

TEACHING TEAM DYNAMICS: EXPERIENCES IN SECOND-YEAR MECHANICAL ENGINEERING DESIGN

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ABSTRACT

The evolution of team dynamics activities in Mechanical Engineering at the University of British Columbia (UBC) is presented with student feedback and key lessons learned. Rather than leave it to students to learn team skills on their own, formal teaching of team dynamics has been part of the second-year Mechanical Engineering curriculum at UBC for approximately the past ten years. In early attempts, students displayed widespread disinterest and resistance towards learning team dynamics. The content and delivery of team dynamics material has evolved to the point where, now, almost 85% of students cite this material as being valuable and helpful. The key elements that appear to have made the new approach successful include presenting the material in a manner that is directly and immediately relevant to individual students and project teams, as well as having the material permeate throughout all elements of the course.

KEYWORDS

Team dynamics, engineering teams, engineering education.

INTRODUCTION

Team work is an essential experience in an engineering student's education, and is increasingly expected in higher education in general [1][2]. As part of new outcomes-based requirements for engineering graduates, programs must demonstrate to accrediting bodies (including CEAB in Canada, ABET in the US, EAB in the UK) that graduates can "function effectively as an individual, and as a member or leader in diverse teams" (to use the language in the Washington Accord [3]). Often, opportunities are provided in engineering courses for students to work in teams but explicit instruction and discussion of team function and maintenance is not included; rather, teams are left on their own to learn about team dynamics and the course instructor's role is to react to issues when they arise. As Lovgren and Racer [4] found when instituting a series of projects for integrated engineering teams, it is often easier to teach engineers advanced technical tools than it is to get them to function effectively in a group.

There is hope, however. In working with medical students, Bergen et al. [5] found students' attitudes towards teams dynamics was positively influenced by a one-week experiential learning course in professional development. Moreover, they found the students who would be least likely to voluntarily attend such a course were the ones who learned the most. Others too have reported success in including team dynamics instruction as part of their curriculum [6][7][8]. But, as Babad and Oppenheimer write [9], "the most basic dilemma in teaching group dynamics is how to balance and integrate the cognitive-intellectual learning and affective 'personal' learning." In our experience, this is a particularly important issue as the majority of engineering students' formal instruction is based almost entirely in the cognitive domain and they dismiss or oppose learning activities that delve into the affective domain or non-technical subjects.

In short, students need team skills and there is evidence to suggest it is possible to teach and develop these within courses. The challenge in engineering is in presenting the material in a manner engineering students will appreciate and embrace.

Formal coverage of team dynamics was first introduced to the Mechanical Engineering curriculum at UBC in approximately 2000. During these first years, students were largely disinterested in the content and resisted opportunities to engage in the material. Starting in 2004, significant changes to the curriculum were adopted including an increased emphasis on team work. The emphasis on team dynamics and the content presented has evolved year-upon-year such that a vast majority of students now report that they find this material as being valuable and helpful. What follows is a description of the evolution of team dynamics activities in UBC Mechanical Engineering. A description of the context (the course and the student teams) is provided followed by an overview of the team dynamics elements incorporated within the courses. The paper concludes with student feedback on the team dynamics coverage and a summary of key lessons learned.

CONTEXT

Second Year Mechanical Engineering Design Curriculum

Prior to 2004, the second year Mechanical Engineering curriculum at UBC was conventional in nature. The roughly 120 students took 15 separate courses running over a 2-term system. Design was covered through a 3-credit course (MECH 251) that utilized 2 lecture hours per week, 2 tutorial hours, and 2 out-of-class design projects. Design projects were conducted in teams and included the design, construction, and operation of physical prototypes as well as formal oral presentations and written reports. Starting in 2004, significant changes to the entire curriculum were adopted with the introduction of an integrated program called Mech 2 [10][11].

Included in the Mech 2 program was an increased emphasis on design through a new 7-credit course (MECH 223) running full-time over 7-weeks in total. The first part of MECH 223 begins in January and runs full-time for four weeks. Students learn about design theory and immediately apply it, along with engineering science content from their first term courses, to a team design project. The projects culminate with a competition between all teams followed by formal oral presentations and submission of formal written reports. Following nine-weeks of instruction in a separate engineering science course, there is a second portion of MECH 223 which lasts three weeks, again full-time. This second half of the course follows the same format as the first but this time the project focuses on the more recent engineering science course.

Course grading in MECH 223 has both individual and team components. 50% of each student's grade is based on individual elements (6 reading quizzes, 2 midterm exams, and 2 final exams)

and 50% is based team elements (6 team reading quizzes, 2 projects, 5 computer labs, and 20 tutorial exercises). Team grades are modulated by a peer evaluation score for each student.

Team Formation

The MECH 223 course has approximately 120 students divided into 20 teams of 5 or 6. Following recommended practice, teams are instructor-formed [12] in order to maximize diversity [13][14] and to minimize previously established subgroups [15]. Near the end of the first term, roughly one month prior to the first MECH 223 class, students complete an online personality type assessment modelled after Myers-Briggs (*TypeFocus* [16]) as well as an online survey where they self-rate their ability in a range of capacities (machine tools, hand tools, software tools, written and oral communication, and instrumentation). Additional survey questions are used to determine if students have vehicles they can use during projects (for procuring project materials), if they have laptop computers (for in-class team exercises), where they live (so they can be placed with students who live nearby), and so on. The results of the personality type assessment and the survey, as well as grades from first term courses, are then used to sort students into teams. (The use of Myers-Briggs types in forming student teams is also used by others; Lester et al. [7] suggest the use of Myers-Briggs is one approach to minimize 'disaster groups' in engineering projects.) The same teams are maintained for the course duration.

METHODS OF TEAM DYNAMICS INSTRUCTION

Early Approaches and the Need for Change

Since roughly 2000, team dynamics has been formally presented in workshops within the design courses. The workshops are lead by trained facilitators from UBC Career Services and have focused on discussing characteristics of effective teams, reviewing common group dysfunctions and strategies for addressing them, and providing strategies to manage interpersonal conflict.

The early attempts to teach team dynamics enjoyed limited success. Students demonstrated little interest in the material: they were physically disengaged during the workshops, they were at times disrespectful to workshop facilitators, and in some cases they commented openly during workshops that team dynamics was not an important topic for engineers to learn or practice. Consequently, workshop attendance was poor, requiring attendance checks and penalties for those not attending, and students often left during workshop breaks and did not return. With the change from the MECH 251 course (conventional curriculum) to MECH 223 (Mech 2 integrated curriculum) in 2004, the team dynamics workshops were also redesigned. The primary changes in the workshops were targeted at:

- making the workshops more personally relevant to individual students
- making the workshops more relevant to the design projects
- integrating the workshop content more closely with the rest of the course material

As a 'hook' to make the team dynamics workshops more personally relevant, the workshop topics were changed from general presentation of working styles to specific discussions of working preferences associated with Myers-Briggs. The thinking behind this was that students would be naturally more invested in learning about team dynamics material if there were specific elements that applied personally to them; through Myers-Briggs, each student would be able to see how their approach to viewing the world, interacting with others, and making decisions differs from their classmates. In addition, it was believed that Myers-Briggs would appeal to

engineering students in that Myers-Briggs is a proven scientific instrument that has been widely adopted and has extensive data to validate its accuracy.

To make the team dynamics workshops more relevant to the design projects, in about 2007 they were moved to the start of each of the two projects. (Previously, the workshops were schedule somewhat arbitrarily through the term and project links were made on an ad hoc basis.) With the workshops at the start of the two projects, the teams are asked to anticipate possible problems and think of strategies to deal with them. The workshops build on the natural excitement that comes at the start of the projects; they provide tools before they are needed and before the workload, personal stress, and group tensions rise. The second workshop in particular, at the start of the second project, allows the revisiting and debriefing of experiences from the first project, after students have had time for personal reflection and some emotional separation from the team experiences.

Lastly, whereas team dynamics used to be relegated to isolated workshops, it now permeates through the course. At every opportunity, the course instructors make reference to the team dynamics material and draw from experiences and activities in the workshops. Recognizing that assessment is an essential component of significant learning experiences [17], evaluation of team dynamics theory appears on reading quizzes, midterm exams, and final exams.

Overview of the Current Approach

The current implementation of team dynamics includes the following elements:

- Before the start of the course, students complete a *TypeFocus* assessment to identify their personality temperaments. This information is also used by instructors to form project teams that possess all Myers-Briggs personality types.
- Material on Myers-Briggs is included as part of assigned readings and is tested, along with material on design theory, on a reading quiz at the start of the course.
- A 2.5-hour workshop at the start of the course explores the Myers-Briggs types and how they function together on a team (the workshop details are summarized below).
- Each team prepares their own “team contract” at the beginning of the course to agree upon expectations of behaviour, effort, and the use of peer evaluation. Teams revisit and rewrite their contract at the start of the second project.
- After the first project, students complete a survey reflecting on and assessing the performance of their team and themselves in various aspects related to team dynamics (a summary of survey questions is provided below).
- A second 2.5-hour workshop at the start of the second project debriefs the survey results from the first project and provides tools for giving and receiving feedback as well as addressing conflict within the group (a detailed workshop summary is provided below).
- *iPeer* [18] (an online peer evaluation tool) is used for students to conduct compulsory peer evaluations of their team mates each week in the course; 50% of each student’s course grade is based on team marks adjusted by a peer evaluation score (see [19]).
- Midterm and final exams assess students understanding and their ability to apply team dynamics material in hypothetical situations.

Summary of Workshop 1 (Personality Types)

Workshop 1 focuses on differences in personality types and working styles (through Myers-Briggs). The workshop is run in two sessions of approximately 60 students each, and students attend the session with their team. The specific elements of the first workshop are as follows:

- Some “ground rules” are presented (communication is to be respectful and professional; personality types are on a continuum and are meant to describe, not to “pigeon hole”; all types have their own strengths and blind spots; and so on).
- Having already conducted the *Typefocus* test and read about Myers-Briggs, students are split into small ad hoc working groups to summarize the different personality types. Each group takes a particular continuum (introversion-extroversion, sensing-intuition, thinking-feeling, and judging-perceiving). An informal discussion follows where the groups report back to the class. The focus is on the strengths that each type brings to the team as well as the possible trouble spots they need to be aware of.
- A variety of activities have been used at this point to demonstrate and reinforce that there are observable differences in thinking and behaviour for the various personality types. For example, an interesting photograph has been shown for a short duration and then students write freely about the words come to their mind; when students report back to the class, this activity highlights how those with a preference for sensing tend to focus on observable details while those with a preference for intuition tend to focus on abstract qualities. Likewise, the survey used for group formation comes with a time stamp so it is possible to statistically demonstrate that students with a preference for judging tend to both start and finish the survey more quickly than those with a preference for perceiving.
- Some additional material is presented on common strengths and issues associated with each of the Myers-Briggs types when working in a team. Using this material, the teams work to identify where they feel they may have problems in the first project. These issues tend to relate to having equal voice, idea generation, decision making, and staying on task (i.e. the Myers-Briggs I-E, S-N, T-F, and J-P continua). The teams then identify specific strategies they will use to avoid or mitigate the issues they have identified.

Survey Questions Asked Following the First Project

Immediately following the end of the first project, students are given a compulsory online survey about their team experiences in the project. The purpose of this activity is twofold. First, it is used to encourage students to reflect on the team process they just went through in the first project. Second, the survey responses are used to identify common difficulties among teams so that in the second workshop the underlying issues can be discussed and possible solution strategies can be identified.

The actual survey consists of 21 questions, including 18 multiple choice questions on six key areas of team dynamics adapted from Otto and Wood [20]. These six areas are described below (using the same wording students see) and, for each, students use a 1-10 scale to rate the importance of the criteria, how they feel they themselves performed in that area during the project, and how they feel their team overall performed in that area.

- **Unity:** Unity exists when the team creates a strong common purpose, sticks together, and people support one another.

- **Communication:** Effective communication is open and two-way, with discussions that are in-depth with careful listening.
- **Distribution of Responsibility:** Effective distribution of responsibility occurs when all members have equal say and tasks are fairly distributed and carried out by all members.
- **Problem Solving:** For effective problem solving, everyone's ideas are used to solve problems and contribute to the project's final plan.
- **Conflict Management:** In effective conflict management, differences in opinion are acknowledged and a sound and fair resolution is reached through discussion.
- **Group Self-Evaluation:** Effective group self-evaluation occurs when the group periodically takes time to critique, discuss, and improve its performance.

In addition, the survey includes three open-ended (written response) questions about more general team dynamic issues. These questions (using the same wording the students see) are:

- Thinking in terms of team dynamics, comment on one or two areas where you feel your team did exceptionally well during the project. This could be something specific or something general. It could be something that you did, something another team mate did, or something the team as a whole did.
- Thinking again in terms of team dynamics, comment on one or two areas where your team had problems during the project or where you could stand to improve. If possible, try to phrase your comments in terms of one or more of the six criteria above (unity, communication, distribution of responsibility, problem solving, conflict management, and group self-evaluation).
- If you have any questions or additional points you would like to raise for discussion in the second group dynamics workshop, you can use this space. You may want to ask about possible ways to deal with particular situations or difficulties that arose within the project.

Summary of Workshop 2 (Reflection and Conflict Management)

The second workshop is run much like the first and it has two main parts. The first part focuses on reflection and debriefing of experiences from the first project. The second part involves techniques to deal with conflict, ideally using effective feedback to diffuse it before it grows.

The reflection and debriefing centres around the survey outlined above. Students get to see general statistical data and representative comments. Several key observations from the surveys have been identified year-after-year and are presented using the actual data:

- Individuals tend to rate their performance as being superior to their teams in the six survey criteria – taken on average, the team and individual performance should be the same. These leads into to a brief discussion of the self-attribution bias (i.e. people tend to attribute successful outcomes to their own efforts and abilities, while undesirable outcomes are attributed to external factors).
- A positive statistical correlation between individual performance on the survey criteria and peer evaluation scores is shown. Put bluntly, the students who rate themselves as

performing better in the team dynamics criteria also tend to receive higher peer evaluation scores. This data helps reinforce the importance of team dynamics.

- A second positive statistical correlation between team performance on the survey criteria and project scores is shown. Teams that perform better in team dynamics also do better on the projects, further reinforcing the importance of the material.

The individual comments from the survey concerning problem areas (and areas of success) are used to lead into the second part of the workshop on conflict management. This part of the workshop includes a discussion of conflict management styles (avoiding, accommodating, competing, compromising, and collaborating [21]) with an opportunity for first individuals, and then teams, to examine their conflict management preferences. Similar to the first workshop, this material is used to help identify possible trouble spots heading into the second project.

In addition, students are given tools for diffusing conflict through techniques for giving and receiving feedback. Specifically, students are shown how to give constructive feedback by expressing observed actions and the impacts of those actions; they are also shown that feedback that either suggests an underlying intent or personally targets the recipient can escalate conflict. Similarly, students are shown techniques to receive feedback that acknowledges the feedback, reduces defensiveness, and allows a lead-in to constructive dialogue. Students practice both giving and receiving feedback in the workshop through role-playing exercises.

The workshop closes with teams discussing and sharing possible approaches to deal with specific questions brought forward by other students on the survey (see the final question in the survey above).

OBSERVATIONS AND RESULTS

With the evolution in delivering team dynamics to the current approach outlined above, there were dramatic changes in student buy-in and engagement. Myers-Briggs was introduced as a “hook” intended to make team dynamics personally relevant to each student. Rather than speaking in general terms about how teams function, the workshop focus shifted to specific characteristics, working styles, and strategies associated with Myers-Briggs, which seemed to resonate with the students. Having team dynamics material appear alongside more technical content in reading assignments, quizzes, and exams seemed to elevate the topic’s importance to the class. Other changes, such as adding extensive use of peer evaluation, soliciting and debriefing feedback on team process, and highlighting positive correlations between team health and project performance, all seemed to improve students’ interest and engagement with the team dynamics material. There is now full attendance and eager participation in the workshops, and students freely incorporate team dynamics material in their project planning and reports.

A subset of results from a recent optional questionnaire of student perceptions of the team dynamics in the course are provided in Table 1. (This questionnaire is not to be confused with the compulsory survey used in conjunction with the workshops.) For each statement shown in the table, students were asked to respond on a Likert Scale from 1 (strongly disagree) to 5 (strongly agree). The questionnaire results suggest that the current approach used to teach team dynamics is effective at increasing students’ appreciation for the topic, increasing students’ confidence with their team at the start of the projects, and increasing students’ understanding of how they and others work in teams.

Table 1

Team dynamics questionnaire results for 2010 cohort (n = 80, 64% response rate)

Question	Number of Responses at Each Rating					Mean	Percent Agree
	1 SD	2 MD	3 N	4 MA	5 SA		
I found the team dynamics activities in MECH 223 to be valuable	0	2	10	41	22	4.1	84%
As a result of the team dynamics activities in MECH 223 I now feel team dynamics is more important	0	0	22	31	23	4.0	71%
I feel my team will have a better chance of success in the projects as a result of the team dynamics workshop	0	5	17	38	16	3.9	71%
I feel my team is less likely to have serious interpersonal conflict as a result of the team dynamics workshop	2	9	23	29	13	3.6	55%
The team dynamics workshops helped me to learn more about myself and the way I work in a team	2	2	10	39	27	4.1	83%
The team dynamics workshops helped me to learn more about my team mates and the way other people work in a team	0	2	10	37	28	4.2	84%

Written comments as part of the survey were primarily positive (with roughly a similar proportion to the agree ratings above). The comments largely focused on the benefits of getting to know more about other people. For example, one student wrote:

[The workshop] was well thought out and opened my eyes to the 'types' of people out there. Because of this, I'm now forced to take another second before responding to some things people do/say in my group to see where they are coming from.

Another student wrote:

I liked the way [the workshop activities] broke down the barrier amongst people. It was sort of like "hey, yes we are all different, and we aren't all going to get along, but here are your strengths and here are your team mates strengths; by using this knowledge, group projects will be finished faster, and more smoothly".

Of the negative comments, many were in conjunction with not going into enough depth, such as:

I wasn't a huge fan of the TypeFocus test. I did a project in grade 7 about personality types and had the class do a test that was a bit longer but was much better at showing the gradients of personality types rather than just showing the polarized results. The detail allowed you to get a better idea of where on the gradient you lay. Which I think is not only more useful, but also addresses the issue of labelling people which you tried so hard to avoid

The other common negative survey response was from students who felt Myers-Briggs was restrictive in describing their personality or how they behave. This occurred even though we endeavoured to make sure the students did not feel labelled (as alluded to in the student comment above). Perhaps, as the student suggested, further emphasizing the continuum aspect of Myers-Briggs or using a more in-depth tool than *TypeFocus* will address this issue.

CONCLUSIONS

It is impossible to know precisely what the effect was for each change that was implemented in teaching team dynamics. Likely, the changes in student attitude are due to a combination of all the course modifications, as well as, perhaps, due to external changes in the K-12 and first year education systems. Based on the experience since 2000, and the extensive formal and informal feedback from students, there are several key lessons learned that are apparent. In particular, teaching team dynamics to engineering students is most effective when:

- The material is delivered in a manner that is personally relevant to the students
- The material is directly usable by the students and project teams
- Feedback mechanisms are in place (such as peer feedback as well as debriefings and discussions) such that students are aware of and can respond to team dynamics issues
- The team dynamics material permeates through the course, including assessment, and is not relegated to one or two standalone activities

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