The Challenges of Teaching an Interdisciplinary Multi-Participant Manufacturing Projects Course

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ABSTRACT

Good projects courses simulate the real world, generate student enthusiasm, and are rich in learning experiences. One way to enhance the real-world nature of projects courses and enrich the learning experience is to incorporate customers and senior managers--groups similar to those students will encounter on the job after they graduate--into the course. We recently team taught a manufacturing projects course to master's-level engineering and business students. This graduate course included five participant groups: instructors, students, graduate assistants, sponsors, and board members who acted as senior managers. Although including multiple participant groups enriched our students' experience in the course, it also complicated our job as instructors. This paper includes a description of our course, challenges we encountered while teaching it, and our thoughts about how to cope with those challenges.

I. INTRODUCTION

There we were, only one month into the semester, and one of our student project teams already wanted to drop their project. The team's board of directors, comprised of senior business people we'd asked to participate in the course, was advocating finding another project and sponsor. Each of our projects had been sponsored by a local business, and this particular sponsor had been challenging to work with. Nevertheless, we were shocked by what we were hearing. The team had barely gotten to know its sponsor, yet, because they felt he was uncooperative, the team and its board wanted to dump him and find another project and sponsor. We were alarmed at the thought that our students would leave our course thinking that, in industry, you can simply dump customers you deem "difficult." The situation cried out for an intervention. We interrupted the board's discussion and argued that it was too early to dump the sponsor and give up on the project. As we stated our unpopular opinion, the tension became palpable.

Through incidents like that, we learned that projects courses, where students work on projects from industry, can be difficult to teach. And projects courses can be even more challenging when you add multiple participant groups (e.g., sponsors and board members) and disciplines (e.g., engineering and business) to a course.

In this paper we describe challenges we encountered while teaching a master's-level, multiparticipant, interdisciplinary manufacturing projects course. We also provide advice for instructors planning to teach a similar course--advice we could have used but had to learn by experience.

II. THE ORIGIN AND DESCRIPTION OF OUR MANUFACTURING PROJECTS COURSE

Many employers, faced with decreasing product lifetimes, increasing competition, demanding customers, and stringent regulatory requirements, have responded by using interdisciplinary teams to tackle the interrelated marketing, design, manufacturing, customer satisfaction, and management issues that must be dealt with to be competitive in today's marketplace.¹ When successful, interdisciplinary teams can shorten the product development cycle, improve quality, and reduce costs.² Success hinges not only on team members' technical skills, but also on their ability to work with others. As a result, employers are looking for college graduates who know how to work on a team and how to complete projects in a timely manner. Many organizations--particularly small and medium-sized firms--can't wait a year or so for recent college graduates to make a contribution; they need to hire graduates who can quickly make a positive impact. Responding to this need, New Mexico State University (NMSU) launched its Manufacturing Engineering & Management Program in 1994. The program's goal is to produce master's-degreed business and engineering graduates who can immediately be productive in a globally competitive manufacturing environment. A subsidiary goal of the program is to produce business-literate engineers and engineering-literate business people.

Manufacturing Projects, the capstone course of the Manufacturing Engineering & Management Program, is a master's-level course listed jointly in NMSU's business and engineering colleges. The intent of the course is to help students learn how to make positive contributions to interdisciplinary work teams and manufacturing firms. In the course, business and engineering students work together on teams to develop an appreciation for the interdependence of business and engineering decisions.

In preparation for *Manufacturing Projects*, business students take a course that introduces them to engineering concepts and engineering students take a course that introduces them to business concepts. To accommodate students' varying needs, *Manufacturing Projects* is offered for five credit-hours in the business college and variable credit of three to five credit-hours in engineering.^{*} Because of the demanding nature of the course, we encourage students to take it for five credits. The course meets twice a week for 2½ hours each class session. Regardless of the number of credits students are registered for, they are required to come to the two weekly sessions. In reality, student teams must meet much more frequently than twice a week to achieve their project objectives. For most students, this course demands a large share of their time during the semester.

When designing the course, we were influenced by David Kolb's ideas about experience as the source for learning and development.³ We believe the best way to achieve the course objectives is through experiential learning, whereby students learn from working on real problems.

^{*}The course is listed for five credit hours in the College of Business Administration & Economics to reflect the course's time demands. The College of Engineering allows only three credit hours of projects courses to count toward masters degree requirements. Hence, engineering students are allowed to take the course for between three and five credit hours, with anything more than three hours of credit not counting toward degree requirements.

Therefore, students in *Manufacturing Projects* are extensively involved in "hands-on" activities rather than memorizing formulas and studying for examinations. Our hope is that *Manufacturing Projects* will approximate what it's like to work on a product-realization team in industry. But experiential learning depends on more than hands-on work; it requires reflecting on one's experiences and learning from them. Therefore, because we want students to emerge from our course as reflective practitioners, we ask them to think and write about their experiences in our course.

Manufacturing Projects requires students to integrate much of what they have learned from diverse dimensions of their life including formal education and work experience. When they experience knowledge gaps, we expect students to be resourceful in obtaining new knowledge from peers, professors, and practitioners. We act as resource persons, but we don't serve as project leaders or solve problems for the students.

Many manufacturing professionals work under tremendous time pressure and have little time for reflecting on the nature of their work and what they've learned. In *Manufacturing Projects*, students also experience time pressure and other demands. Nonetheless, we want our students to do more than just complete a project. We want them to learn about group dynamics and interpersonal relations--things that will help them throughout their careers. And, upon completing the course, we want them to know their strengths as managers or engineers and be able to convince prospective employers they have these strengths. Therefore, our course includes a number of components that complement the project work. Before we describe the challenges the *Manufacturing Projects* course presented us with, it would be helpful to understand a bit about some of the components of our course. As you will see, many of our challenges were a direct result of our unusual course design and our inclusion of multiple participant groups.

III. COMPONENTS OF THE COURSE

A. Projects and Teams

As the course title implies, projects were the foundation of *Manufacturing Projects*. We assigned from six to eight students to each project. The project teams were comprised of an equal or near-equal mix of graduate students from engineering and business. We created mixed teams because we want our business and engineering graduates to be able to work together cooperatively to develop products and services that meet customer needs.

The projects were provided by New Mexico State University's Advanced Manufacturing Center, which receives requests for assistance from local businesses and entrepreneurs and has a backlog of projects and problems needing attention. Although the projects varied in nature, we ensured that all of them encompassed both engineering and business aspects. For example, one of the project teams worked on commercializing a local entrepreneur's hovercraft design. Another team designed an assembly and quality control process for manufacturing a biohazard-detection device. And the third team produced a marketing plan and a prototype decorative fountain for a local firm.

B. Project Sponsor

For each project, we identified a sponsor. In most cases the sponsor was the individual who had brought the project or problem to the Advanced Manufacturing Center. Each team met its sponsor during the first week of the semester; this individual was to be treated as the team's customer. The team's primary objective was to meet or exceed the sponsor's expectations. We highlighted the fact that successful teams in industry work closely with customers to understand their requirements and we asked students to keep their sponsor informed about progress via project status reports.

C. Board of Directors

Each project team had a board of directors consisting of people from industry with varying backgrounds. When choosing board members, we looked for people with extensive experience who would be willing to spend time with students. Many of our board members were retired.

We assigned a mix of backgrounds to each board. In other words, we didn't want one board to consist of all engineers and another board to consist only of people with backgrounds in finance. We asked board members to advise student teams and help them succeed. We also asked board members to

- support and mentor the students;
- help them improve their knowledge and skills;
- give them ideas for resolving project dilemmas;
- act as a sounding board for testing the merit of the students' ideas and plans;
- set guidelines for project reports and other requirements;
- listen to team presentations and provide feedback; and
- help evaluate the team's business/engineering plan.

The number of times teams met with their board during the semester varied, but the mean was approximately six times. And there were many contacts between individual students and board members. Sometimes the purpose of the contacts was to update board members on progress, sometimes the purpose was to seek guidance.

In addition to student-initiated board meetings, we scheduled three formal board meetings: one at beginning of the semester, one near the middle, and one near the end. The first meeting was mainly for purposes of getting acquainted and introducing board members to the team's project. The second meeting was a formal presentation in which teams reported their progress. The third meeting, also a formal presentation, was where teams presented their business/engineering plan, discussed the plan, and showed what had been accomplished. Afterwards, board members gave teams feedback--often in candid language--about project results and business/engineering plans.

D. Business/Engineering Plans

We tasked each team with producing a comprehensive document, referred to as a business/engineering plan, for its project. Although we expected that business/engineering plans

would address how to manufacture a product and introduce it to the marketplace, we knew that the content of the teams' plans would need to vary according to considerations relevant to their projects. Therefore, we deliberately left the scope of the projects vague so the students would have to work with their board of directors and project sponsor to determine the scope of their plan. The team working on commercializing a local entrepreneur's hovercraft design produced a comprehensive business/engineering plan that included drawings for a redesigned hovercraft, facilities for producing it, a projected income statement, and plans for marketing and selling the hovercraft. The team working with the biohazard-detection device produced a plan that specified an assembly and quality control process for manufacturing the device. And the team working on the fountain project produced a plan that included information on design, cost, advertising, and distribution considerations. This team also produced two fountain prototypes.

E. Instructional Team

Because of the cross-disciplinary nature of the course, we formed an instructional team for *Manufacturing Projects*. Our team consisted of a management professor, an engineering professor, and doctoral students who served as graduate assistants.

Much of our effort involved designing processes to help students learn how to successfully accomplish their tasks. We were mostly concerned with helping teams understand how to address important group issues and locate needed expertise. And we were very concerned with helping students learn from experiences so they would be able to apply their knowledge in other settings. We were less concerned with telling students how to accomplish their tasks. Therefore, a small percentage of class time was devoted to lectures; we spent most of our time during class listening to what was happening in the student teams and helping teams when they seemed to need it.

Managing the learning process required a substantial amount of our time. We met frequently outside of class time (at least twice a week for about two hours each session). Some of this time was spent discussing and comparing what was happening in the student teams. At other times we struggled to make sense of unexpected student reactions to course events. We also used this time to diagnose what information our students needed and coordinate the delivery of that information. In addition to the meetings of our instructional team, we spent time individually preparing class lectures or exercises and coordinating events such as the formal meetings with the boards of directors.

Each of the graduate assistants was assigned to a project team; their job was to facilitate, teach, observe, and be a resource to student teams. They were not team leaders. We used the graduate assistants in the role of a facilitator rather than leader because we wanted students to learn to organize themselves and solve their own problems rather than looking to a graduate assistant or instructor to do so.

F. Team-building Exercises

During the first week of the semester, the student teams participated in a team-building exercise outside of class at a local "ropes" course. The purpose of the ropes course is to build cohesiveness among team members and strengthen their ability to work productively and to communicate effectively with each other. The course, which took about three hours to complete, required team members to work together to overcome a series of obstacles. We found that the ropes course is a quick way to form a disparate group of students into a team.

G. Beginning-Of-Class Lectures

We occasionally lectured to students and had guest speakers talk to the class. We reserved the first 30 minutes of each class for this purpose, but we used only about half of these time slots. Topics covered in these sessions included business plans, group norms, scheduling, marketing, managing meetings, and being resourceful and finding expertise. We used a just-in-time philosophy, providing information we thought students needed. Sometimes we conducted posthoc analyses with the class. For example, in the class meeting following the students' first meeting with their boards, we facilitated an analysis of what went right and what they could do in the future to make similar meetings more successful.

H. Journals

We wanted students to be participant-observers of processes, interactions, and results during our course. Students kept a written account, or journal, of their observations, thoughts, and feelings for each team meeting, including the team-building sessions and meetings inside and outside of class. We wanted keeping the journal to be an exercise in reflection and sensemaking. The entries made in journals revealed students' reactions to the class and what was going on within their teams.

Journals were turned in to the graduate assistants at various times throughout the semester. The graduate assistants read the journals and provided students with helpful feedback. They also alerted us to trends or common themes in the journals that suggested that instruction or some other intervention was needed.

I. Readings And Special Assignments

We purposely avoided loading students down with readings and other assignments because project work keeps them extremely busy. However, we sometimes gave students specific topics to read and discuss or write about in their journal. These assignments are opportunities for reflecting and learning. For instance, one journal assignment asked the students to write about their expectations of the course and their personal and team goals.

As with the lectures, we coordinated readings and special assignments with project activities on a just-in-time basis. For example, when we saw that one team was grappling with the difficult sponsor mentioned at the beginning of the paper, we assigned a reading and journal assignment

addressing interpersonal relations and finding common ground with people.

IV. SOME OF THE CHALLENGES WE ENCOUNTERED

Now that we've introduced some of the components of our projects course, it's time to turn to challenges we encountered. We won't discuss all of the challenges we encountered; we'll describe those that met two conditions: (1) they were significant, and (2) we think there's a good chance that other instructors teaching similar courses could encounter them.

A. More Relationships to Maintain

In most courses instructors have only one relationship to maintain--their relationship with students. In courses like ours, however, instructors must be concerned about all of the following relationships: student-sponsor, student-board, student-graduate assistant, board-sponsor, board-instructor, instructor-student, instructor-graduate assistant, instructor-sponsor, and instructor-instructor relationships. Keeping these relationships in working order, which can demand a significant amount of time and energy, is essential to a successful course.

Student-sponsor relationships are especially critical. If a sponsor loses interest and disengages from the course, projects can become what one of our students deemed "a theoretical exercise." When this happens, it's likely to take a toll on student motivation. We've found that students prefer to work on a project that's going to be of practical use to someone.

Experience has taught us that it is important to choose sponsors carefully. Sponsors need to be interested in working with students, have realistic expectations, and have time to meet with students regularly. Although this seems like common sense, we found that sponsors who seem agreeable at the beginning of the course can quickly and unexpectedly lose interest in dealing with students.

If for some reason the relationship between a student team and its sponsor deteriorates, instructors can expect to spend a great deal of effort helping students sort out the situation and motivating them to continue their efforts. The situation described at the beginning of this paper serves as an example. One of our project teams viewed their sponsor as difficult to work with. Because that sponsor feared that competitors would steal his product ideas, he didn't want the students to see his production layout and he wouldn't provide them with much of the information and material (e.g., product prototypes) they asked him for. The lack of cooperation eventually caused the team to become paralyzed with indecision about how to handle the situation. Although we tried to help students cope with the situation, things got extremely stressful when one of the board members for this team recommended that the team find another project. We did not agree with this recommendation for several reasons. First and foremost, we felt that the students could learn some valuable lessons by figuring out how to deal with this difficult sponsor. Second, we were already one month into the semester and starting a new project would have put this team at an extreme disadvantage. We had a troublesome situation on our hands; students were frustrated with their sponsor and, when the board member suggested dropping him, that sounded great to the students. When we nixed the idea we became the "bad guys." That

certainly was a scenario we hadn't expected coming into this class.

Other relationship challenges for an instructor could arise, too. For instance, difficulties could arise between a graduate assistant and the project team he or she is assigned to. Or there could be problems between board members and a sponsor. Or friction could develop between instructors. It's impossible to predict what will arise in such a course; a lot of what happens will depend on the various personalities involved.

B. Less Control Over What Happens During the Semester

Another challenge associated with this type of course is the fact that more variables affecting the class are largely out of the instructor's control. In a typical course, most variables (the content of exams and lectures, class format, etc.) are within the instructor's realm of influence. But in a projects course with multiple participant groups, this isn't the case. For instance, because of things happening in their business or personal life, sponsors may completely lose interest in what student teams are doing. Board members may react to events and form opinions that are very different from yours. Thus, teaching a course like this can occasionally feel like driving a runaway train. One can use influence and, when necessary, authority in working with participant groups, but these have their limits. Participants form their own opinions about what needs to be done on projects and how to go about it. And, ultimately, that's what we want to happen. We don't want students waiting around for us to tell them what to do; we don't want our boards of directors to be passive entities; and we don't want sponsors to behave any differently than customers will in the real world.

C. Increased Anxiety Among Students

Student anxiety in our course seemed to come mainly from three sources: unfamiliarity with this type of course, ambiguity encountered while working on projects, and conflicting advice received from participants (e.g., board members).

1. Unfamiliarity: Unfamiliarity can breed apprehension, and the format of a multi-participant projects course is very different from most college courses. Students have real, tangible work to perform, they have a real customer, and they are asked to apply technical knowledge they're expected to have accumulated in previous courses. Because our course forces students to stretch their capabilities, they all experience high levels of anxiety at some time during the semester.

2. Ambiguity: The ambiguity associated with project work can also be stressful for students. Whereas in most classes the instructor lays out what must be done, in our class, students had to do that for themselves. We didn't lay out a task list and schedule for students because we wanted them to define the scope of their project and set their own schedule. We wanted to avoid a situation where students would be dependent on us to tell them what to do, and we believed they would learn a lot from defining their tasks and setting their own schedules. We merely indicated that they were expected to produce a business/engineering plan; what that plan contained was up to them.

During the early part of the semester, ambiguity was the result of student uncertainty about what to do. As is typical in industry, none of our sponsors had a clear idea or a detailed list of what they wanted our student teams to produce for them. As a result, the students spent the first few weeks of the semester trying to get a handle on their project, oftentimes feeling paralyzed and unable to move forward. And the time pressure mounted as students saw the first weeks of the semester pass with little or nothing to show. Later, after they'd established some modicum of direction, the ambiguity shifted to how to do what they needed to do.

3. Conflicting Advice: Conflicting advice was another anxiety-producing sensation for some of our students. For instance, board members sometimes give conflicting advice to their student teams. This typically happens when students contact board members to report progress, and board members give advice about how to deal with project tasks. And advice from different board members on the same board sometimes conflicts. For example, one of our teams had one board member with a technical background who steered them to attend to technical issues and another board member with a sales and marketing background who urged them to focus on marketing issues. We let students decide for themselves how to handle situations like this; we provide advice, but only if asked.

D. Difficulty Getting Students to Reflect on Their Experiences

Because we want our graduates to be able to work successfully with others in group settings, we ask them to reflect and learn from their experiences in *Manufacturing Projects*. Our experience and the experience of others,⁴ however, shows that getting them to do this isn't easy. The projects were challenging, and students quickly got caught up in their project tasks. They became single-minded about their projects just as people sometimes do in industry. This was the result of the conditions we created in the course. Students had a lot of work to do on a poorly-defined project for a customer who didn't know exactly what he or she wanted. Given the one-semester time frame in which the students must complete their projects, it's understandable why some of them resented assignments (e.g., journal writing assignments) that "got in the way" of their project work.

We were surprised by our students' single-minded focus on their projects. At times we regarded the students' involvement with their projects as dysfunctionally high, especially when they viewed other assignments as busywork. And we were dismayed when students made little use of things they were taught (e.g., scheduling methods) that we thought they should have seen as worthwhile. Why didn't the students understand that there was more to learn than how to complete their projects? We desperately wanted them to learn things like how to conduct effective meetings, coordinate project work, and be assertive, supportive, and successful in group settings. Now we realize that we must be patient and help students make small but steady incremental gains in their group-related skills as they work on their projects. *E. Giving Students Information When They Need It*

Although we provided information we thought the students needed in the beginning-of-class lectures, we made those need assessments unilaterally. The result was that the students sometimes seemed bored, disengaged, and unresponsive during these sessions. And they often

didn't connect the information from the presentations to problems their teams were experiencing. It seemed that, unless a lecture was about something the students were desperately grappling with, the information presented wasn't meaningful to them. Talking with students after the semester was over, we learned that they viewed these presentations more positively than we'd discerned. Their main complaint was that our timing was sometimes off. For example, we brought in an expert on writing business plans to talk with the students when we saw they were gearing up to prepare their business/engineering plans. The students told us that we should have scheduled this speaker for very early in the semester. We had believed this information would have been lost on them during the first part of the semester when they were struggling to figure out what to do on their projects. So, in summary, we found it difficult to predict when our students would be most receptive to information we and our guest speakers presented.

V. SUGGESTIONS FOR THOSE WHO PLAN TO TEACH SIMILAR COURSES

Now we'll share some of our thoughts about how to cope with the challenges we encountered. Specifically, we'll share our ideas about managing participant relations, coping with lack of control, reducing student anxiety, encouraging students to reflect on their experiences, and giving students information when they need it.

A. Participant Relations

One of the most fundamental ways to manage relations in a multi-participant projects course is to carefully choose your participants. This is especially critical with project sponsors. Ideally, you'll find someone who has both a realistic expectation of what students can do yet is willing to motivate the students to perform at their best level. It is especially important to choose people who have time to meet with students periodically and who will maintain interest in student efforts and results throughout the semester.

You are also more likely to maintain a successful network of relations among participants if you carefully explain their roles to them. And revisit these roles at various times during the semester to make sure everyone is clear about what they should be doing. This will help motivated participants learn how they fit into the course and meet your expectations. For instance, in the future, we plan to advise sponsors about what they can do to be effective in their role. The following guidelines for sponsors are a start:

- clearly communicate your expectations and requirements and review them frequently;
- permit the team to come to your facility when project work dictates the need for a visit;
- promptly read the project status reports provided by the team and give feedback and, if needed, redirection;
- call the graduate assistant associated with your project or one of the instructors if a problem arises or you have questions or concerns that cannot be addressed with the students; and
- give the team encouragement when they need it and tell them when they're doing a good job.

After you've explained participants' roles and begun the semester, it is important to maintain

contact with participant groups. We learned this the hard way. We didn't stay in personal contact with our sponsors partly because we had assigned that important task to our student teams, but also because we spent a tremendous amount of energy with board members and students and in planning and coordinating course events (e.g., just-in-time lectures, formal board meetings, etc). If we had stayed in contact with our sponsors, we might have been able to keep them more involved in the course and to help our students cope more adaptively with the sponsors.

B. Coping With Less Control

There are several ways to cope with the lack of control you have over the events that will unfold in a multi-participant projects course. One of these is to recognize that you have limited control and begin the semester with a realistic understanding that the unexpected will happen. And this isn't all bad. Things rarely go exactly as planned in industry, so exposure to unexpected events and learning to adapt and cope are useful experiences for students (and instructors). Another way to cope is to closely monitor what's happening so that you're aware of significant unexpected events. We did this by circulating among the team meetings and listening to what was going on. Then, in the next meeting of our instructional team, we discussed what we'd observed and designed interventions to deal with important issues. We also relied heavily on our graduate assistants, who were present at most project team meetings, to address issues as they arose.

Furthermore, it's easier to stay informed if you're seen as approachable by students. Students need to feel comfortable in coming to you if they have significant concerns or problems. We tried to achieve this approachability mainly by being relaxed and friendly during class-time and also by being flexible in our approach.

C. Helping Students Manage Their Anxiety

It's a given that students will encounter anxiety in a course like ours. But our goal isn't to expose students to anxiety; our goal is to promote learning and help them develop skills. So instructors should identify potential sources of anxiety and consider ways to help students constructively cope with the anxiety.

One way to reduce the amount of anxiety students experience is to thoroughly explain the nature of the course and check for understanding. And it is useful to revisit course expectations periodically during the semester. Multi-participant projects courses--which are radically different from most other courses students have taken--are as complex for students as they are for instructors. Because these courses are different, there's a need to spend more time explaining the course to students and telling them how to get the most out of the course. For instance, there was confusion among students during the first part of the semester about the role of the graduate assistants. Although we thoroughly explain these things in our syllabus, we've found that a syllabus often receives little attention from students. Discussion and dialogue are the key to understanding. And it's important to find out what students are thinking and address their frustrations and misperceptions throughout the semester; waiting until the end of the semester to gather feedback from students is a mistake.

Another way to keep student anxiety to manageable levels is to reduce the time pressure they'll experience during the semester. One way to do this is to, if possible, perform some of the upfront work before the semester begins. The one-semester time frame for completing projects is tight. To allow students to make progress on their projects more quickly, we recommend forming teams, selecting projects, and introducing students to their project during the preceding semester. Then students will already be familiar with their project and sponsor when the semester begins.

Many of our students experienced anxiety during their first meeting with their board of directors. Although we suggested that students plan for this encounter, several of our teams didn't. They quickly regretted this, however, once the less-than-successful meeting began. Although the experience taught the students much about the importance of planning for meetings, in retrospect, maybe we should have given them a bit more direction. At the time we interpreted their lack of preparation as the result of feeling that it was unnecessary to prepare for the meeting--cockiness, if you will. Now, in retrospect, we believe they didn't understand what we meant about preparing for the meeting and why it was important. We discovered that most of our students had never been responsible for a formal meeting before. Looking back, we probably should have helped them prepare for the meeting by leading them through an idea-generation session about how to have a successful meeting.

Graduate assistants can also help students cope with their anxiety. Our graduate assistants attended most of the meetings of their student team. At the close of student meetings, our graduate assistants sometimes initiated group-maintenance sessions. Group-maintenance sessions are a chance for students to focus on and talk about group dynamics and interpersonal issues. The sessions often started with the graduate assistant asking how team members felt about that day's meeting. In addition to discussing that day's meeting, these sessions were also opportunities for team members to talk about how they felt about the project and how things were going. These discussions allowed students to share their feelings and frustrations; they often realized that most if not all of their peers felt the same way. It also gave them a chance to talk about what they were enjoying about the project and their team members. In one of these sessions a student commented that "I just want you all to know that I'm having fun." During the project definition phase of the project, comments like "I think it's good to plan, but I think we need to get started on the work" were quite common. In other group-maintenance sessions the focus was on how the team was working together and how they might do better.

By reiterating the importance of being resourceful and identifying sources of expertise, we were fairly successful in helping students cope with the anxiety of applying much prior learning for the first time. Therefore, because we made it clear that there were many people inside the class (e.g., board members) and outside the class (e.g., other professors) who could help them, our students didn't feel like they had to sink or swim on their own.

Regarding anxiety resulting from conflicting advice, our students eventually learned how to decide for themselves how to deal with it. For instance, when one of our project teams was getting what appeared to be conflicting advice, they talked about the advice they were getting and chose for themselves which advice to take and which to disregard. But if a similar situation occurred in the future, we might counsel students about the value of getting all board members

together and "hashing out" which direction their project should go.

So, in general, we recommend that instructors try to predict major anxiety sources for students and help the students learn for themselves how to manage their environment to deal with sources of anxiety. Keeping student anxiety at a manageable level may help you accomplish other goals, such as getting students to reflect on and learn from their project work.

D. Selecting A Limited Number Of Learnings and Making It Clear Why They're Important

We haven't arrived at a neat package of solutions that will ensure that we can complement project-related learning with other learning. We do know that we must carefully select a limited, reasonable number of learnings to complement project-related learning. The project work students are required to complete during the semester amounts to quite a workload, so there's a limit to how many additional learning assignments students can absorb. Therefore, we need to be selective. We also need to make a strong, clear, convincing case to our students why those learnings are worth the time and effort. For example, we feel that journals are a viable way of bringing about reflection and learning. But we can't expect students to be motivated to spend time and effort on their journal just because we regard it as important. We need to show them how maintaining a journal can promote deeper learning and self-insight.

E. Giving Students Information When They Need It

Based on our experience, we'd recommend that instructors include students in the assessments of what information they need. We felt we had a good handle on this because both we and our graduate assistants monitored what was happening in the student teams. Nonetheless, it seemed that students weren't particularly receptive to much of the information we provided. Our timing was sometimes off. We do not recommend leaving decision making about what information needs to be provided completely up to students. There may be times when they don't know what they need to hear. As instructors, we may be able to make more objective observations about team needs than team members themselves. But we do recommend asking students from time to time about what information they would find useful. This should generate student commitment to learning about topics they have requested information on. Another reason for including students in the assessments of what information they need is that they may ask for information on topics you hadn't included in your agenda for the semester.

We also recommend sharing the list of topics you plan to cover with them and asking which they would like to hear about first. And, when you present students with information they haven't specifically requested, we think it's important to clearly communicate how the information can be useful to them.

F. An Expected Challenge That Never Materialized

Before concluding, we'd like to mention one challenge we expected to encounter but didn't: difficulties between engineering and business. For instance, we might have expected an engineering professor to downplay the importance of group dynamics or for a business professor to over-emphasize the business aspects of projects and under-emphasize engineering considerations. As it turned out, nothing like this happened. We truly functioned as an instructional team rather than a couple of instructors who happened to be team teaching a course, and there was no conflict between us. One thing that helped us was that both instructors were present at all of the class meetings. Both instructors saw what was going on in class meetings and, when situations arose, they could compare notes, make a decision, and present a united front.

Along the same lines, going into the semester we weren't sure how well our business and engineering students would work together. Would they truly form a team and work together, or would they function as loosely coupled sub-units divided along disciplinary lines? As it turned out, our students worked fairly closely with their cross-disciplinary counterparts. There were occasions when the nature of the tasks required that students break into sub-groups according to their discipline. But we noticed little or no "us vs. them" behavior within the teams. The teambuilding exercises at the beginning of the semester probably were effective in minimizing cross-disciplinary conflict. And students may have observed and learned from the effective teamwork in our instructional team. But we have to give our students credit; most of them seemed genuinely interested in learning about what their cross-disciplinary teammates know and how they work. Our students recognized that they will work with cross-disciplinary counterparts in industry after they graduate, and they were motivated to learn how to work together effectively in our course.

VI. FINAL THOUGHTS

Multi-participant projects courses are challenging and, at times, exasperating to teach. We sometimes felt unappreciated when the focus of attention was on what wasn't going right in our course rather than what a great experience it was for students. We have found that one must be patient at times like that; the best thing to do is to keep your faith and realize you may not hear many good things until after the students have left the course. Be patient and keep your sense of humor. And be reassured that, if you have spent the time necessary to design a good projects course, the plaudits will come. They will come later, when you hear from students how helpful the course was in helping them stand out during a summer internship or how it helped them land a job.

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