AC 2011-2608: TEAM BUILDING IN A PROJECT-BASED LEARNING COURSE

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Team Building in a Project-based Learning Fluid Mechanics and Heat Transfer Course

Abstract

Implementing a project-based approach in a core macroscale equipment design calculations course sounds like a good idea as students become motivated to learn fundamental concepts to accomplish their project design and at the same time develop team skills through an industry-like team approach. However, we find organizing the class into teams and assigning a project task is a small part of what needs to happen for those teams to function properly. Typically teams have considerable issues in terms of interpersonal relationships, schedule miss-matches, distribution of labor, and sharing leadership responsibilities. While there are websites that help with senior level design team performance these are not usually used for courses offered earlier in the curriculum. In a recent offering of a junior level two-credit one-semester Fluid Mechanics and Heat Transfer course we asked students to use a team-centered website originally developed for senior level integrated design course assessment and learning. The process begins with joint development of a team contract followed by team citizenship assessments for formative improvement of the team process during the semester. Finally a summative aspect is added in which team members rate each other on their contributions and achievements. The website provides the instructor a listing of team comments that affords ample opportunity for assessing team development. We find by use of the website that students who typically overwork to accomplish tasks left undone by others now begin to challenge others and encourage them to reach a higher potential. In this paper we document a case study for one particular team and demonstrate how use of a team-training website adds significant benefit to the team experience.

Introduction

Project-Based Learning has been touted as an excellent paradigm even for learning core fundamental principles in engineering and the sciences. Generally these Projects are conducted by a team and in many instances can be semester long or at least take up substantial portions of a course. While concept test results may be informative of student learning and student surveys may show affective gains it is difficult to document and determine how much of the learning took place as a result of the team Project-Based Learning process that would not have taken place otherwise.

In this paper we present results surrounding the use of a team building instrument which to date has been limited to use in capstone design courses. This instrument is known as TIDEE and is part of what is now a web-based instrument known as Transferable Integrated Design Engineering Assessment and Learning System[1]. We applied three key team building and assessment features from the site namely a Team Contract, Team Member Citizenship and Teamwork Achieved response instruments. The instruments were used in a Project-Based Learning course where the Project drove the pedagogy with the novel use of Desktop Learning Modules for hands-on active discussions for conceptual understanding of principles in a junior-year two-credit one-semester Fluid Mechanics and Heat Transfer course. Our research questions are: 1) does the TIDEE assignment process serve to document that changes were indeed occurring to enhance team member involvement and productivity? and 2) When changes do occur can they be

attributed to the TIDEE process or would they have happened anyway as a result of natural interactions that occur in most if not all team activities.

Effective Team Skill Development

While functioning on effective teams is essential in industry Engineering practice [2, 3] students generally lack that ability and we cannot afford to let them graduate from our institutions without providing adequate training [4]. Despite this industrial norm the teaching of teamwork skills can be better integrated into our engineering curricula [5]. While this has motivated recent efforts to provide concerted efforts to teach design skills in capstone courses [6, 7], little has been done to our knowledge of implementing team skills development in pre-senior year fundamentals and calculation based courses as will be discussed in this paper.

Methodology

Course Content, Logistics & Format

The study was implemented in a junior level Fluid Mechanics and Heat Transfer course which focuses on understanding of macroscopic design considerations and calculations surrounding momentum transport for fluids passing through piping networks, particulate beds and heat exchanger systems, and transfer of heat via natural and forced convection, evaporation and condensation, and in double-pipe, shell & tube and extended area heat exchangers, boilers, condensers, and evaporative cooling processes.

For the Project-Based Learning approach we assigned five students per team for seven of the teams and then had an eighth team with only four because of the number of students, 39. This team size is considered optimal for three reasons. First, there's a practical reason because in our situation we typically had about four working DLMs so with eight teams, each could use the DLM for half of a 50 minute period. Second, the optimal DLM/person ratio is three to five persons because that's how many that can comfortably sit around a DLM and still visualize the cartridge, controls and digital read-outs. Third, there's a pedagogical reason as this number gives each person a task because if a team is to get operating values quickly it takes one person to adjust flow rates on a rotameter, a second to read values from a display, and a third to record those values. With four and five member teams, one can supervise while another can reflect on the process. Team member placements were based on convenience sampling to distribute students so there was a fairly equal GPA spread among teams. We also took schedule conflicts into consideration such that students with very dissimilar outside-of-class schedules were not placed on the same team. Finally, diversity issues were considered as it is desirable to distribute women, ethnic minorities and internationals among the teams so people learn to associate with a diverse population; at the same time some think it advisable not to isolate a woman or minority as the only person of diversity on a team so we tried to pair such individuals. The teams developed their own design project descriptions by the beginning of the second week of class and were provided with instructor feedback to make sure projects contained equipment to be designed such that all the major concepts of the course would be included. A list of projects appears in Table 1.

Table 1. Project Topics for Project-Based Learning in Fluid Mechanics and Heat Transfer

Supply for A Small Village on Lake Kyoga, Africa
Geothermal Heating and Cooling System on the Planet Centron 5
Steam Methane Reforming Fluidics and Heat Exchanger Design
Butch High School Gym Facility Shower System Utilizing Green Technology
Self-Sufficient, Mobile Van Coffee and Tea Service, "Jumpstarter"
Holiday Flow: Warm Drinks for Santa's Little-helpers
Seattle Aquarium Thermal Regulation
Brewery Processing Facility

The Team Contract was requested by the end of Week 2, the Team Member Citizenship by the end of Week 3, and two Team Work Achiever's, one following submission of a substantial mid-term report at the end of Week 9 and the other after the final report at the end of Week 15.

TIDEE site features

The TIDEE resources have recently been converted to a web-based set of instruments[8]. They consist of several instruments originally designed to aid in capstone design teamwork and inter-action mechanics, professional development, design processes and solution assets. They are use-ful for inter-team-member and instructor feedback and summative assessments. While the re-sources are meant to provide rigorous exercises for training and assessment in senior level cap-stone design teamwork there is no reason they cannot be applied to a simpler pre-capstone Pro-ject-Based Learning environment like the Fluid Mechanics & Heat Transfer course at hand. For this we used three of the four team development instruments, the first two being formative, the Team Contract (TC) and Team Member Citizenship (TMC), and last being summative the Team Work Achieved (TWA) instruments. The instruments all are built on 12 performance indicators based on the teamwork literature[6] which are grouped into four general categories: (1) Team Re-lationships / Climate; (2) Joint Work / Achievements; (3) Members / Individual Contributions; and (4) Team Information / Communication. The subcategories are further highlighted in Table 2 and exercises contained in the TC, TMC & TWA are designed to evoke responses surrounding the 12 team performance indicators.

Table 2. Performance factors assessed in the TIDEE instruments used in this study.

Perform Area	Performance Factors
Team Relationships	Inclusive Climate: Building an inclusive supportive climate for all members. Member Commitment: Gaining buy-in and interdependence of all members. Conflict Resolution: Resolving conflicts to enhance teamwork.
Joint Achievements	Goal Establishment: Establishing shared team goals. Planning and Management: Managing tasks to achieve team goals. Joint Work Products: Producing competent consensus outputs.
Member Contributions	Work Allocation: Allocating responsibilities fairly to members. Performance Quality: Achieving quality work from all members. Member Growth: Facilitating team member growth.
Team Information	Internal Communication: Achieving effective in-team communication. Stakeholder Communication: Managing other stakeholder communication. Knowledge Assets: Building shared knowledge assets.

Herein we further explain the specific emphases, content and usage intent for each of the individual TIDEE instruments[7].

Team Contract (TC)

This formative assessment exercise promotes team consensus building on climate, interdependence in terms of work load, and how specifically they will resolve their own conflicts. Their goals, task management and standards for product output are outlined. There is a focus on how work is allocated and how team members will be encouraged to grow to reach desired quality standards. Finally, there is a section on communication both internally within the team and externally in terms of displaying knowledge in the form of reports. The exercise is typically performed as a team and begins with rating the 12 team performance indicators in Table 2 as being of "Low", "Medium" or "High" priority in terms of importance in contributing to the team's productivity. Next the team is asked to provide written statements about how they will accomplish each of 12 performance criteria. Then they define roles for each team member, such as organizational leader, secretary, technical support person, performance evaluator and how the roles were determined and whether they will rotate roles, etc.

Team Member Citizenship (TMC)

The TMC, a formative assessment, is normally implemented after the TC and may be used multiple times in a capstone course. It has each team member rate their other team members on 12 team performance indicators listed in Table 2 using a 5-point Likert scoring system and each team member can ascribe their own relative value of importance of each of these criteria. Written peer feed back is provided and is focused on individual team members, their relative Strengths and Member Coaching tips that will serve an individual in their efforts to improve the team process. They can view comments made by each team member, but do not know specifically which person made the comment. Also, team members may receive formative feedback from the instructor who will assess each person's feedback and provide suggestions for improving the team process.

Teamwork Achieved (TWA)

The TWA, a summative assessment, is similar to the TMC in terms of rating the relative importance of the 12 categories and Likert ranking of individual team members on each of the 12 indicators by their peers. However, it can also serve as in our case as a formative assessment if it is applied to a midpoint team product such as a mid-semester report. The TWA also requires a brief performance summary on each team member that gives supporting evidence for their Likert rankings and sheds light on each person's relative contributions, growth and needs for improvement. The team member is finally asked to describe a team process known to them that effectively supported team performance.

Assessment of the TIDEE Instrument in Terms of Benefit to the Team Process
We used a Likert Survey questionnaire produced and distributed through Survey Monkey. The questions appear below: Likert ratings were: 1 = Not Helpful; 2 = Slightly Helpful; 3 = Helpful;

4 = Very Helpful; 5 = Extremely Helpful. In addition there were two questions about the general usefulness of the TIDEE process and how it could be improved.

1. To what extent did the Team Contract (TC) assist your team in working together through the semester?
2. To what extent did the TC prompt you to improve your own teamwork contribution?
3. To what extent did the Team Member Citizenship (TMC) feedback from your teammates and instructor prompt improvement in your own teamwork?
4. To what extent did the TMC promote team member interaction?
5. To what extent did the TMC lead to improved performance of other team members?
6. To what extent did the Teamwork Achieved (TWA) cause you to think through your own performance on the team and make changes?
7. To what extent did the TWA cause you to reflect on other team members' performances and seek to address them with those individuals?
8. What about the TC, TMC and TWA do you think prepares you better for professional practice? Please explain your comments with a concrete example.
9. Please give suggestions on how the TIDEE experience could be improved.
10. Please identify the team you were on; information will be kept confidential.

Results

While a thorough analysis of every group would provide the most complete information, the objective for this paper, as stated earlier, is to do a Case Study to assess the progress made by one team in particular with whom the instructor had several interactions with some of the team members. Members of this team, Team Four, had expressed initial concern about full team participation, seemed at least on the surface to be taking advice from the professor on how to address concerns, and then reported changes in behavior were indeed occurring. Again, our main research questions are: 1) Does the TIDEE assignment process serve to document that changes were indeed occurring; and 2) When changes do occur can they be attributed to the TIDEE process or would they have happened anyway as a result of natural interactions that occur in most if not all team activities. A third question is in order of course and that is how the TIDEE assignment process can be improved to enhance the benefits derived from the process. Once we make this assessment it would be instructive to do a more thorough study on the existing data, or to simply scan the existing data and combine what is learned to set a strategy for improvement in a subsequent course. We would then undergird this approach taken with a sound theoretical base, and cite specific objectives, and implementation and assessment methodologies.

Team Contract – Week 2

Before citing insights from the Team Contract we summarize for Team Four team performance expectations and how they sought to grow with respect to the 12 performance factors.

Team Relationships

1. *Inclusive Climate:* The team agrees to be committed to each other, communicate freely especially with regard to their problems and accommodate each other to a reasonable amount.

2. *Member Commitment:* At least two weekly meetings to apportion work with a consequence of missing a meeting - bringing snacks and serving as the secretary at the next meeting.
3. *Conflict Resolution:* Consistent lack of commitment to meeting attendance and preparation for meetings can lead to the consequence of removal from the group.

Joint Achievements

1. *Goal Establishment:* Coming to meetings prepared with research to further the project.
2. *Planning and Management:* Begin meetings with progress review; end with brainstorming to decide individual member tasks for the next meeting / Voting on any changes.
3. *Joint Work Products:* Assignments according to team member strengths; review of work before submitting.

Member Contributions

1. *Work Allocation:* Assignments by demonstrated participation at meetings, expertise, time availability.
2. *Performance Quality:* Assessed meticulously by other group members with potential to vote off members or put on probation if work is not up to par.
3. *Member Growth:* If there's a desire to learn team members will help individuals so they can learn to facilitate group growth.

Team Information

1. *Internal Communication:* Notifications via texting and email as a problem arrases / Meeting records in spiral notebook
2. *Stakeholder Communication:* Regularly as a group with our instructor and TA's concerning any problems, or questions, and progress.
3. *Knowledge Assets:* Meeting records and calculations kept in a binder and brought to all group meetings and monitored by the secretary and group as a whole.

Roles and Responsibilities

The following team member roles were assigned and rationale give for the role: 1) a Leader, because she is organized and confident about her ability to lead the group would keeping the group on task, delegating work responsibilities, and who would have "veto power" over tied votes; 2) a Technical Person, because of computer familiarity, who would assist with any computer programming needed; 3) a Questioner, because of his inquisitiveness and enjoyment in "poking holes in theories", who would challenge group reasoning and therefore foster better understanding; and 4) a Secretary and time keeper, because of the need for such a person and because others were better suited for their respective roles, who document meetings and group decisions and send reminder emails about team member tasks and upcoming meetings.

Instructor Team Contract Feedback and Insights

The instructor and TAs encouraged the Team Four with strengths noted in the Team Contract and suggestions for improvement through the TIDEE website. Noted as a strength is a reasonable plan for encouraging team member participation alerting the team if they would miss a meeting, receiving an assigned task and being responsible to bring snacks to the next meeting. Noted for Improvement are details on how soon after a missed meeting a person contacts the other team members. More importantly before voting someone off the team they group was encouraged to follow these steps:

1. A group meeting should be planned in which the issue is discussed. Members with a complaint should tell what the problem is. The other person should listen without defending themselves - they should only summarize the complaint. Then the other person should tell their side and those with the complaint should summarize. Next creative solutions should be presented by both sides.
2. If that does not solve the problem then a meeting with an instructor should be arranged.
3. In this case the instructor will take the role of a plant manager rather than a client. Finally, if there continues to be no resolution a team member could be voted off.

The recommendations for improvement on punitive measures proved critical in this team as will be seen in the subsequent TIDEE observations. Had the team stood by their original contract one or two team members would certainly have been voted off leaving a team of only two and the lack of opportunity to observe team member growth. In fact the team Leader contacted the lead instructor concerning this point and at an early point in the semester. The suggestion was to transform a merely punitive approach to fostering member compliance with team needs to one of promotive face-to-face interaction before punitive measures were implemented.

Team Member Citizenship – Week 3

Shortly after the team contract (Week 2) we see the team's first assessment of how they are doing. We will take each team member individually and refer to them by their designated roles. It is interesting to note strengths emerging that are consistent with the original rationale for assigning the roles. Accompanying those strengths are growth edges, some of which are serious that if not addressed can derail the team.

TMC Leader

In the Member Strengths portion of the TMC reveal her natural abilities to take charge as well as lead by example are highlighted by other team members: "good at completing tasks on time", "accurate", "delegates", "assigns a deadline", keeping to "the timeline decided". By her own admission she can be "slightly ambitious" making it so "none …were able to" meet an internal team deadline, but they still accomplished enough to "get it all done with time to spare".

In the Member Coaching input from team members note because she has "a lot of experience" she has high expectations on herself and others manifesting itself in a "stoic" tendency to "do most of the work" and therefore a need to "help others to develop their skills", and "engage members with more respect". She herself states a "need to work on informing others in a more timely fashion".

TMC Technical Person
His Strengths are that he is "reliable" completing work promptly and "with quality", respectful" in offering and asking for advice, "flexible" to the point of sharing "others' workloads" and one who "can easily diffuse any tense situation".

Coaching for improvements is also consistent among the team members citing his need for "stepping up as a leader and taking charge in delegating team tasks". He himself along with other team members desire improvement in communicating with group members.

TMC Questioner
His Strengths are that he's a "team player", "follows direction", "gets it done", "on time", is "always present during group meetings", and can "voice his opinions in a constructive manner".

Coaching tips include effort to "enable development in self and others" making "team efforts more of a learning experience". While he voices his opinions he is sometimes seen as offering ideas that lead to a "digression" and is encouraged to "still maintain his character, without being as abrasive about some of his opinions".

TMC Secretary
Her Strengths are in "communication". She's "constantly asking questions", makes "sure that each person knows what's going in group meetings despite absences"," ensures that everyone gets a say", a "offers ideas to build upon", adds luster to assignments by "finding diagrams to go with the definitions" and plans well though she has busiest schedules.

Coaching tips are focused. While a good communicator on some levels she notes a need to "step back before diving into resolving a conflict" and this was confirmed by her group. Her absence at two of the four meetings, and failure to "show up for her specially arranged meeting" are cited as areas of improvement.

Team Work Achieved #1 – Week 9

We have highlighted improvements needed in teamwork that if not taken care of early could manifest in significant problems by Week 9 when the first substantial team Project Report was due. In fact we will see that some of the issues brought out in the TMC Coaching responses were addressed, while others still showed need of improvement and one lingered till very near the due date and therefore was difficult to fix. For this team, however, the collective strengths carried the day and set them up for further improvements based on constructive team feedback shared on the TIDEE. This discussion seems to be providing the motivation for this team to make further improvements. Let's look at how things are shaping up through the window of the TWA#1.

TWA#1 Leader
Her technical Strengths and ability to delegate tasks are helping the group to succeed. Further-more, she has heeded the Coaching tips in terms of not doing all the work, and providing a milder approach in confronting difficult situations.

"She knew the most about the different aspects" … "created the spreadsheets for the pressure drops in the Double Pipe Heat Exchanger," … "as well as developing the concepts for the copper piping system used after the filtration beds."

"Delegating the tasks to be done greatly improved the group's efficiency."

"I handled difficult and stressful situations great" …"Once we had discussed our concerns about group members actions, productivity increased dramatically," …"I am not a confrontational leader, so it was difficult to bring up any situation that was not pleasant. However, once I did bring it up, it was much easier than I anticipated."

TWA#1 Technical Person
This person continues to apply his technical Strengths and ability to diffuse diffusing difficult situations under the pressures of completing a challenging team project and, though improve-ments in team resource allocation are still needed, is benefitting from the Coaching tip to take more leadership in delegating tasks along with the leader.

He's seen as a "major contributor" … "on pipe optimization and the pressure drops within the shell and tube heat exchanger."

"He provided a boundary between group members when tensions were high."

"I think the thing that helped our group the most was our ability to allocate responsibilities" … They repeatedly emphasize the importance of "schedule" and highlight the Leader and Technical Person as examples of reliability. "We all got a full night sleep the night before the project was due and turned the project in with no problem."

Evidence that delegation and team resource allocation issues still need to be fully resolved are contained in the statement. "We were able to still get the project completed with one of our four members leaving for break two days early."

TWA#1 Questioner
Early indicators in the TC of Strengths concur with TMC comments such as "(he) kept to the tasks delegated to him". "He also conducted a lot of research concerning the agricultural crops" and helped with Photoshop diagrams. "His relaxed attitude … helped diffuse some stressful situations".

While there is recognition of the Coaching tip on self development there is evidence of further need for growth as well: … "it has … been difficult to motivate him enough to do the level of work we required." … "while the work was not always satisfactory, it gives me a great apprecia-tion for group work."

TWA#1 Secretary

Her Strength in getting things done in the midst of the "busiest schedule", "holding two jobs" is evident: "I … made contributions in … the calculations spreadsheet for the Packed Bed Reactor, as well as …"

Yet her communication Strength still needs an outlet. She has improved on meeting attendance: "present at all meetings but the first few". Yet, other time conflicts remain through Week 9. She also points out a need for other team members to improve their confidence in her, an area we will see improves by TWA#2 as she earns back their confidence. This is already evident in team member comments:

"We respectfully brought up our concerns, and (she) listened and responded in a very respectful way, attempting to do the amount of work she could before she left early for spring break. Her attempt to fix her participation was appreciated greatly, …" "I look forward to coming back from spring break and working with her on the remainder of the project, as I am confident she will step up as promised. :)"

Team Work Achieved #2 – Week 15

TIDEE responses for this team on TWA#2 provide us with evidence of exemplary attention to development of team skills, and if not prompted by reflection of previous comments made to each other through TIDEE at least documents a successful team development process.

TWA#2 Leader

"What didn't (she) contribute to the project?" is a typical response from her teammates with regard to her technical and written report contributions. She further documents interacting with an expert from another university to enhance project depth.

By her own admission she is still somewhat challenged in her approach to others, "I was very stressed out … I know I did not react as professionally as I could have" , but did not know how to confront a team member that did not care. However, she has grown in being quick to recognize the need to heed the warning signs that might be provided by other team members: "he could have improved on … being honest … concerning frustrations of the group … to tell me I was not handling everything properly, if I had known that, then my actions would have been different."

TWA#2 Technical Person

His technical, "the all-star", and personnel strengths, "amazing people skills", have blossomed. Furthermore, he has addressed the Coaching Challenge in terms of stepping up as a leader, "He … delegated the majority of the tasks" and "shined as a leader during this crucial and stressful time …" He himself states "I feel like I was placed in a role similar to that of a manager." Yet, he could go a step further in leadership development with earlier communication "concerning frustrations" as noted above by the Leader.

TWA#2 Questioner

His Strengths are exhibited in some aspects of the work such as "diagrams" and the "cost analysis" which he was assigned, but consistent with the Coaching tips noted earlier he has not yet gone beyond to "volunteer" to make contribution in other areas but stops short to "let others complete the project". He cites growth in ability to communicate from a distance, "home", to update drawings, but because he mentions the need for constant changes in the drawings it seems he could benefit from more face-to-face communication.

TWA#2 Secretary

It is with this person that the TIDEE comments document the most improvement. She has risen to the challenge documented by her group in the TMC and TWA#1 for more in depth participation. "She was present at every group meeting", "did a great job for the second half of the semester"; her "contributions went through the roof" with technical detail such as modeling the packed bed flow…" and "heat loss", and researching, "the WHO document to find all the necessary information." She was known to be "working on the project when no one else was and with out being asked. Awesome!"

Her own comments show significant growth in the Member Coaching issue of communication, "you need to take the time to sit down individually with each teammate … to ensure quality performance. By communicating goals and expectations well…" She also shows significant attention to quality: "I'd rather have quality work as opposed to "a lot" of work", which may have resulted from meaningful interactions with other team members who are technically astute.

Survey on Usefulness of the TIDEE Site

Though all 39 members of the class were invited to participate in this survey, only 7 chose to do so. This response rate, 18%, while low is fairly common for surveys, and does not invalidate the results. There are two possible interpretations of the survey data. With a survey of this kind, it is common for the scale to run from very negative to very positive with neutral as a midpoint. The scale given with this survey ranged from slightly negative to very positive with positive as the midpoint. Our students are used to the conventional scale, as it is used in our end-of-semester course evaluations. While it is impossible to know with certainty which scale the students used when responding, it is likely that they went with the standard one. An analysis of the comments should shed some light on this as well. Figure 1shows the results and illustrates the problem in interpreting them. Most of the results average somewhere between 2 and 3. Depending on the viewpoint, this is either slightly negative, or slightly positive.
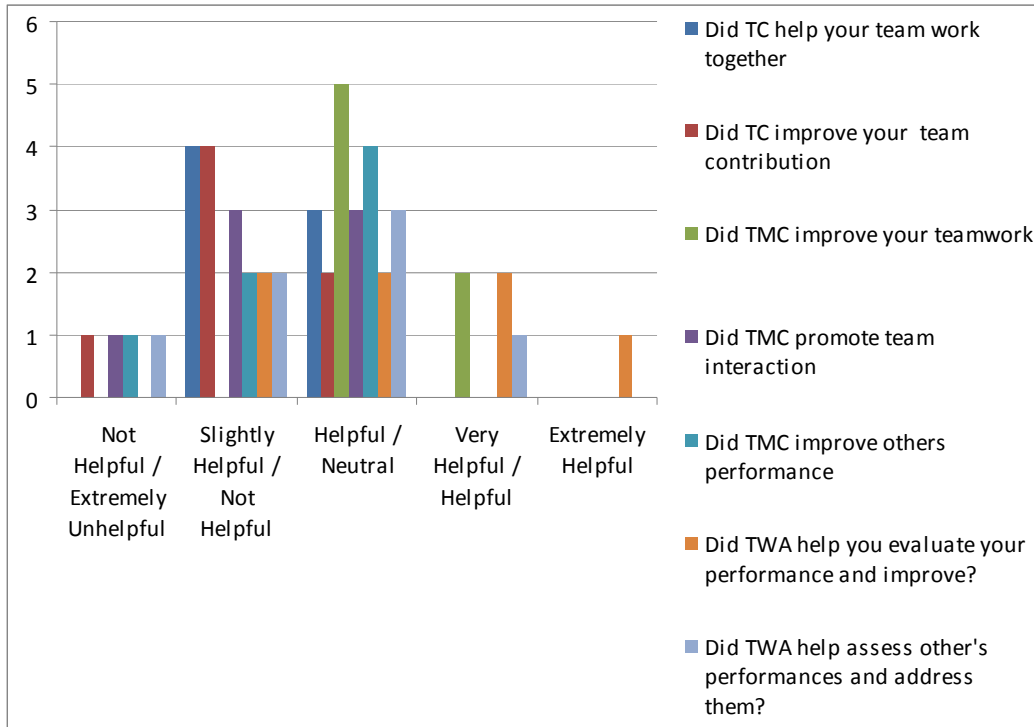
Figure 1: Histogram showing the results of the 'Likert section of the survey. Note that the x-axis displays both of the two possible scales the students may have used when answering the survey.

In response to how the TIDEE activities; TC, TMC, & TWA; prepared them for professional practice, four of the students gave very similar responses, namely that the peer feedback allowed them to "evaluate my team interactions through their eyes." One student commented that "Most people make up stuff to write about and don't take it too seriously … Everyone has the mentality that the other group members will pick up the slack and that the professors aren't going to fail us." Interestingly, when asked how to improve the TIDEE experience, the students were not so positive. There were two responses that boiled down to "students rarely read the feedback posted by others" and another response that "it felt as though it was designed to address that one team member who is really bad at being a team member". However, one student responds that she is currently in a Washington State University Capstone Design course that relies heavily on TIDEE assessments. She notes they spend considerable time learning how to give correct feedback and notes people are graded on the feedback they give in which case everyone takes the TIDEE exercises more seriously. This is consistent with existing recent findings reported in the literature by co-author Davis[7] where six institutions participated in Capstone Design classes where TIDEE exercises were used to varying degrees, but with a minimum that all institutions used the TMC. Here a survey administered to a subset of roughly half the participating students shows 61% of the students perceived instructor feedback on the TMC as very accurate or mostly accurate, 48% saying the TMC exercise was personally very valuable or generally valuable, and 44% responding that the TMC was very valuable or generally valuable to the team. Comments about the exercise were also insightful with many expressing considerable value in the self reflective aspect provided by the TMC. One example comment illustrates the point:

> *"I believe this assignment was very good overall; it inspired confidence in what I was doing well and allowed me to see what else I needed to do in order to create a better team environment. It took me a while to be critical of not only everyone else but also of myself; it definitely made me think and consider what needed to be done."*

The first Capstone Design respondent above also notes further that a weakness exists in the assessment in that it really does not allow allotment of extra credit to someone going above and beyond all others without taking points away from those who are otherwise carrying out expected responsibilities. It isn't really possible to get a sense of overall value from these two questions, since they were focused so much on either what worked well or what needs improvement. However it is clear that, for those students who read their feedback and took it seriously, the TWA worked well for helping students increase their productivity within a group.

Implications

Without a doubt the TIDEE process allows an instructor to monitor and document team progress. Furthermore, the comments are of significant aid in summative assessments to determine student grades - while details are not provided here the TIDEE site provides averaged Likert responses that can serve as multipliers on a team project in order to establish individual grades. In our case we used the square root of the averaged score divided by the team average. Not surprisingly the multipliers served to boost the grades for the Leader and Technical Person. Also, not of surprise is the substantial improvement in the multiplier factor, by about 9%, from TWA#1 to TWA#2 for the Secretary with the reverse trend for the Questioner. When an instructor is asked to support decisions about relative evaluations for members of a team it is often quite difficult and one is left with the default of giving everyone the same grade. In this case the numerical rankings along with substantial TIDEE site comment documentation allowed the instructor to boost the grade with confidence.

The above answers Question 1 of our study about documentation through TIDEE for a non-capstone course. Question 2 about attributing growth to TIDEE is somewhat uncertain. While it is clear that students who read the TMC and TWA comments believe they improved in team performance, survey responses are mixed as to whether all students actually took time to read the comments. Nevertheless, in the Case Study presented it is quite evident that student comments to each other were very beneficial whether they resulted from TIDEE or not.

We conclude a follow-on study is in order where all teams receive faculty comments on their TIDEE responses throughout the semester and that significant weight be given to student reflection on those comments so that students are more apt to take the comments seriously. In addition we would add a reflection assignment for individuals after each submission of either the TMC or TWA which requires students to go to the TIDEE site and view the comments made. The will be asked to respond on one or two specific ways in which they were encouraged about their performance through comments made by others, and one or two specific changes they will make regarding their own contribution to the team environment. Given the Case Study documentation we suspect that overall group performance will improve significantly for all teams.

The TIDEE exercises are available for use by instructors at other institutions and can be found in updated form on the following website: http://ideals.tidee.org/. It is recommended that first time users began with the TMC as the most work has been done in terms of development for this exercise. Questions on how to proceed and load student and professor names can be addressed to co-author Prof. D. Davis (davis@wsu.edu).

Conclusions

We conclude the TIDEE site is effective even when only portions of its features are used in a non-capstone course where teams are involved in Project Based Learning. First, the TC can be used to prompt students to reflect on what makes a good team and to set ground rules for their own team. Secondly, the TMC and TWA comments are an excellent way to document team growth in terms of the composite contributions from all team members. Third, there is evidence that the comments when viewed by team members are taken to seriously and therefore promote team member growth. Finally, the collective findings form the impetus for a more comprehensive study where reflection on team member comments is taught and encouraged. We expect this to help team member growth substantially.

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