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Capstone interdisciplinary team project: a requirement for the MS in sustainability degree

Capstone interdisciplinary team project

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Abstract

Purpose – This paper aims to describe experience gained with a required six-credit year-long course, the Capstone Interdisciplinary Team Project, a key component of the Master of Science (MS) in Sustainability degree at the City College of New York. A common feature of sustainability problems is their interdisciplinary nature. Solutions to sustainability problems often require professionals with different training and backgrounds to work as a team. A sustainability curriculum should provide students with the skills needed to competently participate in an interdisciplinary team.

Design/methodology/approach – Instructors drawn from different departments and divisions of the college developed a pool of sustainability-focused Capstone projects and acted as mentors to teams of students with diverse undergraduate backgrounds. Students attended workshops designed to provide training in teamwork, research and report preparation. An independent evaluator designed an evaluation protocol to assess the course's impact both while it was implemented and after the course was concluded.

Findings – Early experience with the program strongly indicates that the Capstone project requirement is an effective learning tool. However, identifying qualified mentors, developing suitable projects, assembling teams and administering the Capstone course are demanding tasks. Although students often experience difficulties in the early stages of their work, they ultimately express satisfaction and appreciation for the skills learned in the course.

Practical implications – The inclusion of a capstone team project in a graduate sustainability curriculum is strongly recommended. Adopting such a course requires significant effort and sustained faculty engagement.

Originality/value – Although there is considerable experience with undergraduate engineering Capstone course requirements, little is known about interdivisional capstone requirements at the level of master's degree in Sustainability. This paper details new and relevant experience helpful to the implementation of such a requirement.

Keywords Capstone course, Inter-divisional team project, Inter-disciplinary sustainability course, MS in sustainability, Sustainability curriculum

Paper type Case study



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1. Background

In 2010, the City College of the City University of New York (CCNY) launched a new graduate program, Sustainability in the Urban Environment, leading to the degree of Master of Science (MS) in Sustainability. The program was developed by a college-wide committee of faculty, representing four academic divisions: architecture, engineering, science and social science. Faculty developers insisted upon a fully interdisciplinary program that would apply to the administrative structure as well. The program is not housed within any of the College's component divisions. This structure created a number of administrative challenges, ranging from sources of budgetary support to faculty-hiring decisions and even to the details of commencement procedures.

The committee developed a 30-credit curriculum designed to give students with diverse educational backgrounds and perspectives a common language and sense of common purpose. The curriculum departs from the traditional specialized training and emphasizes working collaboratively across conventionally defined academic disciplines.

A unique component of the curriculum is the Capstone Interdisciplinary Team Project ("Capstone project"). The Capstone project is a required six-credit year-long course, representing 20 per cent of the overall credits required for MS in Sustainability. Capstone projects are interdisciplinary microcosms of the curriculum as a whole, which is an integrated mix of the four disciplines. Capstone teams must consist of 2-4 students who bring with them an interdisciplinary mix of academic backgrounds.

Our program strongly emphasizes Capstones partly because of the successful role Capstone courses have played within undergraduate engineering programs at institutions in the USA and elsewhere. To satisfy generic capstone design requirements of the Accreditation Board for Engineering and Technology (ABET; [ABET, 2013](#)), many undergraduate engineering and technology departments include a required senior capstone design course in the curriculum. Such courses help satisfy ABET requirements that students develop the ability to synthesize knowledge and skills learned in undergraduate courses for the purpose of solving real-world problems. The skills include application of fundamental laws, working in teams, verbal and written communication, project management, etc. Although each department in a school usually offers its own senior Capstone course, there are examples of interdisciplinary capstone arrangements that offer students opportunities to work on teams comprising undergraduates majoring in different disciplines ([King, 2008](#), [Montana State University, 2009](#)). Such a team orientation is recognition of the importance of working across disciplinary lines.

The designers of our program, inspired by the experience of undergraduate Capstone projects, carried out an extensive review of graduate programs in sustainability to assess the role of Capstone courses within these programs. The Association for the Advancement of Sustainability in Higher Education has provided a very useful compendium and now lists 426 sustainability-focused master's programs, [AASHE \(2013\)](#). In addition, our program participated in a 2011-2012 survey by Dalhousie University that examined more than 600 postgraduate-level programs related to environmental sustainability, and as a result, had the benefit of the survey database ([Van De Keere, 2012](#)).

To our knowledge, no interdisciplinary program leading to an MS in Sustainability integrates architecture, engineering, science and the social sciences and requires a

year-long Capstone team project. Perhaps the closest analog is the program at the University of Sidney, whose MS in Sustainability requires a Capstone project proposed by a team of students (possibly based on their employment) in collaboration with managers at their workplaces (University of Sidney, 2013).

Although capstones are not common, some existing programs do offer various forms of capstone experience. Arizona State University requires a three-credit *Applied Capstone* course. This requirement is satisfied by an internship, applied project or a workshop (Arizona State University, 2013, Brundiens *et al.*, 2010). Columbia University (2013) requires a three-credit course, *Workshop in Sustainability Management* (2013). This is a client-based capstone that integrates elements of the curriculum into an applied project. Saint Louis University (2013) offers a sequence of two courses (five credits), where students work individually or in teams (2013). Rochester Institute of Technology (2013) requires a thesis for the degree of MS in Engineering Sustainability (2013). Blekinge Institute of Technology (2013) (Sweden) requires students to work in teams with industrial firms for the degree of Master's in Sustainable Product-Service System Innovation (2013).

The decision to give Capstone projects a prominent role in our program was a deliberate choice of the program founders and was not pre-ordained. It departs from conventional experience and charts new directions. It could be that the flexibility and energy needed to effectively develop, staff and administer this type of Capstone project program has dissuaded other institutions from implementing Capstone courses in this full-bore manner.

2. Capstone project criteria

The Capstone course is crucial to the success of our sustainability program and as such it requires careful planning and execution. Our first task was to establish project criteria. Four were identified:

- (1) *Interdisciplinarity*: Assigned projects should be such that their analysis and solution requires education and experience in more than one discipline (e.g. engineering and botany for a green roof project).
- (2) *Relevance*: Assigned projects should tackle real-world sustainability issues.
- (3) *Balance*: Students are often intimidated by interdisciplinary problems. Although projects should be challenging and interesting, they should not be at a level of difficulty that is overambitious for a two-semester effort.
- (4) *Mentoring*: A project should be of interest to a faculty member who is available to mentor a team of students enrolled in the course.

Preparing material for the Capstone course that meets these criteria is a challenging task. It involves reviewing a broad range of sustainability issues, defining specific problems and outlining solution strategies. The task requires judgment and balance. Moreover, it can only be accomplished by a team of faculty with background in, interest in and commitment to sustainability. Contacts with the industry should be explored to identify relevant sustainability projects.

The initial challenge for the Capstone faculty team was to develop a meaningful number of substantive Capstone projects that would:

- provide the first set of student projects; and
- serve as models for subsequently developed Capstone projects.

The projects to be developed had to focus on issues of sustainability, as that somewhat broad term is conventionally used by leading academic programs. The projects had to be fully interdisciplinary. They had to provide suitable intellectual contexts for training graduate students with diverse educational backgrounds, training that would foster the ability to implement strategies for solving sustainability-related problems. The faculty had to encourage – indeed, to practically compel – students to work collaboratively across traditionally defined disciplinary boundaries, freeing the students from specialist paradigms and preparing them to tackle problems outside of their specific areas of formal preparation.

Capstone projects should be challenging but should still allow for meaningful progress in two semesters. The projects should offer students avenues for substantial academic research, possibly leading to a journal article and/or presentations at relevant conferences. Wherever possible, projects should have a broad applicability, meaning that ideally they could be adapted as local conditions change and be transferable to sites other than that of the original problem formulation.

Clearly, the task of developing and mentoring suitable projects cannot be accomplished by a single faculty member or a team of faculty within a department or even a school. The task requires the engagement of a significant segment of the college community as well as the industry.

3. The role of the US Department of Education: support by the Funds for the Improvement of Postsecondary Education (FIPSE)

Preparations to launch the MS in Sustainability program focused attention on three aspects:

- (1) staffing course offerings;
- (2) the development of material for the Capstone projects; and
- (3) the assignment of participating mentors.

Although the staffing issues were relatively routine, the development of projects required careful planning. It was important to give students an opportunity to review available topics, explore the formation of teams and meet mentors prior to committing to work on a project. Thus, material for the Capstone projects had to be completed and posted at least one semester prior to student enrollment in the course. This presented serious obstacles, as college resources are typically not available to compensate faculty in the form of time given for the preparation of course material. A decision was made to seek external funding to support the development of substantial material for the Capstone course. A proposal was prepared and submitted to the US Department of Education's FIPSE to underwrite a two-year program to support the project. FIPSE approved a \$290,600 grant to provide released-time for seven instructors to develop and mentor 21 Capstone projects. The grant also provided stipends for 13 graduate students to participate in the development of educational material for the Capstone projects. At the request of FIPSE, an independent evaluator was assigned to provide a detailed evaluation of the funded program.

The FIPSE grant was crucial to our MS in Sustainability program, in effect serving to jump-start the new program. The grant allowed the development of a critical component of the program with a speed and refinement that otherwise would have been difficult to

achieve and laid a robust foundation for a continuing Capstone project component of the MS in Sustainability program.

4. Creation of 22 Capstone projects

Soon after receiving FIPSE support, our participating faculty held a series of meetings to discuss and plan the development of the educational materials for the project. Each faculty member was asked to develop materials for three Capstone projects. By the end of the second year of the grant, materials for 22 projects had been developed. Prior to the grant expiration, project leaders decided to apply for a no-cost extension of the grant for three reasons:

- (1) Initial feedback from our project evaluator suggested ways to usefully modify developed Capstone projects that had not yet been selected by students.
- (2) Our initial experience with implemented Capstone projects made clear that students embarking on Capstone projects could be helped by a series of workshops that would supplement and reinforce their work on individual projects.
- (3) The additional time provided by a no-cost extension would allow our final project evaluation to include more participating Capstone students.

Following are the titles of the 22 developed Capstones:

- (1) A Systems Approach to Urban Community-Scale Composting.
- (2) The Solar Roofpod: Implications for New York City's Long-Term Sustainability Plan.
- (3) High-Performance Glazing for Energy-Efficient and Bird-Safe Buildings.
- (4) Food Grinders and Sustainable Food Waste Disposal.
- (5) Low-Tech Global Reuse and Recycling in a Local School.
- (6) Factors Affecting the Decision to Demolish or Deconstruct an Existing Building.
- (7) Carbon Trading Markets.
- (8) Analysis of Household Energy Consumption Choices.
- (9) Separating Risks to Cash Flows for Heating/Cooling.
- (10) The City College Waste Stream, Part I: Food Rescue and Recycling.
- (11) The City College Waste Stream, Part II: Removing Barriers to Paper Recycling.
- (12) Green Wall Technologies.
- (13) Using Pyrolysis to Convert Unused Urban Biotic Material into Bioenergy and Biochar.
- (14) Plant and Soil-Based Carbon Sequestration in Urban Areas.
- (15) Reconfiguration of Manhattan Bus Stopping Frequency.
- (16) Designing an Urban Food-Vending Stand.
- (17) Designing Urban Green Roofs for Modularity and Recyclability.
- (18) Design of a Modularized "Smart" Façade System.

- (19) Water Use Reduction in Buildings.
- (20) Optimizing Building Energy Use.
- (21) Sustainable Construction Material.
- (22) Using Natural Zeolite Based Sorbents to Remove Contaminants during Groundwater Recharge with Reclaimed Municipal Wastewater.

Detailed descriptions of each project were posted on the program Web site, [CCNY \(2013\)](#). By clicking on the title of any posted project, visitors come to a standardized summary description of the project consisting of four elements: Title, Objective, Background and Suggested Approaches. This standard format was found to be useful for introducing projects in a way that achieves a basic parity among disparate projects. These standardized summary descriptions enable a process of matching up students with suitable Capstone projects that does not favor any project over others, stresses the topic rather than the mentor and provides some “suggested” approaches to resolving the challenges posed by that particular project without any implication that these are the only, or even necessarily, the best approaches.

5. Capstone projects workshops

Based on the feedback from the project evaluator and our experience with the undergraduate capstone senior design course, even very well-designed Capstone projects will be much more likely to succeed if reinforced by supplementary training that provides some useful background information and suggests basic methods and approaches for working on projects. Our program has institutionalized this broader understanding of the problem with a series of Capstone Workshops.

As noted, one reason for our request for an extension of our FIPSE grant was our growing realization of a need to provide institutional reinforcement for our newly developed Capstone problems. Our initial Capstone implementation pilot, during the program’s first academic year, taught us that no matter how well-crafted their individual Capstone problem, students have a real need for a series of workshops that supplement and reinforce their work on their individual projects. It is important to maintain a uniform standard with regard to project complexity and final report expectation, a challenge given that project mentors are drawn from several departments and disciplines. In response to the challenge, the project team developed a series of workshops for the purpose of providing all Capstone students with some key background information relevant to all projects, some strategies for integrating multiple areas of expertise into the research component of projects, some project management challenges and strategies and some tips on how to ensure that their project will flow coherently into the final project report format that our program requires.

Key features of the Capstone Workshops are detailed in four sessions covering:

- (1) Academic Research and Academic Integrity.
- (2) Project Management and Teamwork.
- (3) Preparing for the Capstone Final Report.
- (4) Capstone Project Progress Reports.

The Workshops were piloted in the second year of program offering and are expected to remain an integral part of the program.

6. Beyond FIPSE: perpetual development and mentoring of capstones

The FIPSE grant for Capstone project development helped solidify cross-divisional collaboration at CCNY. This collaboration was an outcome not entirely certain at the outset. Even within academic departments, thoroughgoing teamwork is not always to be assumed. Fostering such teamwork among those from entirely different divisions and with widely diverse disciplinary perspectives can be challenging indeed. The set of 22 initial Capstones, as well as our experience with their creation, represents a body of collective experience and learning that has begun to have larger ramifications and to influence CCNY faculty members beyond the original cadre of FIPSE-supported faculty. The first task was to secure the Administration's commitment to provide the appropriate amount of released-time for mentoring Capstone projects. With this in place, and using the initial 22 projects as exemplars, additional interdisciplinary projects have been created, and ten additional college faculty members have been recruited into the effort. These additional faculty members are meeting a definite need, given the imperative to continually develop new projects, and the need for additional mentors able to take over for mentors who become unavailable because of newly acquired research grants, sabbatical leaves or increased teaching loads.

Our additional ten Capstone project developers have collectively created 16 additional Capstones:

- (1) A Geospatial Building Energy Model for Manhattan, NY.
- (2) Sustainability Metrics in the Master Plan for Newark, NJ.
- (3) Insulation Materials with More Sustainable Flame Retardant Properties.
- (4) Possibilities for Sustainable Manufacturing in Tonawanda, New York.
- (5) Understanding NYC's Changing Vulnerability to Flooding from Climate Change.
- (6) HydroInformatics for Green Infrastructure Data Management.
- (7) Reconstruction and Development of Infrastructure for Leogane, Haiti.
- (8) Dual-Function Louvers for Energy-Efficient Daylighting in Existing Buildings.
- (9) Optical Systems for Enhanced Optical Collection Efficiency in Photovoltaics.
- (10) Using Hydroponics to Grow Food in New York City During the Winter.
- (11) Solutions for Neighborhood Development in Haiti Slums.
- (12) Hidden Biases in the Presentation of Sustainability Issues.
- (13) Helping Design NYC's New Sustainability, Energy, and Property Tracking System.
- (14) Enabling Advanced Building Automation Systems (ABAS).
- (15) Performance Evaluation of Porous Pavements in an Urban Setting.
- (16) Climate Change and Sustainable Electricity Production in the Northeast.

The increased Capstone development work has also begun to have wider ramifications. Because of our emphasis on selecting real-world sustainability problems as Capstone projects, the projects have generated working partnerships with other units of the City University of New York, with New York City and federal agencies and with private industry. Capstone projects have already begun to emerge from these partnerships.

7. Early experience and lessons learned

With no prior experience with Capstone projects, our program anticipated a need to make modifications and take corrective measures as our work progressed. During the first two years of the program, feedback from our program evaluation allowed us to fine-tune the Capstone course.

7.1 Lessons learned – student perspective

Bringing students from diverse disciplines together into teams that take on difficult interdisciplinary problems is bound to generate challenges. From the student point of view, the toughest challenges are those associated with logistics of team meetings, delegating and sharing of project tasks, project pacing and interaction with mentors. Certain “best practices” have emerged. These include: use of a shared repository of electronic files, articulation and delegation of project sub-tasks, strategic use of outlines, regular team meetings, setting of deadlines and continual collection of notes on procedures and informational sources. These best practices have been worked closely into the topics covered by the Capstone Workshops, in an ongoing effort to help students overcome the predictable challenges of Capstone teamwork.

7.2 Lessons learned – program perspective

CCNY is breaking new ground with its Sustainability in the Urban Environment program, and, in particular, with the priority the program gives to interdisciplinary team of Capstone projects. Numerous lessons have been learned from the academic administrative perspective, including the following seven.

7.2.1 Accept that Capstone projects will evolve. Once teams and mentors become fully engaged in the details of project analysis and execution, the project that finally emerges sometimes deviates significantly from the original project description. This is to be expected and accepted.

7.2.2 Accept that Capstone projects can have diverse objectives and deliverables. Projects can aim for sets of recommendations, proposals/plans, designs for structures or experimental findings. A relatively flexible Capstone Project Final Project format has been developed, one that can accommodate this diversity.

7.2.3 Allow students to help produce the initial literature review. For our 22 exemplary projects, faculty produced or closely supervised the lists of academic references. For the subsequently developed projects, it was found to be both more efficient and more pedagogically effective for students to take the lead in the initial literature review, albeit with mentor supervision.

7.2.4 Matching students and projects take time and effort. The process can be partially orchestrated, but ultimately will involve a combination of bottom-up student requests, top-down mentor requests and changing student relationships. The process cannot be rushed.

7.2.5 Mentors need to be properly compensated. Good Capstone mentoring can be quite time-consuming. There is a need for an approved formula that sets out an equitable and consistent way to translate capstone supervision into faculty released-time.

7.2.6 There is a continual need for new Capstone projects and available mentors. Some developed Capstone projects can be repeated with variations. But there is an ongoing need to generate new projects and ensure mentors are available to supervise them.

7.2.7 *Expect conflict among team members.* Personality conflicts are inevitable. They will occasionally occur, just as they do in workplaces.

7.3 *Capstone workshops: impacts, lessons learned and open questions*

To date, 31 of our students have participated in Capstone Workshops. Faculty mentors are copied on all email correspondence regarding the workshops but are not expected to attend them. One clear outcome of the workshops is that students do not have to “reinvent the wheel” with respect to some useful project management tools, e.g. the use of DropBox or an equivalent. Also, all Capstone students now “begin with the end in sight” in an important respect: they are introduced right away to the Capstone Project Final Report format, and thus begin early on to consider how their particular project will “flow into” this final report format. From the standpoint of program administration, three significant lessons learned can be noted:

7.3.1 *Capstone final report format works reasonably well.* The somewhat general format developed by the program is compatible with a wide variety of project types. Some require slight modification of the format, but overall the form is flexible and effective. Samples of actual Capstone Project Final Reports for several completed Capstone projects are posted at the bottom of the Curriculum page of the [CCNY program Web site \(2013\): www.cuny.cuny.edu/sustainability/curriculum.cfm](http://www.cuny.cuny.edu/sustainability/curriculum.cfm).

7.3.2 *Subsequent Capstone workshops focused on individual teams are effective.* The first few Capstone Workshops bring together in a single group all students who are simultaneously embarking on projects. But after this, Capstone Workshops are most effective if they involve meetings between the Workshop instructor and individual teams. This allows a more in-depth workshop focused on the content area of the particular project.

7.3.3 *Final workshop devoted to project presentations is expanding to become a major program event.* The project presentations initially envisioned as a final Capstone Workshop have expanded into one of the signature events of our Sustainability program, with invitations extended to program faculty, students and invited guests. It is an effective way to motivate quality project presentations and simultaneously showcase a key component of the program.

To date, the results from the Capstone Workshops have helped us better understand a central challenge of Capstone projects. Students receive academic credit for their projects, and thus, of course, the projects must represent genuine scholarly work. At the same time, our projects purport to be truly interdisciplinary, so in their very design they resist disciplinary specialization. Moreover, they typically have a very real-world flavor, i.e. are somehow related to analyzing practical problems and finding solutions to them. Given all this, how does one build in academic quality?

This question currently stands as an ongoing issue for the Capstone Workshops and indeed for the program as a whole. Our partial answer is to remind students to conduct Capstone project research that initially moves beyond the confines of their particular practical problem. Capstone Workshop participants are asked to resist the urge to jump fully and completely into the problem space of their particular topic. They are advised to strive for a larger, more general sphere, or a higher level of abstraction, or a more theoretical level, and search for relevant prior studies with this in mind. The goal is to help students develop a literature review for their final project report that accomplishes the following:

- gives them broad authority/expertise and conveys the same to the reader;
- saves them from proposing a “new” approach that in fact has been well-tried;
- gives them a breadth and depth of knowledge that could be immensely suggestive when they immerse themselves completely in their particular topic/problem; and
- provides a contextualizing discussion and set of references that will be essential for any other presentation of their work, e.g. as a published journal article.

8. Evaluation

Formative feedback was received from an independent evaluator, while the students were engaged in the first semester of the Capstone course. It allowed us to troubleshoot and make corrections midstream. Such feedback is particularly important when faculty members are first starting up a Capstone course, and the Capstone experience is new to students and teachers alike.

In a post-course questionnaire, students were asked to rate their entire Capstone experience in response to the following questions: planning and executing a sustainability project requires special skills. To what extent did this course teach you such skills? To what extent has this course helped you gain confidence working on a project outside your training field? Responses to the questions are found in the table below (Table I).

These findings show that students deemed the Capstone course helpful in both teaching the planning and executing of sustainability-related skills and building confidence in working outside their areas of training. A limitation of the findings is that the skills-taught question could have been better informed with four response alternatives. Clearly, no student asserted that he or she failed to acquire skills. Six students (20 per cent) reported little in the way of a boost in confidence working outside their field of training. That 80 per cent of the students reported feeling more confident about their ability to work outside their field of training suggests success.

9. Conclusions

Our activities have progressed during four years from initial Capstone project planning to development of projects, implementation of project mentoring and creation and implementation of our Capstone Workshops. Valuable feedback has been received from participating faculty members, students and the program evaluator. From this accumulated experience and feedback, the authors draw a number of general conclusions that could be offered as advice to others who may be contemplating a program of Capstone Project development similar to ours.

Extent	The course-taught skills for planning and executing sustainability projects		The course helped students gain confidence working outside field of training	
	Extent	<i>n</i> (%)	Extent	<i>n</i> (%)
Significantly		15 (54)	Significantly	8 (28)
Marginally		14 (48)	Somewhat	15 (52)
Not at all		0 (0)	Marginally	5 (17)
			Not at all	1 (3)

Table I.
Results of post-course questionnaire

First, it is clear that the incorporation of interdisciplinary Capstone team projects within a graduate degree program in sustainability is a powerful educational tool. It allows students to pursue an investigation of a real-world sustainability problem in a manner that gives a depth of understanding that complements the broader understandings provided by other coursework in the sustainability master's degree program. If done carefully, a Capstone course can give students an unforgettable lesson in how to systematically apply academic expertise to a practical sustainability problem.

Second, our several years of experience have made clear that developing and supervising Capstone projects is a challenging undertaking that places demands upon faculty and program administration in ways that should not be underestimated. Experienced and dedicated faculty members from several different disciplines are needed. These faculty participants should be willing and able to mentor student teams in ways that take them beyond their usual disciplinary boundaries. A variety of processes need to be developed, e.g. posting of project descriptions in uniform formats, communications with potential mentors and students in ways that efficiently move forward the complex process of team formation, topic selection and matching of teams and mentors. These minimum administrative processes need to be set up and conscientiously implemented to ensure a robust Capstone project program.

Third, it is very worthwhile to explore the development of Capstone projects with interested industry and government partners. Such collaborative projects serve practical research needs of the partners, lending the projects a real-world relevance that can inspire, excite and motivate students. With such projects, both students and supervisors must keep in mind that the need to ensure the project is not merely a practical exercise but also preserves an academic richness and breadth.

Fourth, it is important to have an independent evaluator in whom students, early in the capstone experience, can confide. Without mentioning student names, the evaluator can convey to the program leader what is going wrong with the course and what is going well. In that way, the program leader can make adjustments before defects in the program get frozen into a year-long pattern. Having an independent evaluator is particularly important when the program is first getting underway, before the faculty members have had much experience with the implementation of Capstone courses.

Finally, a program of reinforcing project guidance – which in our case takes the name Capstone Workshops – is a key element of an effective Capstone project program. This workshop component of the program simultaneously serves several purposes. The workshops:

- provide all of the participating students with a common body of knowledge about research techniques, ways to effectively bring academic expertise to bear upon practical problems and team and project management techniques;
- ensure that from the very outset students know the program expectations regarding the basic format of the final written report they are required to submit, thereby helping them organize their project work in anticipation of the final product; and
- by focusing on matters of process and format, serve to take some of the burden off faculty mentors, thereby making the capstone mentoring process more content-focused, more fulfilling for the mentors and more valuable overall for the students.

References

- AASHE (2013), "Sustainability-focused masters degree programs", *Association for the Advancement of Sustainability in Higher Education*, available at: www.aashe.org/resources/academic-programs/type/masters?page=3 (accessed 9 February 2013).
- ABET (2013), "Criteria for accrediting engineering technology programs, 2012-2013", *Accreditation Board for Engineering and Technology*, available at: www.abet.org/DisplayTemplates/DocsHandbook.aspx?id=3144 (accessed 9 February 2013).
- Arizona State University (2013), "Master's in sustainability solutions", available at: <http://schoolofsustainability.asu.edu/graduate/master-of-sustainability.php> (accessed 9 February 2013).
- Blekinge Institute of Technology (2013), "Project PSS extreme innovation - MT2509", available at: www.bth.se/tek/mspi.nsf/pages/pss-ei (accessed 9 February 2013).
- Brundiers, K., Wiek, A. and Redman, C.L. (2010), "Real-world learning in opportunities in sustainability: from classroom into the real world", *International Journal of Sustainability in Higher Education*, Vol. 11 No. 4, pp. 308-324.
- CCNY (2013), "Sustainability program website ['Curriculum']", available at: www.cuny.cuny.edu/sustainability/curriculum.cfm (accessed 22 August 2013).
- Columbia University (2013), "Master of science in sustainability management", available at: <http://ce.columbia.edu/sustainability-management> (accessed 9 February 2013).
- King, P.H. (2008), "Capstone design and ABET program outcomes in the US, presentation and paper submission in program CD, SEFI meeting", *Aalborg*, July 2-5, available at: www.sefi.be/wp-content/abstracts/1008.pdf (accessed 9 February 2013).
- Montana State University (2009), "Capstone courses for seniors", available at: www.montana.edu/wwwprov/assessment/CapstoneCourses.html (accessed 9 February 2013).
- Rochester Institute of Technology (2013), "Sustainable engineering MS", available at: www.rit.edu/programs/sustainable-engineering (accessed 9 February 2013).
- Saint Louis University (2013), "Capstone project: masters in sustainability (MA/MS)", available at: www.slu.edu/sustainability/graduate-programs/sustainability/sustainability-capstone (accessed 9 February 2013).
- University of Sidney (2013), "Capstone research project", available at: <http://sydney.edu.au/science/sustainability/capstone/index.shtml> (accessed 9 February 2013).
- Van De Keere, L. (2012), "Database of graduate programs in sustainability", College of Sustainability, Dalhousie University, Halifax, Nova Scotia: Note: This proprietary database assembles key data from a review of more than 600 post-graduate level (MA, MEd, MASc, MAA, MEng, MSc, MS, etc.) programs in "Environmental Sustainability or very related fields" at US, Canadian, and international universities.

About the authors

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Capstone
interdisciplinary
team project

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