

CAPSTONE INTERDISCIPLINARY TEAM PROJECT FOR MASTER OF SCIENCE IN SUSTAINABILITY

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This paper describes a six credit year-long capstone course for teams of students from different disciplines working on interdisciplinary projects. The course is required for the degree of Master of Science in Sustainability, a newly introduced graduate program at the City College of New York. The program, Sustainability in the Urban Environment, integrates the disciplines of architecture, engineering and science. Team members from different disciplines work together on sustainability problems. Course motivation, objectives, outcomes, evaluation plans, and conduct are discussed. A sample of course material prepared by a team of instructors is presented. This material describes project topics and includes a sample guideline to facilitate project supervision.

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I. Background

Responding to a dramatically increasing interest in sustainability, more and more universities are offering courses, certificate and degree programs in sustainable design, development, manufacturing, construction, and urban and environmental planning. The Association for the Advancement of Sustainability in Higher Education (AASHE) reports that since 2006 the number of sustainability programs has increased from a handful to several hundred¹. The majority of such programs have evolved around established disciplines such as engineering, environmental studies, ecology, earth sciences, and architecture. However, sustainability is a multidisciplinary field. As the field developed, sustainability problems no longer fit into neat separate categories. They require team efforts of professionals in disciplines such as: engineering, architecture, science, economics, law, government and business. To address sustainability issues, team members must learn to work together, develop common values and priorities, and function together to construct solutions to unfamiliar problems.

Responding to this need, in 2009 the City College of New York (CCNY) launched an innovative and interdisciplinary graduate program, Sustainability in the Urban Environment, which integrates the disciplines of architecture, engineering, science and economics. This 30 credit program leads to the degree of Master of Science in Sustainability. The first student enrollments in the program began in Spring, 2010. A key feature of the curriculum is a required course: Capstone Interdisciplinary Team Project. This six credit year-long course is designed

to train teams of students to work collaboratively on real-world interdisciplinary problems, develop a holistic approach to sustainability issues and jointly prepare a final report. The inclusion of this course was motivated by the widespread success of the ABET requirement of an undergraduate capstone senior design course. Although the majority of undergraduate projects are department specific, a 2005 national survey showed a trend towards interdepartmental projects and team composition².

The requirement of a capstone course in graduate engineering programs has been limited and varied. They vary in credit and format. Examples include zero credit course³, individually assigned project⁴, collaborative team work⁵, and others. Of more interest here is the curriculum of graduate sustainability programs leading to the Master of Science Degree. A review of Master's Degree programs listed by the AASHE⁶ and other sources was carried out with special focus on the requirement of a capstone course, thesis, or research project. Table 1 summarizes such requirements by seven universities. Although the term capstone is often used it can refer to a thesis, course, workshop or project and carry credits ranging from 3 to 9. None of the programs listed in Table 1 require students to work in teams. Clearly no uniformity is found with regard to a capstone course requirement. This is not surprising in view of the fact that sustainability programs are relatively new and are still developing. Departing from these models, the CCNY program incorporates a required course: Capstone Interdisciplinary Team Project. This six credit year-long course is designed to train teams of students to work collaboratively on

real-world interdisciplinary problems, develop a holistic approach to sustainability issues and jointly prepare a final report.

TABLE 1			
University	Degree	Capstone Course	Cr.
Lipscomb	MS in Sustainability	thesis	6
Slippery Rock	MS in Sustainable Systems	thesis	6
Illinois Institute of Technology	MS in Environmental Management and Sustainability	class	3
Arizona State	MS in Sustainability	optional thesis	6
Villanova	MS in Sustainability Engineering	optional thesis	9
Columbia	MS in Sustainability Management	optional workshop	3
Michigan	MS in Sustainable Systems	optional thesis	6

II. Course Motivation and Objectives

Traditional curricula for architects, engineers and scientists lack the broad perspective and training needed to address sustainability issues. Recognizing that an effective sustainability program must integrate multiple disciplines, provide a strong interdisciplinary structure, and train students to work collaboratively on complex projects, a specially configured capstone course was included. The objectives of this course are to:

1. Train graduate students with diverse educational backgrounds to plan and implement strategies for solving sustainability related problems.
2. Prepare students to work collaboratively across traditionally defined disciplinary boundaries.
3. Free graduates from the specialist paradigm and prepare them to tackle unfamiliar problems outside their training field.

This course comprises 20% of the degree requirements and holds a critical role in the success of the program. Course organization, identification of project topics, formation of student teams and the selection of faculty mentors are challenging issues that had to be addressed before the course could be offered. Although the first enrollment in the course is

expected to be in the spring of 2011, considerable attention is given to its planning and execution.

III. Project Topics and Mentoring

Identifying project topics emerges as a central issue to be explored. This task requires judgment and balance. The following criteria for identifying project topics were formulated:

1. **Interdisciplinary.** Solutions to assigned projects should require team members to have training and backgrounds in more than one discipline. For example, engineering and botany for a green roof project.
2. **Relevance.** Assigned projects should address real-world sustainability problems.
3. **Balance.** In general students are intimidated by interdisciplinary problems. Although projects should be challenging and interesting, care must be exercised to select projects that avoid major stumbling blocks, setbacks and delays common in research projects.

It soon became evident that the preparation of material for this course could only be done by a team of faculty with diverse backgrounds and interests. A proposal to support the project was prepared and submitted to the Fund for the Improvement of Postsecondary Education (FIPSE) of the U.S. Department of Education. The proposal was approved. Specifically, the objective is to prepare material for 21 projects for the capstone course. Seven faculty members representing the disciplines of architecture, engineering, science and economics began work on the project late last year. In addition, the grant has a project director and an evaluator with a background in education and psychology.

Early on, it was clear that a team of faculty of diverse educational backgrounds and experiences need to learn each others' languages and perspectives. What is meant by an engineering "project" and how does it differ from the term "studio," commonly used in architecture courses? What should the level of project complexity be? What defines an interdisciplinary project? What should the mentor's role be? These and other issues had to be addressed before formulating projects for the capstone course.

To start the project development process, each participating instructor was asked to prepare a one page description of a possible topic for the course. What makes this exercise difficult is insuring that the content is interdisciplinary. An initial list of recommended projects was compiled, distributed to team members, and discussed at a subsequent meeting. Some projects were eliminated while others

were modified. As a project became more focused and team members became more familiar with the subject, preliminary mentoring partnerships were identified. This early experience in developing projects for the capstone course demonstrated the need for a broader participation by the faculty of the sustainability program. A memo was circulated to 30 college wide instructors inviting participation in the process. Clearly, beyond the FIPSE grant period the faculty must continue to prepare material for the capstone course.

Anticipating that students will view the capstone course as a challenge and an opportunity and that they would seek detailed information about a project before selecting it, educational material will be prepared and posted on the capstone course web page. The following format will be used.

Mentor
Co-mentor
Composition of student team
Project description
Project objectives
Project progress schedule
Bibliography

Sufficient project information will be included to avoid unnecessary delays. Of course encountering stumbling blocks, experiencing setbacks, and overcoming obstacles are an important part of the learning process. How much information is given requires balance and judgment. Not included in the posted outline is any solution strategy. This is part of the material being prepared under the FIPSE grant. It is for use by mentors and designed to facilitate project supervision.

IV. An Example: Manhattan Bus Routes

To provide a sample of the prepared material for the capstone course that will be made available to mentors, the following abridged example is presented.

Composition of Student Team: engineering, science, social sciences.

Project Description: In 2006 New York City unveiled its *PlaNYC 2030 A Greener Greater New York* and challenged citizens to generate ideas to achieve sustainability in “Land, Water, Transportation, Energy, Air and Climate Change.” Inspired by this challenge we are interested in a proposal to improve transportation and reduce air pollution. Most of the Manhattan avenue bus routes usually make a stop every two blocks. Such frequent stops increase fuel consumption, atmospheric pollution, and cause delays. Carry out a study to evaluate the impact of making a stop every four

blocks.

Project Objectives. Provide supporting data and information on the following:

1. Energy savings
2. Reduction in air pollution
3. Impact on route time
4. Impact on the number of busses serving a route
5. Annual cost savings
6. Public reaction

Based on the findings, prepare a proposal to the Metropolitan Transportation Authority (MTA) and other funding agencies for a grant to implement your recommendation on a trial basis.

Outline of solution strategy: The following is a suggested approach for carrying out this project. It is prepared to assist mentors in project supervision

1. Select two typical Manhattan avenues routes. Ride the bus during and off rush hours. Collect time and number of passengers data on loading and unloading, stops at traffic lights, and total route time.
2. Contact the MTA and obtain data on bus model and manufacturer, daily fuel consumption, route and run time, as well as other information that you judge as relevant.
3. Certain Manhattan bus routes also have “Limited” busses. These buses make fewer stops than regular busses. Data on these routes may be useful in evaluating the effectiveness of reducing the number of bus stops. Contact the MTA and request data on the Limited busses.
4. Contact the bus manufacturer and obtain data on fuel efficiency, exhaust gas composition, etc.
5. Carry out an analytical study to estimate fuel consumption and carbon footprint for the regular bus and reduced stops cases.
6. Prepare a questionnaire for passengers to obtain data that will shed light on public reaction to a reduction in bus stops. Collect information on walking distances to and from bus stops, attitude about stops and transportation service, concern about air pollution and energy conservation, etc.
7. Carry out cost savings analysis taking into consideration the following: (a) fuel cost, (b) number of busses serving a route, and (c) revenue from added parking meters on the eliminated bus stops.
8. Identify agencies that may be interested in supporting a grant to carry out a detailed study of the proposed bus stop reduction concept.

V. Course Conduct

Careful attention is given to how the capstone course is organized and administered. Although we have extensive experience with our undergraduate senior

design capstone project, the graduate course differs in that the majority of team members are expected to be part-time students with full-time employment. To insure that projects will move forward and team members have opportunities to work jointly, class meetings will be held once a week in the evening. A class room with computers will be dedicated to the course and an instructor will be assigned to act as the course administrator attending the weekly meetings. Lectures are planned on project management and team work. Teams will be required to make class presentations summarizing their projects and progress.

VI. Evaluation

An evaluator is assigned to the project to assess the extent to which project objectives and outcomes have been achieved. Although the first enrollment in the course will be in the spring 2011 term, evaluation plans have been designed. Two student questionnaires have been developed: pre and post course. Students will be encouraged to add their comments about their course-related concerns on the questionnaires. Project supervisors will also evaluate and report on the extent to which student team members learned to implement a strategy for successfully completing their projects.

Bearing in mind the academic specialties of entering students, since a primary goal of the course is to prepare graduate students to work collaboratively across the traditionally defined disciplinary boundaries, the pre- and post course questionnaires will evaluate student confidence in working: (a) in the sustainability area, (b) outside one's field of expertise and (c) in acquisition of the skills needed to work as part of a team.

References

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