

Using Student-Managed Projects to Enhance the Capstone Experience

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ABSTRACT

Capstone courses are the culminating experience for graduating students. Typical capstone courses in the geosciences consist of senior theses or field camps. In this capstone course, the whole class works as one team assessing the environmental impact (EIA) of a real project requested by a client outside the university. The course is divided into thirds, with the last third devoted exclusively to the project. The other two thirds cover the legal aspects and methodology of EIA. The students carry out, organize, supervise, and assess all work related to the project. The course instructor only serves as a consultant to the students. Students' performance on the project constitutes a large part of the final course grade. The students find the course engaging and challenging, and the client many times actually chooses the alternative for the project based on the students' findings. This course provides several pedagogical benefits such as experiential learning, engagement, and development of professional skills.

INTRODUCTION

Kerka (2001) defines capstone courses as "culminating experiences in which students synthesize subject-matter knowledge they have acquired, integrate cross-disciplinary knowledge, and connect theory and application in preparation for entry into a career." Capstone courses better prepare students for the professional world where strong interpersonal and team skills are highly valued. One of the main characteristics of the current generation of students is that they are team-oriented (DeBard, 2004). They are more interested in working with each other on a project than individually.

Capstone courses in the geosciences typically revolve around individual senior research theses or summer field camp. There are few examples of team-oriented capstone courses in the geosciences (for one example see Harbor, 2000). In contrast, team capstone courses have a long history of use in the different fields of engineering education (Dutson et al., 1997; Rover, 2000). These courses are typically the engineering senior-design courses, where a small group of students perform hands-on work on real or made-up projects for real or fictitious clients. However, few of these courses involve active management of the project and team assessment by the students.

Having students manage the project creates a sense of ownership of the course in their minds. That ownership affects student attitudes because it gives students an enhanced perception of influence and control: they become more personally involved with projects, they learn to work more effectively in groups, and the students achieve learning objectives (Wood,

2003). Team assessment also increases the sense of ownership by further attempting to simulate an actual working environment, where peer supervisors evaluate the performance of individuals within the team, a practice that occurs less frequently in science courses than in other subject areas (Liu et al., 2002).

The theme of the capstone course is Environmental Impact Assessment (EIA). The United Nations Environment Programme (1987) describes EIA as an examination, analysis, and assessment of planned activities with a view to ensure environmentally sound and sustainable development. EIA is a methodology to examine the environmental costs and benefits of development projects when they are proposed, rather than after they are constructed (Thompson, 2002). In the US, federal and private organizations carry out Environmental Impact Assessments to support federal or federally funded actions. In addition to federal agencies, over 30 states have legislation requiring similar procedures. Many regional planning organizations and local municipalities have EIA requirements for land-use planning and zoning decisions (Canter, 1996). The result of an EIA is a report called an Environmental Impact Statement (EIS) that details the best course of action or the best alternative with respect to the environment to execute a proposed action.

My efforts to use a student-managed, project-oriented capstone course as a teaching tool have been adapted and modified from the experiences of others, especially from engineering senior-design courses. Previously, this course consisted of small made-up projects that teams of three or four students would work on to produce a report that was graded by the instructor. The course did not engage the students, did not involve the community, and did not give students the tools to enter a career. It covered the academic material, but was not a true capstone course. The previous course lacked the engagement and challenging components of a capstone course. The projects were not relevant because they were only made-up academic exercises that included no one outside of the small team of students preparing each report. The students were not challenged to extend their university-learned skills as the report constituted just one more of the typical term-projects from other courses.

The new course described here is both engaging and challenging. It requires the whole class to work as one team on a real project requested by a client outside the university. The client is interested in the results of the student-managed project, the EIS, and many times this final report decides what the client's course of action will be. The students are challenged by having a client they have to respond to and by having their work influence a decision in the community. They are also challenged by having to work together in a team managed and assessed by their peers and not the instructor.

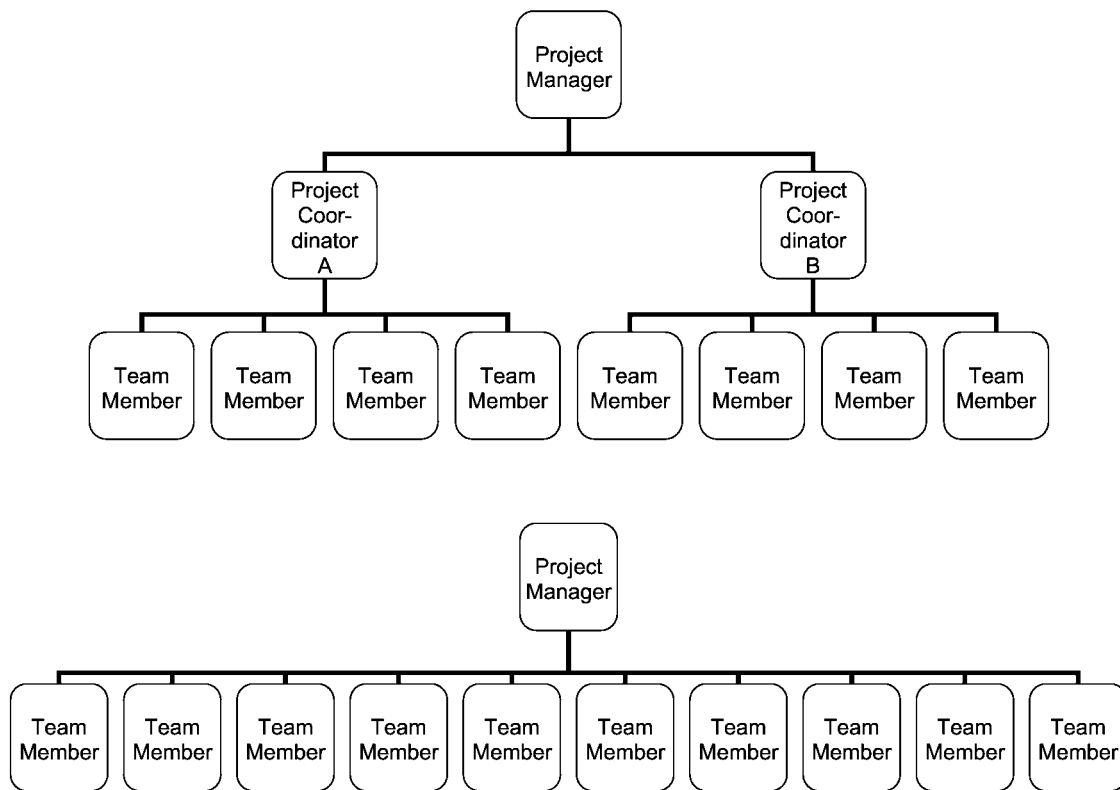


Figure 1. Tall versus flat organizational structures (adapted from Mintzberg, 1979).

CLASS STRUCTURE

The capstone class meets twice a week for 75 minutes each time. The length of the course during the semester is divided roughly into equal thirds. The first third briefly covers the history, philosophy, and legal authority for environmental impact assessment. This part of the course is based on a combination of lectures and discussions from assigned readings from several sources and the textbook. Specific assignments for this section of the course include summaries and reviews from actual Final Environmental Impact Statements (FEIS) produced by federal agencies and easily found in the documents section of the library or the federal agencies' websites. During this part of the course I use varied active learning techniques that stress team work and cooperation, such as think-pair-share (Lyman, 1987), jigsaw classroom (Aronson and Patnoe, 1997) and gallery walk (Holbrook and Kolodner, 2000). These active learning techniques serve two purposes for students in this class: to have more control of the course and to start working with each other (Wood, 2003).

The second third of the course focuses on methodologies and techniques for Environmental Impact Assessment (EIA). This section is strongly tied to the capstone project. Each methodology and technique is presented with respect to the specific capstone project of the course, and each homework assignment directly applies to the progress of the capstone project (see Student-managed Project Section). At the beginning of this section, I reserve two lectures to bring all the team members up to speed with respect to one or more technical aspects of the capstone project. For example, if the project is related to parking lot construction, then we

discuss rainfall-runoff processes and the impacts of impermeable surfaces.

The last third of the course is devoted exclusively to the capstone project. No new material is introduced in this part of the course. The class periods are used only for team meetings to discuss progress, assign new work, and keep everyone on the team on track. During the last week of the semester the students present the results of the EIA project orally to the client and to interested community members, and in written format (electronic copy of the Environmental Impact Statement).

STUDENT-MANAGED PROJECT

The student-managed project is the core of this capstone course. Except for the instructor's task of finding the project and framing it with respect to an Environmental Impact Assessment, the students carry out, organize, supervise, and assess all project work. The course instructor only serves as a consultant to the students. The whole class works on only one project during the semester. The deliverables to the client are a written copy of the Environmental Impact Statement, detailing the best course of action for the project, and a copy of the electronic file used for the oral presentation.

The project for this course varies every semester with respect to the location (environmental setting) and the type of project. In contrast, typical project-oriented or capstone courses in the geosciences utilize the same physical location (e.g. a watershed) on a continuous basis (Harbor, 2000; Woltemade and Stanitski-Martin, 2002; Salvage et al., 2004).

Projects for this course have included environmental impacts of siting wind turbines, constructing porous

PROJECT TEAM EVALUATION

Use the following scale: A+, A, B+, B, C+, C, D, F

| Name | Availability | Performance | Disposition | Effort | Overall |
|------|--------------|-------------|-------------|--------|---------|
| | | | | | |
| | | | | | |

Availability: easy to contact, responds timely to e-mail or phone messages.
Performance: accomplishes the duties assigned to him/her.
Disposition: has good relationship with the rest of the team members, does not complain about his/her duties.
Effort: puts in the time and work required for the project.

Figure 2. Rubric for team member evaluation after each section is completed.

parking lots, switching a vehicle fleet to alternative fuels, and constructing an interstate truck plaza. Although these projects would not generally require the development of an Environmental Impact Statement (EIS) due to their reduced magnitude and significance of impacts (Canter, 1996), they are good examples of the kinds of issues occurring in project management. Once our students graduate, they will likely face similar situations at work.

The usual enrollment in this course is around twelve students, though it has been as high as eighteen or as low as ten students. The project team is assembled by electing a project manager and two project coordinators. The rest of the students become part of any of two teams under one coordinator. In my experience, this tall structure (see Figure 1) versus a flat structure (only a project manager) works better at distributing the work and delegating responsibility among all team members. The better functionality of a tall structure may also be due to limitations of an inexperienced manager in handling a large team (Miller, 1956). When using only a student project manager and no project coordinators, the project manager got overwhelmed very quickly as the tasks quickly accumulated. Having two project coordinators and no project manager created some decision-making conflicts and the look of the final report was not uniform.

The project manager and two project coordinators are elected by voting from all the students in the class. It is typically done with a secret ballot. Any of the students in the class can be elected. However, any student can be excused from becoming a project manager if they think that they will not be able to perform the duties due to other time commitments such as a heavy academic load or demands of current job. Project coordination demands less time than project management and typically students do not need to be excused from becoming one. Obviously, more time spent on the class has to be rewarded and the project manager gets a 5% bonus on the final grade for performing this duty. The election takes place approximately one month into the semester, once the students have the chance of meeting and working with each other. This is a capstone class, so

most of the students have taken classes together before and already know one another.

The duties of the project manager are to be the point of contact with the client; to keep the client informed of the progress and to make sure that all the client's issues are addressed, and to put together the final document (EIS); making sure it has a unified look and feel, since the writing is done by all the team members. The project manager also works with the project coordinators to find the best way to subdivide the project into tasks and distribute them to the team members. Some projects work better by grouping the team members by knowledge and skill and others by grouping them by work process and function (Mintzberg, 1979).

The project coordinators' tasks are to distribute the work to the team members, deal with the every day issues of managing the teams, and compile the work done by the team for submission to the project manager. The project coordinators, together with the project manager, create the oral presentation from the information gathered by all the team members, and the coordinators present it to the client and community.

The instructor serves as a consultant to the project manager and coordinators as well as to any team member. This consulting role may involve how to deal with people management issues or detailed technical questions. My role as a consultant is not a passive one. I stay in contact with the project manager and coordinators to make sure that the project progresses smoothly. I attend all group project meetings, but only as an observer and usually take a seat in the back of the room. In contrast to the availability of the consultant (instructor) at all levels, the project manager is the only student with direct contact with the client.

Working with an actual client and project makes this course a capstone experience, not just an academic exercise. The clients have a genuine need for the results of the project. The report prepared by the class will help in the decision making process of the client with respect to the project (an environmental impact assessment determines what is the best way to carry out a project). This aspect of engaging in a "real world" project as well as the realization that the team work will have a direct impact on how a project may proceed really excites the

PROJECT COORDINATOR EVALUATION

Use the following scale: A+, A, B+, B, C+, C, D, F

| Name | Leadership | Support | Clarity | Team Bldg. | Overall |
|------|------------|---------|---------|------------|---------|
| | | | | | |

Leadership: influences, motivates, and challenges others.

Support: provides additional information when requested.

Clarity: defines the project goals for each team.

Team building: inspires, motivates, and guides others toward goal accomplishments.

Figure 3. Rubric for project coordinator evaluation at the end of the semester.

students. They work hard not only for a grade, but because their work can make a difference outside of the classroom.

PEER ASSESSMENT

The content of an Environmental Impact Statement (EIS), the written report, is well defined (see Canter, 1996). For purposes of assessment and report integration, the main project load is typically divided into four or five homework assignments that correspond to the different sections of an EIS. As each section is completed by a team or teams, it is turned in to the project manager and instructor for review. The project manager and instructor review each section and give feedback to the appropriate project coordinator if information is not thorough or complete. The project coordinator will then assign the revision to a team member or may revise it himself/herself. However, the project coordinator may not have any enforcement authority if part of the assessment does not reside in that position. Together with each homework assignment (completed section) the project coordinator submits a rubric to the project manager and instructor assessing the work of the team members for that section. This rubric is presented in figure 2. The rubric is handed out before the project starts, so the team members can better understand what is expected from them. This periodic assessment helps the team improve their skills as they go. Peer assessment encourages the students to become more involved in their own learning process and repetitive assessment is a necessary part of it (Loacker, 1988; Liu et al., 2002).

The grading by the coordinators constitutes a large part of the final grade of the members of the team in the project, and since the project makes a large part of the course, a large part of the final course grade. The team members also have an opportunity to assess the work of their own coordinator (see Figure 3). However, the coordinators' assessment only takes place at the end of the course. I have debated not doing a repetitive assessment for the coordinators. My concern is that having mutual and continual assessment of both parties (team members and coordinators) may influence the

objectivity of the evaluation. Nevertheless, throughout the project I am in contact with the project coordinators and am able to give them feedback in their performance. The project manager is assessed by the project coordinators at the end of the course.

TRANSFERABILITY

I recognize that not every capstone course can be turned into a student-managed project due to the size of the project or the nature of the material covered in the class. However, many capstone courses are project-based and turning over the management and assessment of the project to the students can be a very rewarding experience for the students and the instructor.

Finding a "real project" has not been difficult. However, it requires the instructor to spend time before the semester starts talking with possible clients to find a suitable project. It is always advisable to have a back up project in case the main project does not go through, is not approved, or gets canceled.

Clients for the course have included municipal utilities, regional planning commissions, city parks departments, and even our own university administration. It is my experience that once the surrounding community, especially the city and county authorities, and NGO's (non-governmental organizations), realize that there is a group of students at the senior level eager to work on some aspects of project development (EIA) the list of possible projects increases. So, the instructor of this course also has a public relations function.

It is my intention to gradually evolve this class into an environmental management tools course (see for example Thompson, 2002), where EIA would be just one of the tools. This would give more flexibility with respect to the type of projects that could be addressed each semester in the course such as environmental site assessment, life cycle assessment, environmental auditing, ecosystem-based management, environmental risk management, etc.

I am also interested in integrating into the capstone course a junior-level course currently being developed in

field methods in environmental science. This new field methods course could serve as a "subcontractor" for some of the field work measurements needed for the capstone project. Currently, most of the research done for the EIA is bibliographical in nature due to the double constraints of time and expertise. However, with the use of some of the time of the field methods class, research in the capstone course could be more dependent on actual data collected at the project site.

PEDAGOGICAL BENEFITS

The pedagogical benefits of a student-managed capstone course are many. Students learn to think through and resolve problems on their own, which is a skill that many science students are missing (Picard, 1999). The experiential learning of this course, where students learn by doing, actively involves and empowers them through a "bottom-up" versus "top-down" educational process (Wood, 2003). The classroom becomes an environment where students make the decisions through applying what they have learned.

This course also better prepares them for the professional world, where strong interpersonal and team abilities are highly valued, by making group work among students more effective. For the project manager and coordinators, it provides them with an added set of managerial skills. These are not learned in the typical classroom setting and are eagerly sought in the professional world.

Engagement is another pedagogical benefit of this course. The students provide a service (the EIS report for a proposed project) to the community (the client from the municipal utility, regional planning commission, or city parks department) and in return receive experiential learning (Smith et al., 2005). The students have the opportunity to contribute to their community in a concrete way and learn valuable professional skills.

The majority of the students' comments on the class reflect their enjoyment of a course that applies the concepts rather than just reading about them, and their high regard for the practical experience gained, as well as having a say on a project that affects the community where they live.

CONCLUSIONS

The students' experience in a capstone course can be greatly enhanced by transferring the management of the capstone project to the students. My role as an instructor then becomes more of a designer and facilitator of learning experiences and opportunities rather than an imparter of knowledge (Smith et al., 2005). Returning the control of the course to the students, especially when their work is going to be reviewed by someone outside of the classroom (the client), can be somewhat frightening. However, in my experience with the different groups of students that have participated in this course, the students always perform at or above expectations because they are interested in the outcome of the project and want the approval of the client. This is reflected by the comments and decisions with respect to the projects that the clients have made (i.e., following the recommendations of the project report, assigning other projects for this course to work on, etc.)

This course has benefited the students by increasing the number of skills they have to enter a career. It better prepares them for the workforce. The course has affected

me, the instructor, by giving me a new appreciation for the effort and responsibility of the students when challenged with a concrete project that influences the world outside the classroom. So, it begs the question, are we challenging our students enough with our courses?

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