

Lessons Learned and Best Practices in Multidisciplinary Teamwork and Teaching of a Small Product Realization Course

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Introduction

The Small Product Realization course has been offered for two semesters (Spring 2003 & Fall 2003) at Penn State Erie, The Behrend College. The course is 3 credits, meeting for 50 minutes 3 times a week. In addition to the scheduled class periods, the students spend one weekend at the beginning of the semester attending a seminar at an off-campus location. This weekend seminar is similar to that described by Swamidass and Bryant¹, except in addition to having students work on team-related activities, there are also guest speakers who present their entrepreneurial activities, and the teams begin to concentrate on identifying a single product idea. For each offering, 3 teams of between 3-5 students were selected.

Course outcomes include being able to:

- Understand and experience selected elements of the product realization process.
- Demonstrate that students can function effectively on multidisciplinary teams.
- Develop a complete business plan for the introduction of a new product.
- Have a demonstrated understanding of intellectual property and ethical issues associated with new product development.

The course is interdisciplinary in nature, with students in both the School of Engineering and Engineering Technology (SEET) as well as the Sam and Irene Black School of Business enrolling in the course and working together in teams. The course is taught by two faculty members in SEET (one engineering professor, one engineering technology professor), and one faculty member in the school of business. Much of the content is similar to that presented by Cagan, et. al.² for their Integrated Product Development course, and by Lumsdaine³ for the ME 490 course. However, due to time constraints, teams are not required to construct and test a prototype. One engineering design text⁴ and one business plan text⁵ are the primary textbooks for the course. Currently, the course is taught without industrial sponsorship, to provide teams with more flexibility for brainstorming product ideas.

The course is separated into 6 main subject areas:

- Project proposal
 - Team creation
 - Brainstorming
 - Market survey
 - Competitive and patent analysis
- Specification development
 - Identifying marketing and engineering requirements
 - House of Quality

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- Engineering design
 - Concept generation
 - Concept selection
 - Engineering tradeoffs
- Financial analysis
 - Development cost estimation
 - Income statement, balance sheet, cash flow statement
- Marketing plan
 - Distribution
 - Pricing
 - Promotion
- Integration of the previous items into a business plan

Each subject area is covered within 2-3 lectures, with the exception of the project proposal area, which is covered heavily during the weekend seminar and the first 2 weeks of the course.

Issue 1: Team Dynamics

Upon completing the initial course offering, the faculty identified two principal areas of improvement. The first area concerned student team dynamics. Engineering and technology curricula often focus on the technical abilities of students, neglecting the “soft skills” that will often determine success or failure for a graduate when (s)he enters the workforce. As an example, project management skills are often neglected in an engineering curriculum, requiring additional training for those engineers who end up in management positions⁶. Skills such as the ability to lead and work effectively as a member of a team are frequently identified as critical to the success of an engineer, but typically are lacking in new engineering graduates⁷. The same is true of business students. While the business curriculum utilizes many team-based projects, students frequently resist building good, effective team-building skills, failing to realize the importance of fine-tuning these skills until they have some practical application in an actual work setting.

It became clear that the teams which were most cohesive tended to develop a more practical and effective business plan. According to Forsyth⁸, cohesion is the strength of the relationships linking the members [of the group] to one another and to the group itself. A cohesive team, as defined here, uses meetings effectively, distributes work fairly, provides constructive criticism, and encourages participation of all members. The development of positive team dynamics as it relates to an interdisciplinary team has been studied, but remains a complex area to evaluate and improve. For example, Ochs, et. al.⁹ indicate that the most reported problem with their entrepreneurship activities was related to teaming skills, both within student teams as well as between teams and their faculty advisors. Swamidass and Bryant¹ have focused on teamwork in their entrepreneurial program at Auburn, utilizing a retreat to focus on basic teambuilding skills, namely:

- Effective communications in teams
- Principles of meeting management
- Tools employed by effective teams
- 360-degree feedback.

The 360-degree feedback discussed by the authors emphasizes gathering data on students in the following areas:

- Agreeableness
- Communication
- Conflict resolution
- Conscientiousness
- Collaborative problem solving
- Extraversion
- Goal setting
- Meeting management
- Planning and task coordination

The interdisciplinary nature of the teams is itself an issue for the Small Product Realization course at Penn State Behrend, for the following reasons:

- Business and engineering students tend to study differently. Engineering students at Penn State Behrend tend to work on assignments in a familiar laboratory, whereas the business students tend to work on assignments at home.
- The schedules of business and engineering students make it difficult for teams to find a time for everyone to meet. Additionally, many students work 20-40 hours per week at outside jobs, further complicating the coordination of mutually convenient out of class meetings.
- The skill sets of business and engineering students are different, so communication issues become more important. For example, the engineering students may need to spend more time explaining technical ideas to the business students, so the business students can translate the ideas into a viable marketing strategy.
- The business deliverables address a wide range of coursework, requiring the business students to have a thorough understanding of many business topics, including finance, accounting, management, marketing, and strategy. Additionally, business students are expected to be able to explain difficult topics to their engineering counterparts when there are questions. This puts those teams with weaker students at a disadvantage and requires extensive faculty involvement at times.
- Engineering students quickly appreciate the value of learning business skills, whereas the business students do not necessarily realize the value of their learning experience until they are in the work force. As an example, one former business student who took the course provided the following feedback to the instructors:

“I have further grown to appreciate the Small Product Realization class after starting a co-op at GE Transportation Systems. In the marketing department I had to deal with the terminologies and processes that were discussed in class. Familiarity with some of the Six Sigma concepts taught in class made it easier for me to understand my job duties. I also became aware of the day-to-day need for the dialogue between the marketers and the engineering department. The large lesson that one takes out of the Small Product Realization class is that one has to be able to negotiate and compromise in order for the project to be completed.... Overall, Small Product Realization was a mini version of the real business world. I would highly recommend this class to anyone who is in business or engineering fields and is interested in generation of new product ideas and a deeper understanding of the processes involved.”

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The faculty has responded with a number of initiatives to improve student team dynamics for the second offering of the course. They are:

- Implementing a web-based course management system to reduce the need for teams to meet in person.
- Having the counseling office present a session on conflict resolution.
- Incorporating additional team exercises during the weekend seminar at the beginning of the course.
- Presenting a video on how one successful product design team operated.

The faculty incorporated the use of a Penn State university-wide course management system, known as Angel, for the second offering of the course. This software enables electronic management of the class. Some of the features include electronic folders for distributing information, communication tools (email and bulletin boards) for both faculty and students, as well as the ability for students to submit deliverables in a paperless format for easy retrieval and grade submission. Team folders were set up, which enabled each team to communicate with one another from remote computers, thus enabling access to documents by all team members. Drop boxes were also set up for each team. A time/date stamp is applied to all submitted material, making it easy for the faculty to determine if a deliverable was submitted on time. Angel was also used as a repository for lecture materials and handouts throughout the course, enabling faculty to have access to lectures, and students to have easy access to handouts. Angel does have certain drawbacks. For example, a faculty member cannot save documents in Angel.

Documents must first be saved on their home computer and then uploaded to Angel. Also, faculty using Angel must be knowledgeable of the different settings available within Angel, otherwise email and other information may not be seen by (or forwarded to) a faculty member. The use of Angel also requires that faculty and students check the Angel website regularly, since the course involves a significant amount of communication, both between students as well as between students and faculty. It is noted that Angel cannot substitute for productive group meetings, and each team recognized the need to hold regular face-to-face meetings, although the faculty did not strictly require them.

At the beginning of the course, a member of the personal counseling office, Ms. Allison Parr-Plasha, discussed conflict resolution techniques. She described to the students how to approach and resolve conflict from a “win-win” perspective, thereby minimizing the possibility of long-term negative consequences for the team.

In the first offering of the course, the weekend seminar included one team building exercise, where teams attempted to recreate a Lego structure that the instructors had built. Teams were arbitrarily chosen for this activity because team formation for the product development occurred at the very end of the seminar. In the second offering of the course, the faculty selected the teams prior to the weekend seminar, and included two team building activities. The first activity required the teams to compete to build the highest structure using only spaghetti and marshmallows within a 20 minute time constraint¹⁰. The second activity was a game called “The Prisoner’s Dilemma,” where teams elect to either “cooperate” or “defect”^{10,11}. The game is based on the idea that two (presumably guilty) suspects have been apprehended and are put in separate cells for interrogation. Each prisoner has an option, either “cooperate” (confirm guilt)

or “defect” (blame the partner). The sentence received depends on what the partner decides, though. If both defect, then both get a stiff sentence. If both cooperate, then both go to prison, but for less time. However, if one person cooperates and the other defects, then the defector will go free while the person who cooperates serves the full sentence. The basic approach can be extended to multiple teams as well. The students tended to favor the first game, because of the obvious need for ingenuity and teamwork. However, the faculty thought the dynamics of the second game were more intriguing, because once one team “defected,” the trust between the three teams deteriorated rapidly and was hard to restore. This is consistent with the discussion provided by Holtzaple and Reece¹¹.

The faculty also spent one class showing and then discussing a video about a well-known product design company known as IDEO. The video was originally presented on a late night news program (Nightline), but is now available on DVD¹². The video shows how the design process can be successfully performed by teams made up of individuals with varying expertise, who think “outside the box.”

Issue 2: Communication between Student Teams and Faculty

The second area of concern dealt with communication between the student teams and faculty. With multiple faculty teaching the course, student teams often received varied if not conflicting information, depending on the faculty member approached. Areas of conflict included submission deadlines, required information for deliverables, returning graded materials within a reasonable period of time, and overall coordination of the course. The faculty responded to this area of concern by:

- Using the Angel course management system identified above to improve communication between faculty and students.
- Assigning a faculty advisor for each team.
- Setting up a weekly meeting amongst the faculty to resolve issues and review the action plan for the upcoming week.
- Developing an overall class Gantt chart so the students could clearly identify the deliverables due at any point in the semester.
- Identifying a faculty point of contact for each deliverable to be submitted, as well as a general faculty point of contact for each team.

The use of a Gantt chart was proposed such that each team could visually see, on one chart, how the course material was laid out for the entire semester, leading up to the development of the final business plan.

Results and Analysis

A survey was provided to the students at the end of the course. The relevant questions for this paper are provided below, along with the average score on a 1-5 scale, with 1 representing strongly disagree and 5 strongly agree. A total of eight students completed the survey.

For the issue of team dynamics, the following are the survey questions and average respondent score:

1. The team exercises during the weekend seminar helped identify the strengths of my team members: 4.25
2. The team exercises during the weekend seminar helped identify strategies that led to successful team processes and results. 3.875
3. My team was able to work effectively together. 4.125
4. My team was able to apply conflict resolution strategies to resolve issues. 3.5
5. I have developed a better understanding of how to work effectively on cross-functional teams. 4.25
6. The lecture on conflict resolution enabled me to more effectively resolve conflicts with my team members. 3.375
7. The IDEO video helped me to understand how multi-disciplinary teams work together. 4.375
8. The IDEO video helped me to better understand the design and product realization process. 4.25
9. The use of ANGEL improved my ability to communicate with my team members. 3.875

For the issue of communication between students and faculty, the following are the survey questions and average respondent score:

10. The use of ANGEL improved my ability to communicate with the course instructors. 3.5
11. My team was able to communicate well with the appropriate faculty member on specific course deliverables in face-to-face discussions. 3.75
12. My team was able to communicate well with the faculty member assigned as the advisor for my team. 3.5
13. GANNT Charts were an effective method for communication of course scheduling and identification of deliverable dates. 2.625
14. Traditional calendars were an effective method for communication of course scheduling and identification of deliverable dates. 3.875

The teamwork approaches that tended to resonate best with the students were the IDEO video and (to a lesser extent) the team exercises during the weekend seminar. The use of Angel to communicate between team members was considered moderately successful. The students did positively indicate that they could work effectively on cross-functional teams.

The lecture on conflict resolution seemed to have little impact on resolving team conflicts. At the end of the weekend seminar, each team was tasked to develop a set of guidelines that each team member would abide by. These guidelines were reviewed by the faculty to ensure that each team considered (and provided strategies for dealing with) issues such as not showing up for meetings (or showing up late), not doing their share of the work, etc. Unfortunately, the guidelines were often overlooked when conflicts arose. In addition, the teams tended to work on a “just in time” basis, where deliverables were worked on the night before. This tended to

obviate the use of the team guidelines. The ability of team guidelines to enable teams to “fire” a team member will need to be more clearly identified in future course offerings. In addition, the faculty has investigated grading some of the deliverables in two stages. Each stage corresponds to a portion of the overall grade for that deliverable (e.g., 50% of the grade for the initial submittal, and 50% of the grade for the revised submittal). Although this grading approach does not eliminate the issues regarding “just in time” submittals, it may help the teams provide higher quality work during the revised submittal phase.

There was only a marginal response to the survey questions relating to communications between students and faculty. For questions 11 and 12 above, one student yielded a score of 1, which skewed the results slightly (no other students rated these questions less than 3). In particular, for question 11, all other students rated communication with faculty on specific deliverables at least 4. However, the use of Angel to improve faculty-student communication will need to be reviewed.

The use of the Gantt chart was poorly received. The Gantt chart was implemented in the middle of the semester. In addition, a number of deliverable dates were moved back to enable the teams to have sufficient time to complete the assignments. Unfortunately, this often required an updated Gantt chart to be uploaded to Angel. Students often were looking at an outdated version of the Gantt chart in class. However, the faculty viewed the Gantt chart favorably, and will likely incorporate it into the next course offering. The key will be to limit changes in deliverable dates during the semester.

The survey also included a section for students to provide handwritten answers to a number of generic questions. One of the questions was ‘What are the most important things that you learned in this class?’ The following are some of the responses:

- “I have learned the importance of team work.”
- “Learning how to work in multi-disciplinary groups was probably the most important thing learned in the class.”
- “How to work in a multidimensional group.”
- “To come together as a team.”

Conclusion

This work has focused on the second outcome for a Small Product Realization course, namely, the ability of students to function effectively on multidisciplinary teams. The faculty at Penn State Erie, The Behrend College has tried a number of methods to improve both team dynamics as well as the communication between faculty and students. Results indicate that the students have identified the importance of teamwork in the course, and have reacted positively to some of the initiatives designed to improve teamwork. The initiatives to enhance communication between students and faculty were received less favorably, and will be rethought. Some of the areas that were not generally well-received may be due to difficulties in their implementation (such as the Gantt chart), but may still be valuable tools to improve communication. These areas will be re-evaluated during the next offering of the course.

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