals/needs |
| To H ave feelings |
| To have T roubles/make mistakes |
| To S elect/choose whether to meet other's expectations |
| To Never Achieve your RIGHTS by violating those of others |

Table 2: Seven Fundamental Personal RIGHTS of individuals used to equip student teams with a common language and expectation for interpersonal relations.

The four Team Killers are Contempt, Criticism, Defensiveness, and Stonewalling/Withdrawal. The students were involved in role-playing activities to explore the impact of team killing attitudes on their own team satisfaction. Each team member was asked to take on one of the four team killing attitudes and work through a simple brainstorming exercise. The impact on the teams was immediately evident. Each team member gained valuable lessons in experiencing and creating these Team Killing attitudes. Again the focus was on equipping the students with the language to identify and cope with potential team conflicts before they rose to meltdown levels.

What a Good Team Feels like

The last session focused on examining the stages of team formation and what roles appear in good teams. We used the five stages of team formation; Forming, Storming, Norming, Performing, Adjourning; to prepare the students' expectations on what they were about to experience in their design teams. Specifically the notion that Storming was part of team formation and a necessary stepping stone on the path to Performing surprised most teams.

The following list details the various team roles members adopt during the team lifecycle. Students were asked to consider which roles they occupied as well as those of their teammates. Special attention was given to the value each role has in the success of a team.

- **Communication**
 - *Active Listener*
 - Very attentive teammate that ensures everyone's voice is heard.
 - Very good at feedback!

- *Influencer*
 - Member that communicates their viewpoint in a manner that wins the team to their path.
 - Member is confident and uses facts to support viewpoints
- **Decision Making**
 - *Analyzer*
 - Analyzes problem from different points of view
 - Uses logic to address potential problems and view system interdependencies
 - *Innovator*
 - Challenges status quo, accepts changes
 - Generates new ideas
 - *Fact Seeker*
 - Focuses on fact based solutions rather than intuition
 - Adds rigor to decision making process
- **Collaboration**
 - *Conflict Manager*
 - Works for win-win, brokers discussions between differing views
 - Openly accepts criticism, resolves team conflicts
 - *Team Builder*
 - Cooperates with others, shares credit
 - Encourages and reinforces contribution by all team members
- **Self-Management**
 - *Goal Director*
 - Creates action plans and timetables
 - Ensures team understands goals and prioritize getting results
 - *Process Manager*
 - Keeps team on task during work sessions
 - Identifies ways to proceed during sessions
 - *Consensus Builder*
 - Solicits inputs from all team members
 - Involves team members in decisions that affect them
 -

Team Intervention

The final intervention took place after a major deliverable for the design contest. Each team was asked to submit peer reviews to the instructor evaluating their teammates as well as themselves in the task to date. The peer review used a monetary bonus and qualitative evaluation system to assess the student teams. The peer assessment appears in the figure below:

Please write the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing the homework assignments. Sign your name at the bottom. The possible ratings are as follows:

Excellent Consistently went above and beyond, tutored teammates, and routinely went above and beyond the basic team responsibilities.

Very good Consistently did what he/she was supposed to do, very well prepared and cooperative.

Satisfactory Usually did what he/she was supposed to do, acceptably prepared and cooperative.

Ordinary Often did what he/she was supposed to do, minimally prepared and cooperative.

Marginal Sometimes failed to show up or complete assignments, rarely prepared.

Deficient Often failed to show up or complete assignments, rarely prepared.

Unsatisfactory Consistently failed to show up or complete assignments, unprepared.

Superficial Practically no participation.

No Show No participation at all.

Additionally your contracting team has been awarded **\$5000** to use as bonus money. Distribute the bonus money amongst your team member s based on your view of their performance. Don't forget to give yourself some funds!!

These ratings should reflect each individual's level of participation and effort and sense of responsibility, not his or her academic ability.

| Name of team member (Include Yourself) | Rating | Bonus |
|---|--------|-------|
| | | |
| | | |
| | | |
| | | |
| | | |

Figure2: Sample Peer Assessment Form using a shared language qualitative assessment and a limited resource monetary bonus assessment method.

The qualitative method relies on the use of a shared language of assessment. By providing definitions for the vocabulary used in rating yourself and your teammates, this creates a more consistent and understandable assessment of team effort between team members. The monetary bonus system differs from the typical 1-10 rating in that there are limited resources to distribute to yourself and teammates. Typically in this scenario students rate everyone on the team 10's!

With the limited resources of the bonus pool, students cannot “firewall” teammate ratings. Additionally it seems that because this is a money based peer assessment, students tend to take it more serious. Both tools lead to better understanding of team performance and inter-teammate relations. The instructors then used this information to conduct a team interview. This was an opportunity for the instructor to comment on team behavior he had observed while also exploring the interpersonal dynamics revealed by the peer reviews. This team-instructor interaction proved invaluable to understanding and addressing teaming issues. It also provided an excellent chance to assess the course and gather suggestions from students.

ASSESSMENT

Initial results indicate improved team satisfaction for the teams that received the training. During the semester prior to the implementation of the teamwork content had several team problems including three significant team meltdowns. In these meltdowns there was a total breakdown in team communication and project performance was dismal. In the semesters with the team training, not only were there not any meltdowns but also an increase in team satisfaction. This is not to say there were no conflicts but in every case the students worked through the issues, sometimes with some faculty assistance. One potential reason for this improvement is that the training provided student teams with an understanding that conflicts will arise in the course of the project and equip students with a common language and framework to communicate and address these issues.

The class had a perspective student visit during the second of the teambuilding lesson. Puzzled that a design class would be covering such a "touchy-feely" topic, he asked the instructor why this was the lesson of the day. Before the instructor could respond to the question, students in the class began to defend the lesson. "Although this stuff seems like common sense it's good to have a reminder." "Yeah, something happens when you come to college and you forget how to work well with people. This has been a great review of how to be a good team." I was proud of my students and surprised at how much they realized the need of such content.

Did the class adequately prepare you for your group experience?

1 2 3 4 5

Describe how your team worked together.

Group of Individuals

1 2 3 4 5

Integrated Fluid Team

Did everyone have an equal voice?

One person's monologue

1 2 3 4 5

Everyone was heard

How would you rate your team experience?

Never want to see them again.

1 2 3 4 5

We all hung out last night.

Were your teams goals achieved by the end of the project?

What's a goal?

1 2 3 4 5

All achieved.

Were your individual goals achieved by the end of the project?

No

1 2 3 4 5

Yes

Would you work with this team again?

When _____ freezes over.

1 2 3 4 5

When do we start?

How often did conflicts arise?

It was a constant argument.

1 2 3 4 5

Never?

How effective was the team at resolving these conflicts?

They wouldn't stop talking about my mom.

1 2 3 4 5

Conflicts were resolved quickly and professionally.

How well did you manage each other's expectations regarding project efforts?

They have needs to?

1 2 3 4 5

We were fully aware of everyone's motivation.

How well did you express your expectations with respect to project efforts?

I wanted them to guess what I wanted.

1 2 3 4 5

The team knew of my needs and desires.

Figure 3: Student Team Survey of team satisfaction based in individual assessments. This survey was given to students after the end of the semester and the final design contest in conjunction with a peer assessment form.

A class survey on team satisfaction was given to the students. Analysis of this data will be published at a later date. Preliminary results indicate that there are significant improvements in

student satisfaction in the semesters with the team building training. In the semesters the team awareness training was implemented student performance and team satisfaction went up. In fact student performance was the highest in the ten-year history of the course! It would be absurd to assume that this is due only to the introduction of team training. There is a well-known relation between student satisfaction and performance. We have shown that the training has improved team satisfaction and therefore can make some claim for increased performance levels as well.

FUTURE DIRECTIONS

This material is still being used in the introductory design course at the United States Air Force Academy. The last two lessons have been combined into one and the team interventions are still taking place. There have been no major team meltdowns since the material was introduced. The material is now being integrated in a graduate Global Entrepreneurial Marketing class for engineers in the Management Science and Engineering Department at Stanford University. It is being used to better prepare students for working in their project teams while building their self-awareness. Similar assessments are being performed with this group of students and it will be reported out on in the future. The content continues to evolve as best practices are integrated.

BIBLIOGRAPHY

- 1) Donne, John. "Devotions Upon Emergent Occasions", Meditation 17 (1624).
- 2) Katz, Susan M. The Entry-Level Engineer: Problems in Transition from Student to Professional. *Journal of Engineering Education*. 82(3), July 1993, 171-174.
- 3) Morgan, R. P., P. P. Reed, and W. A. Wulf. The Changing Nature of Engineering. *ASEE Prism*. May-June 1998.
- 4) Somerton, C. "Incorporating a Team Building Experiment into a Senior Level Laboratory Course," *Proceedings of the ASEE Annual Conference*, June 1999.
- 5) Hunter, K., Matson, J., "Engineering Leadership and Teamwork Development through Experiential Learning," *Proceedings of the ASEE Annual Conference*, Albuquerque, June 2001.

- 6) Crowley, L., Dolle, J., et al, "Engineering Emotional Intelligence: Course Development and Implementation," *Proceedings of the ASEE Annual Conference*, Albuquerque, June 2001.
- 7) Wilde, Doug, "Design Team Roles," Paper no. DTM-99 003, Proceedings of the 1999 ASME Design Engineering Conferences September 12-15, 1999, Las Vegas, Nevada.
- 8) DeBono, E., Six Thinking Hats, August 18, 1999, Little Brown & Co
- 9) Jensen, D., Feland, J., Bowe, M., Self, B., "A 6-Hats Based Team Formation Strategy: Development and Comparison with an MBTI Based Approach", *Proceedings of the ASEE Annual Conference*, St Louis, June 2000.
- 10) Schmidt, L., Mead, P., et al, "BESTEAMS" Building Engineering Student Team Effectiveness And Management Systems," *Proceedings of the ASEE Annual Conference*, June 1999.
- 11) Wilde, Doug, "Design Team Roles," Paper no. DTM-99 003, Proceedings of the 1999 ASME Design Engineering Conferences September 12-15, 1999, Las Vegas, Nevada.

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