Engineering Project Team Training System (EPTTS) For Effective Engineering Team Management

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Abstract

The BESTEAMS: Building Engineering Student Team Effectiveness and Management Systems Mini-Teaching Center has implemented a pilot, in-class, workshop highlighting the influence of learning style preferences on project team management. The workshop has over three semesters been presented to over 400 engineering students at the University of Maryland, The Catholic University of America and Morgan State University. The students ranged from Freshman undergraduates, to first year graduate level students. The workshop includes a learning style assessment using the Kolb model and outlines the challenges to team management related to learning and communication style diversity. Following the learning style assessment, a short discussion on approaches to learning and communication within the context of team based assignments is facilitated, and responses of Divergers, Assimilators, Convergers and Accommodators are summarized.

The results show that of 283 students tested during the Fall 1999 semester, Divergers represent 9.5% of the students tested, Assimilators represent 41%, Convergers represent 35.7% and Accommodators represent 13.8%. Most students reported an expected benefit to having learning style diversity within a team, expressing a perception that learning style diversity would aid in the development of robust solutions to team assignments. When questioned about the impact of learning style diversity on team management, the students expressed an expectation that compromise would be needed (particularly in view of the learning style differences). However, many students also found it difficult to relate the information on their own learning style preference to effective team management skills. The feedback has been used to modify future EPTTS workshops.

Overall, the workshop successfully frames the discussion of peer diversity toward the topic of learning style preference, and deflects attention from traditional stereotypes such as gender or ethnic background. The workshop is also successful in educating students about style differences in engineering approach and encourages tolerance among team members. However, the ability to transfer successful strategies for team management may require regular reinforcement from the faculty advisor.

Background

The challenge of training for effective team performance has yet to be systematically addressed inside the engineering curricula. The most current engineering studies focus primarily on team formation [McIntosh, 1989; Rosser, 1997] and not on training. This is consistent with our own interview data suggesting that engineering faculty have developed ad-hoc procedures to form teams but have not adopted formal training practices or protocols as they attempt to teach students how to work well in teams [Mead et al. 1999]. In response to this gap between skills and training, BESTEAMS has developed training workshops for students and faculty. This paper discusses the purpose and objectives, and some preliminary results of the student workshop.

The student workshop has been designed with two important objectives in mind. First, the workshop provides a guideline, or working model, from which student-managed project teams can be implemented and managed. Second, the workshops heighten the student's awareness of differences in learning and communication styles and how these differences can affect team dynamics and productivity. It is hoped that this knowledge will have two very important outcomes. First, promoting the use of learning styles provides an opportunity to describe differences in educational terms rather than biological terms such as gender or race, and this serves to move discussions of diversity away from stereotypical labels toward less divisive human attributes. Second, students will learn practical methods for achieving productivity in a team setting. If successful, we believe the increased understanding of how we as human beings can have multiple approaches as we go about the business of "*getting things done*" will result in increased objectivity and equity in our assessments of peers and colleagues.

BESTEAMS Philosophy

Based on a survey of several team management resources, discussions with experts, and interviews with engineering faculty and students, the BESTEAMS program has outlined seven basic dimensions that may be used to establish a viable framework upon which effective teams can develop [Gibbs, 1997; Mead et al., 1999; Scholtes, 1988]. These seven BESTEAMS performance dimensions are as follows:

- Unified Purpose
- Human Resource Management
- Time Management
- Decision Management
- Team Dynamics
- Conflict Resolution
- Productivity

It is therefore proposed that these seven dimensions comprise the principle components contributing to effectiveness in a team setting.

BESTEAMS has also developed a training system to help students and faculty effectively manage the engineering student team environment. The Engineering Project Team Training System (EPTTS) includes three basic thrusts: a faculty workshop, a student workshop, and an assortment of tools and aids to educate students and faculty, and assess

the team and team member performance. For our purposes, the performance assessments are not related to technical development or technical learning. It is assumed that these types of assessment are already being addressed by the faculty. Rather, we are focussed on an assessment of the student's performance with respect to positive team behaviors, and the teams performance with respect to the performance dimensions outlined above.

The remainder of this paper will discuss the student workshop and an overview of the BESTEAMS assessment aids .

Engineering Project Team Training for Students Workshop (EPTTS for Students)
The EPTTS for Students workshop serves as a project management strategy for team based engineering design projects. The EPTTS training discusses general guidelines and practices for managing teams, and the impact that different approaches to learning can have on the ways that teams function. The workshop is presented during a single class period and is facilitated by the a resident faculty member who has been trained in the EPTTS program. This is accomplished by attending the day long EPTTS for Faculty workshop. In this study, the student workshop has been presented at the request of faculty who are currently directing a team based engineering class, but who have not undergone the EPTTS for faculty workshop. No additional credit was given to the students for participating in the workshop.

Students participating in the EPTTS workshop are exposed to the following :

- Positive models and guidelines for project team management;
- Various team member roles that enhance project team management and the team experience;
- A review of how learning and communication style preferences influence the reception, delivery and processing of technical information;
- Personal learning style assessment using the Kolb Learning Style Inventory;
- Discussion into how learning and communication styles affect a team's dynamics and management style.
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Pilot EPTTS Workshop Format
The average length of the pilot EPTTS for Students workshop was 75 minutes. The workshop began with a short survey on team attitudes. The results of the survey are discussed briefly below. The students are then led through a personal learning style assessment using the Kolb model. Following the personal assessment, the students discuss the ways that learning style preference can influence desired occupation or our approach to learning. It is then explained that the learning style preference can also influence the role that an individual would prefer to have in the product development process, as well as an individual's approach to the process in general. These discussions were interactive and were done using a small group format. The students were first broken into groups by learning style, and asked to summarize their views on a task that is related either to the team development or learning process. An example might be what types of things should be included in a team contract. Another example might be what

are the most important things you want to have available when you are learning new material for a class. In reviewing the responses of the different groups, students experience how learning styles influence our approaches, and our interpretations of a specific task.

To conclude the workshop, the students were led through the BESTEAMS performance dimensions, and some general guidelines on team management. These include establishing a clear vision or goal for the team. In some cases, the project goals can include team development goals as well as technical goals, depending on the desires of the students and the faculty advisor. The students were also encouraged to establish an agreed upon set of guidelines for internal interactions: including meeting schedule, team organization, rules of conduct, and consequences for poor individual performance. Finally, several aids that can assist the students as they decide on a format and a framework for their teams are distributed and reviewed. These aids include a manual on learning in teams [Gibbs, 1997], handouts describing the Kolb learning styles, and quantitative assessment forms developed through the BESTEAMS program to evaluate the overall team performance and the performance of individual members of the team.

Workshop Handouts and Aids

Several workshop aids and handouts have been used in the pilot workshop as outlined in Table 1. The handouts include background information on learning styles and how learning styles influence the engineering education process, and a manual that outlines positive models for team organization is also distributed. As well, several aids that have been developed by the BESTEAMS Partnership are also distributed. These include a task delegation form to facilitate proactive planning, time management and human resource management.Also, evaluation forms to assess the team and the individual team members against several critical behaviors that impact team effectiveness.

The Kolb learning style handout and the Felder article on learning styles in engineering education reinforce the workshop activities that focus on differences in approach that often correlate to learning style preference. The Learning in Teams: A Student Guide manual, written by Gibbs gives an overview of critical roles that occur in teams. The manual also outlines several strategies for team management and running team meetings. Also, useful strategies for managing the natural conflicts that occur in teams is presented. The students were encouraged to use the manual as a resource and to develop a team structure that is compatible with the styles and needs of their individual teams.

The task delegation form is may be used to help teams develop the performance dimensions of time management and human resource management. Students begin to recognize the importance of sharing the work equitably among members and establishing internal schedules that are compatible with external schedules. The delegation form also serves as a means of documenting the contributions of team members. This form can be distributed several times during the term of the project in line with various phases of the work, or simply as a means of regular project maintenance.

The BESTEAMS Team Evaluation Form serves the purpose of highlighting several dimensions of the team's identity that influence productivity. The dimensions are

outlined in Table 2 and have been compiled based on results of student and faculty surveys and focus groups [Mead et al. 1999], , and the input of several experts from the fields of psychology, education and business management [Gibbs, 1997; Scholtes, 1988]. The team evaluation form is a one page, quantitative assessment tool that can be completed in a few minutes. The students are asked to assess the team across each dimension a few weeks following the start of the project, and at the conclusion of the project. Allowing at least one interim assessment, gives the team a chance to gauge how well it has developed in specific areas, receive feedback from the members, and make changes if needed. Because this form is based on a self-assessment, and there often is little or no incentive to share poor performance with the faculty advisor, this form is recommended as a tool for the team only. For example, the team can track its development across the seven performance dimensions for the purpose of identifying specific areas where adjustments may be needed.

The BESTEAMS Peer Evaluation Form is similar in purpose to the team evaluation form. The suggested behaviors for which the students can be assessed is also given in Table 2. However, the faculty member is free to use additional line items on the assessment form. In general, it is also good to have the students review the form and approve the various line items that they will be assessed against. By utilizing this form, , students can know the behaviors expected of them, and they can receive well defined and specific feedback from peers. The form is a one page, quantitative assessment tool that can be completed several times during the term of the project. Again, interim assessments provide for regular review of individual progress and constructive feedback from peers.

This form has been used by several faculty to determine individual grades on a team, but again the validity of the grade is dependent upon the integrity of the team members. It has been observed that for some environments, the student assessments tend to be virtually equal for everyone on the team. Also, students are some times reluctant to give poor grades to peers [Schmidt et al, 2000]. Several strategies can be considered to offset these difficulties. First, it is recommended that the faculty member establish a standard rating for average behavior. For example, on a scale of 1 to 5, the average rating should be 3 or perhaps 4. This standard should be established by the faculty and understood by the student before completing the form. Second, to avoid cases where students give everyone on the team the same rating, the faculty could require students to rank each team member in certain categories. For example, the faculty could select specific behaviors for which the student is required to rank the relative compliance of their team mates. For example, member A receives the highest rating because she/he performed best in the stated category. Alternatively, member B receives the lowest rating because she/he performed worst in the stated category. The forced ranking helps the faculty interpret the student evaluations. However, since this is a self assessment, it is generally best to look for trends in the assessment ratings as opposed to absolute numbers. If student A is consistently ranked highest, and member B is consistently ranked as one of the lowest performers in a category, this is evidence of a real behavior pattern that may need to be considered in the final grade of the student.

Table 1. Workshop Materials and EPTTS Aids

ITEM	DISTRIBUTION SCHEDULE
Pre-workshop survey on attitudes towards teams	Pre-workshop
Kolb Learning Style Inventory	at the workshop
Article on learning styles in engineering education [Felder, 1998]	at the workshop
Learning in Teams: A Student Guide [Gibbs, 1997]	at the workshop
Task delegation tables	at workshop, 1 or more interim times during project
BESTEAMS Peer Evaluation Form	at workshop, 1 or more interim times during project and at the end of the project
BESTEAMS Team Evaluation Form	at workshop, 1 or more interim times during project and at the end of the project
BESTEAMS Engineering Project Team Experience Survey	at conclusion of project

Table 2. Dimensions of Effective Teams and Effective Team Members

BESTEAMS Team Evaluation Dimensions	BESTEAMS Peer Evaluation Dimensions
Unified Purpose	Regularly attends group meetings
Team Dynamics	Comes to meetings prepared
Conflict Resolution	Actively participates in group discussions
Decision Management	Accepts responsibility for major tasks when needed
Time Management	Arranges personal schedule to fulfill commitments to the team
Human Resource Management	Completes work in a timely and acceptable manner
Overall Productivity	Identifies sources and other resources to aid team progress
	Is considerate of needs of others
	Helps others identify their strengths and weaknesses

Team Attitude Survey Results and Workshop Observations

The survey on student attitudes towards teams was conducted at the start of each EPTTS workshop. The survey has been used to gain baseline data on how students respond to the prospect of working on teams and how they react to the idea of style diversity within a team (without first defining diversity). A total of 283 students were surveyed, including 190 freshmen, 37 sophomore, 48 senior and 8 graduate students. The average responses of students is listed in Table 3. The responses show that:

- Most students have a positive attitude towards working in teams.
- Students strongly agree that team work will be important in their careers.
- Students agree that learning skills to help teams be more effective is important.
- Without defining what is meant by style diversity, 37% of the students responded that teams work best when members have the same style, while the remaining 63% responded that teams work best when members have different styles. By the conclusion of the workshop however, almost all students tended to express that teams should be more robust when members have different styles, where styles generally referred to learning style.

The responses of men and women students were not statistically different, but it is noted that the graduate students had the least positive attitude about working in team. Also, the student agreed strongest that effective teams are important for their careers, but there was not as strong an agreement that learning team skills is important. This could be a reflection that many students feel they already have good skills, or the idea of developing team skills is not as well embraced by engineering students.

The distribution of students by learning styles is listed in Table 4. The statistics show that Assimilators represented the largest population with 41%, followed by Convergers (35.7%), Accommodators (13.8%) and Divergers (9.5%). No analysis of the survey responses could be made by learning style because the surveys were completed and collected prior to the learning style assessment.

Table 3. Summary of Survey Respondents

Class Code†	General attitude about teams*	Effective teaming will be important for my career*	It is important to learn skills that help teams work well*	Teams work best when members have the same styles
1	4.2	4.7	4.4	19.7%
3	4.2	4.6	4.2	46.7%
4	3.5	4.9	4.3	14.3%
5	4.2	4.8	4.3	18.8%
6	4.0	4.7	4.3	44.4%
7	4.5	4.9	4.6	26.7%
8	4.3	-	4.5	21.1%
9	4.2	4.6	4.5	27.3%
10	4.2	4.8	4.4	33.3%
11	4.1	4.8	4.7	28.6%
Overall AVG	4.2	4.7	4.4	37%

* The information in columns 1, 2 and 3 are average responses on a scale of 1-5 where 5 represents very positive or strongly agree, 3 represents neutral or unsure, and 1 represents negative or strongly disagree.

† class codes are defined in Table 4.

Table 4. Distribution of Workshop Participants by Learning Style

Code	Class	Accommodators	Assimilators	Convergers	Divergers
1	Freshman Engineering Design (CUA)	5	7	17	4
2	Freshman Engineering Design (CUA)	5	12	12	1
3	Senior Engineering Elective (UMd)	2	4	9	1
4	Graduate Engineering Elective (UMd)	2	5	1	0
5	Freshman Engineering Design (UMd)	4	12	9	4
6	Freshman Engineering Design (UMd)	4	15	6	5
7	Sophomore Engineering Design (UMd)	3	6	7	1
8	Sophomore Engineering Design (UMd)	3	6	7	4
9	Freshman Engineering Design (UMd)	4	18	10	3
10	Freshman Engineering Design (UMd)	4	17	11	1
11	Senior Engineering Elective (UMd)	3	14	12	3
	TOTAL (%)	39 (13.8%)	116 (41.0%)	101 (35.7%)	27 (9.5%)

Student Feedback

In subsequent focus group or other student feedback opportunities, students described a wide range of reactions to the workshop. Among the more positive reactions was the view that the information on learning style helped to explain otherwise unexplained behavioral tendencies within the group. In an excerpt taken from a student essay on the impact of learning style on team dynamics, one student wrote,

> " . . . A team, which has not been enlightened as to its learning style make-up, can easily become frustrated and unprolific. The worst part of this is that the reason for the frustration will not be apparent. . . .
>
> Since the workshop, however, my team has put considerable effort into thinking and acting outside of our proverbial "boxes." The flow of information has transformed from a small trickle to, at the very least, a moderate stream. I am not saying that Professor Greenberg completely changed my team, and we are now the perfect group, it is just that now we are more aware of our weaknesses and limitations, and of our strengths. "

A more commonly expressed view among focus group respondents however was the idea that knowing ones own learning style is not always helpful for developing good team skills. Many students believed that simply knowing helpful rules would be sufficient to achieve good team skills. It was also observed that retention of the information covered in the workshop is lower among students for whom the faculty advisor did not reinforce the EPPTS training. For example, faculty who did not require periodic submissions of the task delegation forms and team and peer evaluation forms. Finally, it was observed that freshmen students were more open to receive the workshop training, as compared to the senior or graduate level students. The senior students tended to already have an established set of strategies that they relied upon for team environments, while the freshmen students were more willing to consider the strategies discussed in the workshop.

Workshop Modifications

Based on the focus group and other informal feedback, a modified format for the EPTTS workshop has been developed. The modified workshop includes greater emphasis on the team dimensions and individual attributes that positively influence team productivity. The discussion on learning styles is then focussed on how persons with different learning styles perceive the various team performance dimensions. The background on learning style is gained through a homework assignment that should be completed before the workshop is presented, and depending on the length of the class period, the actual Kolb assessment is completed as a part of the homework assignment, or it may be done in the workshop. For example, if the class period is 50 minutes, the Kolb assessment is done in advance of the EPTTS workshop. Finally, the workshop is recommended for freshman or sophomore level classes, and the faculty advisor is strongly encouraged to participate in the EPTTS for Faculty workshop, and to utilize the recommended feedback mechanisms (i.e. regular submissions of task delegation forms, and team and peer evaluation forms).

Conclusions

A student workshop to train students in effective team skills has been piloted over three semesters, affecting over 400 students. The Engineering Project Team Training for Students workshop is one component of the Engineering Project Team Training System, developed by the BESTEAMS coalition. The EPTTS represents a systematic approach to achieving positive team skills, thus addressing a gap in the current engineering curriculum. The student workshop includes a focus on learning style diversity and a discussion of how learning style can influence the roles that individuals prefer within the product development process, and their approach to achieving the team objectives. Student reactions to the workshop as determined from focus group and other feedback mechanisms indicate that upper class and graduate level students are less open to receiving suggested methods for achieving team productivity, reinforcement from the faculty advisor enhances retention of information covered in the workshop, and greater emphasis on practical guidelines as opposed to learning style preference would be appreciated by the students. Based on the stated feedback, the EPTT for Students workshop has been modified to reflect many of these suggestions.

Acknowledgements

The authors wish to thank Drs. Karen L. Proudford and Janet Schmidt for their comments and suggestions on the BESTEAMS assessment forms and the student workshop modifications.

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Biographical Data

BESTEAMS PARTNERSHIP

The BESTEAMS (Building Engineering Student Team Effectiveness and Management Systems) Partnership was initiated in 1997 to research engineering project team performance and effectiveness. The BESTEAMS Partnership builds engineering team-centered programs that support effective project team experiences throughout a student's engineering education and across the engineering curriculum. Partners are engineering and education faculty and professionals.