Group Learning at Georgia Tech

by Donna C. Llewellyn, Ph.D.
donna.llewellyn@cetl.gatech.edu

Georgia Tech’s Quality Enhancement Plan for Student Learning that is being prepared as part of our upcoming SACS review involves increasing the level of experiential learning of our undergraduate students. This can take many different forms across our campus, both in and out of our classrooms. One element that is common to many types of experiential learning is group activity. We often put students into design teams, study groups, or other project-related groups. This newsletter explores various issues related to group learning; including a look at some of the innovative things that are going on around campus, and a literature review about group and cooperative learning.

Why do we, as educators, care about having students work in groups? Through the years I have heard three types of answers to this question: (a) training for later - the students’ future employers will expect the students to have experience and expertise in working in groups; (b) it is more efficient – having students work together ends up with the creation of fewer final products that need grading; and (c) learning concerns - the students learn more/better/deeper when they work and engage with their peers. To some extent, all of these answers are true; however there are still concerns among both the faculty and students about group work.

If you are hesitant about introducing group exercises into your class, then I recommend that you start very small with just a short group exercise. Be sure to give the students an explicit explanation about why you are requiring group work and reward good group dynamics. And, of course, come to CETL – we have a library of resources and we are always willing to meet with you to discuss ways to introduce more cooperative learning techniques into your classes. If on the other hand, you are an established expert in getting your students to work together in productive ways, please also come to CETL – we relish hearing about great teaching and learning success stories.

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Clint M. Lyle, Editor

CETL
Phone: 404/894-4474
FAX: 404/894-4475
e-mail: cetlhelp@gatech.edu
http://www.cetl.gatech.edu
Q & A:
An Interview With
Dr. Richard P. Barke
Associate Professor of Public Policy & Associate Dean of Ivan Allen College
Georgia Institute of Technology
and Dr. Gena L. Abraham
Assistant Professor, Civil & Environmental Engineering
Georgia Institute of Technology

Gena L. Abraham received her B.S.C.E. and Ph.D. in Civil Engineering from the Georgia Institute of Technology.

Dr. Abraham’s research and teaching interests focus on strategic management of construction organizations, prequalification criteria of construction firms, and alternate delivery methods for project construction. She began her career in the public sector as a field engineer and moved to project manager and later to construction manager. She later joined a program management firm in the private sector managing construction across the United States. While working in the industry, she achieved her Ph.D. After completion of her degree, the Georgia Institute of Technology extended an offer to join the faculty of the Construction Engineering and Management Program in the Civil Engineering Department as an assistant professor. She has taught three courses at Georgia Tech including, Construction Estimation, Planning and Scheduling; Construction Organizations; and Designing Progress. On June 24, 2003, she accepted an appointment from Governor Sonny Perdue to act as the Executive Secretary for the Commission and Director of the Construction Division of the Georgia State Financing and Investment Commission (GSFIC). GSFIC is charged with the proper application and execution of bond funds for the State of Georgia and is responsible for a $600 million statewide construction program. She is currently on a leave of absence from Georgia Tech.

Richard P. Barke received his M.A. and Ph.D. in Political Science from the University of Rochester, and a B.S. in Physics from the Georgia Institute of Technology.

Dr. Barke’s research and teaching interests include the regulation of scientific research; national, cross-national, and state science and technology policy; scientific and lay risk perception and analysis; and the impacts of evolving technology on regulatory policies. In 1987 he joined the faculty of Georgia Tech where he chaired the effort to create the School of Public Policy and served as Director of the School (1992-1994). He also has served as chair of the Georgia Tech Executive Board and currently is Associate Dean of Ivan Allen College. He has published articles and papers on a range of S&T policy issues, including the politics of science, risk perception and policy, nuclear waste and weapons policies, state technology and economic development policy, hazardous waste regulation, technical standard setting, and transportation regulation. He is the author of Science, Technology, and Public Policy (Congressional Quarterly Press, 1986), and Governing the American Republic (St. Martin’s, 1985, 1989). He has served as a consultant and researcher for the Center for Growth Studies of the Houston Advanced Research Center, the Carnegie Commission on Science, Technology, and Government, the Department of Energy, the Army Environmental Policy Institute, the Chinese State Science and Technology Commission, and Eastman Kodak. He was a visiting professor at the University of Ghent (Belgium). His current projects include a study of the impact of institutional review boards on research methodologies, and an analysis of how scientists translate uncertainty into policy recommendations.
Q: We understand that you met each other at GTREET (Georgia Tech Retreat Exploring Effective Teaching, held at Amicalola Falls Lodge, October 14 & 15, 2002). Is this true? Please tell us about how you decided to collaborate on a course together. Also tell us about your experiences at GTREET. In what ways was it valuable to you? What comments or suggestions do you have that you believe would make GTREET more valuable to the new faculty who attend?

A: Gena was at GTREET as a new faculty member, and Richard had been asked to discuss a simulation that he developed for his government course. With Gena’s experience in state government, she was intrigued by the prospect of integrating some form of active learning about politics and policy into her construction engineering and management courses. For his part, Richard was intrigued by the possibility that engineering faculty and liberal arts faculty actually have a lot in common. After the conference, we met and discussed our interests. We discovered a common desire to bring engineering and liberal arts instruction together, and a shared intent to tie practical problem-solving to some big ideas.

GTREET was particularly useful in providing an opportunity for faculty – new and “experienced” – to meet. Much of the material on learning theory was interesting, but we wished that all of the participants had had more opportunity to share their best practices and favorite stories. Even the new faculty have such stories; they’ve been immersed in other universities, and meetings like this could provide a unique chance for cross-fertilization.

Q: The two of you offered the course CEE 4803 (cross listed PUBP 4803 and PST 4901), “Designing Progress, Defining Progress”. Tell us how your collaboration came about? What motivated or inspired you to offer this course?

A: Richard had been thinking about a course on “progress” for several years. He hoped to prod students into examining not only how progress is defined in the US and other cultural contexts, but also into thinking about how their own work, as students and as future professionals will contribute to something they would want to call “progress” – and how they would know whether they were truly successful. When he mentioned this to Gena after GTREET, it fit perfectly into her ideas about expanding the perspective of engineering students about their work and careers. At the same time, Gena had been thinking about “design” in construction and engineering — how students learn to design, and how they cope with the complex political and organizational contexts within which real-world design work is performed. It was natural, then, to merge the idea of learning about design with learning about progress. And we were able to

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benefit from the sponsorship of the McEver Program in Engineering and the Liberal Arts, endowed by Georgia Tech alumnus Bruce McEver (and administered by LCC’s Ken Knoespel), which supplied a small budget for the course.

Q: How did you go about developing the class and creating the “instructional design” for it?

A: First, we confess that developing the class was enormous fun. Not only is the world (and especially the world of Georgia Tech) bursting with ideas that relate to progress and design, but every colleague with whom we discussed our course gave us ideas — so many that it became a challenge to sort through them and organize the material into a coherent instructional structure.

We decided that the course should be upper-level undergraduate, with a small number of COE majors and an equal number of IAC majors. We would explore the concept of “progress” first, to broaden our perspectives and acquaint students with the larger implications of what is meant by one of the two words on Georgia Tech’s official seal. Then we would examine how we design, focusing primarily on engineering design, but looking also at how design is performed in other realms such as policy and the arts. We would conclude by addressing the interplay between the two, especially how we know, when we design, whether we’re contributing to something that can be called “progress.”

Q: What did you hope to achieve with the class? What were the desired student outcomes for the course?

A: First, we wanted to experiment with some possibilities for bridging the gap between engineering and the liberal arts. The instructors already had many ideas for this, but we intended for the course to be something of a laboratory as well; in fact, we told students at the outset that they were participants in an experiment — not as subjects, but as co-designers of an exploration.

We began by suggesting that the concept of progress seems to have lost some of its power and attention of modern society; it is more common to describe social and technological processes as “innovation,” “development,” or simply as “change.” Do we still believe in progress in the sense of movement to constantly higher levels of civilization based on advances in scientific and scholarly knowledge, moral understanding, and conventional wisdom? What does our answer imply for our obligations as individuals, engineers, policy makers, artists, and citizens? So we examined the concept of progress and the belief in it, what drives it, what it requires and assumes, and the relationships among the many dimensions of progress — economic, technological, evolutionary, artistic, scientific, political, moral, and others. We asked whether progress is merely a belief, is it designed, is it a result of many fortuitous accidents or an emergent property, is it built into some cultures, or is it a result of interdependencies or conflicts of cultures?

. . . “We thought the engineering students understood that a seminar could be a free-flowing interactive loosely-structured discussion. Instead, they told us they had little or no experience with ‘participation’ in the classroom . . . The liberal arts students generally showed little reluctance to jump into the discussion. Gena devised some clever strategies to pull the engineering students into the conversations” . . .

We also wanted to examine the concept of progress through the lens of “design” (and vice versa). We all engage in design — of buildings and bridges, of policies and legislation, of music and poems, etc. — presumably because we think the result of our designs will be the construction of things or ideas that will make us or society better in some way. What is the connection between the process of design and progress? We explored many of the elements of design that are common across engineering, public policy, and the humanities, examining how
the processes of design relate to those goals that we construe as constituting “progress.”

Finally, we wanted to enhance the intellectual abilities of students to engage in deep interdisciplinary learning as they prepare for careers or graduate school. They read and synthesized ideas from a variety of perspectives, worked on interdisciplinary projects, and shared ideas through formal presentations as individuals and in cross-disciplinary teams.

**Q:** How did the desired outcomes change over the course of the semester? What prompted the changes?

**A:** Our syllabus stated, “Because this is an integrative learning seminar, students will help shape the direction of the course: this syllabus is a laboratory for progress in learning, and the students and all instructors and guests in the course are designers.” We realized part of the way through the course that there were too many degrees of freedom designed into the course. We had twenty students who were being encouraged to interact with each other and their professors in ways less structured than they had experienced before. With a few exceptions, the readings had been assigned more as background to discussions rather than as matters to be addressed directly in class. In both cases, some of the students handled the relative lack of structure very well, while others needed a more familiar format. Similarly, our plan to have the students’ responses to ideas in the first half of the course serve as a guide to the interdisciplinary projects at the end of the course needed to be adjusted as we realized that our explorations – the instructors’ and the students’ – were opening too many very interesting doors.

**Q:** Gena, how did your experiences as a graduate student at Georgia Tech enable you to see the need and path to work across disciplines?

**A:** My professional experience in governmental construction led me to see that there was “more” to civil engineering than just the technical components. As I discovered through my professional work, policy and politics dictated what was designed, how it was designed, what would be built, and the constraints under which construction would occur. This awareness prompted me to pursue and investigate areas that were not taught in the typical engineering curriculum. I knew that I needed to explore other areas that were not in the technical arena to gain a better insight of the architecture/engineering/construction industry. My graduate work allowed me to explore those areas, further understanding and gaining technical expertise as well as investigating interdisciplinary arenas. The rigor of engineering is absolutely essential. However, through my professional experience, I understand that multi-disciplinary approaches to problems provide enhanced technical solutions.

**Q:** What did you learn from your collaboration? How did it benefit you? What barriers or obstacles did you encounter? How did you handle these barriers or obstacles?

There were two significant differences between us that could have created difficulties, but instead became great assets to our collaboration. First, Richard had been teaching for a few years already, while Gena had completed one semester as a Tech professor. But her teaching style had already developed in a variety of ways that Richard found particularly exciting, such as the types of exercises that she used in her civil engineering courses. Second, of course, was the disciplinary differences. Gena’s approach was that of an experienced professional in civil engineering and construction management, while Richard’s approach was, of course, more that of an academic social scientist. Occasionally one would suggest an exercise or approach that the other would find intriguing, but slightly odd. For the most part, these differences were not barriers but learning exercises – not only about how to teach, but more fundamentally about how to approach problem-solving from more than the traditional, comfortable perspective.

**Q:** Your class consisted of undergraduate students in IAC and the engineering disciplines — tell us about any issues you encountered relating to class discussion. Were there differences in the ways the two groups participated?

**A:** During one class that focused on Robert Wright’s book, Nonzero (which was conceptually challenging, if readable), we noticed that the engineering students were silent. When the class session ended, these
students waited outside in the hallway until we left the room, then pounced on us to complain about how they were “ignored.” As one put it, “I raised my hand and you didn’t call on me; I assumed that meant you didn’t want to know what I thought.” Now, at the beginning of the semester we had anticipated a problem with the seminar format and had distributed an instruction sheet on what a seminar is and what is expected of students. We thought they understood that a seminar could be a free-flowing interactive loosely-structured discussion.

Instead, the engineering students told us they had little or no experience with “participation” in the classroom – that in their usual classes, the professor talks, the students transcribe, they perform homework exercises, then generally don’t respond when the professor begins the next class by asking, “Any questions?” The liberal arts students generally showed little reluctance to jump into the discussion. Gena devised some clever strategies to pull the engineering students into the conversations in subsequent classes.

Q: On what types of problems/challenges/projects did students collaborate? What evidence suggests that students worked together, rather than simply dividing tasks between engineers and IAC students?

A: About a half-dozen projects were assigned to students, sometimes alone and sometimes in interdisciplinary teams. In one project, students observed different types of situations in which progress is reportedly occurring. They examined these situations to define progress in this specific context, described the method in which progress is occurring, determined if “progress” can occur, and analyzed the positive outcomes and potential conflicts from this particular type of “progress.” In another exercise, each student independently identified a design topic (e.g., a kitchen, a tree house, a MARTA station, a family reunion, and – our favorite – a “perfect” date) and described the key components, assumptions and historical precedents, and principles they would use to create a design; each was then paired with a student from the other college, who described how their approach to design would have differed. They also worked together to build “something” out a collection of randomly-chosen Legos - then were required to write a description of how they had built it so that another team could replicate their design – a very effective exercise in the challenges of communicating about designs. Another important aspect to getting students working together was the social time in the form of a short break for a dinner in the middle of the three-hour evening seminar (for which students took responsibility); as mentioned, this was made possible by the generous support of the McEver Program in Engineering and the Liberal Arts.

Q: What changes in students’ interactions or attitudes did you observe throughout the semester?

A: Here’s one example. We began with a simple word-association exercise. At the start of the first class, Gena asked each student to write the first five nouns, verbs, and adjectives that came to mind when they thought about the word “progress.” At the next class, their responses were distributed without identifiers, and the students voted on whether each respondent was an engineering or a liberal arts student. They misidentified – often with great confidence – nearly all of the first ten subjects. But they began to realize that their discussions about whether an engineering student would use a word like “equality,” or a policy student would mention “building” was leading them astray. They correctly identified the majors of 9 of the last 12 students. And for the rest of the semester, stereotypes were more easily addressed and often (but not always) overcome.

Q: What type of feedback did students give about their experience? How did feedback change from the beginning to the end of the semester?

A: We had frequent conversations with the students – in class, during breaks, and outside of class – about the course. We obtained direct feedback each week from “meeting minutes”: during each class meeting two students took detailed notes on the discussions, and concluded with points for further discussion and “fuzzy points” about which some students were still unclear.

Q: What do you feel students gained from participating in the course?

A: Many of the students came away from the course with a sense of frustration. Some wanted to go more quickly and into greater depth with some of the historical, social, and philosophical dimensions of progress, while others found the readings (in style, content, and
quality) something of a novelty. But we believe that all of them gained a broader understanding of thinking, decision-making, and professional challenges in other disciplines. A couple of students complained that they had more questions at the end of the course than at the beginning; this is an unfamiliar outcome for many engineering students, but in the liberal arts, and especially for topics such as progress and design, we consider that to be a success.

Q: In what ways has the experience of co-teaching this course been beneficial to your teaching and research (or your work)?

A: With Jorge Vanegas (CEE), we submitted a proposal to the National Science Foundation that involved the integration of engineering and construction management with public policy. Our teaching was affected by the ideas and energy we gained from our collaboration. We recognized the similarities and differences in our approaches to problem identification and problem resolution. As an engineer, Gena approaches problems in a very linear fashion. Engineers define a problem and work towards a solution. In public policy, the approach to problem solving cannot be as linear but must move in a more fluid, dynamic way. These differences presented some challenges but also have improved our teaching and our research. Professionally, recognition of this difference was one of the most significant outcomes of this course. We definitely plan to co-teach again.

Q: How could your course serve as a model for other cross-discipline courses? What advice would you give other professors interested in taking on this type of project?

A: First, of course, is that it must be a project for which both instructors have a real passion. Frankly, this course required much more time and attention than a normal course — in fact, we would argue that a team-taught course is at least as much work as a traditional course, if not more. Second, the instructors must be sufficiently different in discipline and approach or style for the effort to be worthwhile, but they must truly respect each other. Students will quickly notice if there is tension or hostility between the instructors.

Finally, we were inspired by the visitors that joined the class to discuss progress and design. These included former governor Roy Barnes, a six-piece chamber music ensemble visiting Atlanta (for a special Sunday-night seminar, thanks to Frank Clark), and a number of Georgia Tech faculty who discussed our topics relevant to mechanical engineering, public policy, and poetry. The problem with inviting brilliant guests into the class is that they sometimes raise topics that beg for further discussion, but time constraints sometimes interfered with our ability to fully exploit our visitors.

Q: What’s your wider vision? Does it involve more cross-discipline collaboration at Tech? In industry?

A: In our opinion, every student at Georgia Tech should have an opportunity to experience a multi-disciplinary teaching approach to some topic. Our seminar exposed only 21 students to an exploratory classroom setting. To fit this type of experimental session into every students’ “Tech experience” is a lofty goal. We are exploring possibilities for expanding the impact of future seminars such as ours, largely because we feel that globalization and other changes in society are making it essential for both social scientists and engineers to take an integrated perspective to problem resolution.
Collaborative Web Sites at Georgia Tech

Mark Guzdial
Associate Professor, College of Computing

Peter J. Ludovice
Associate Professor, School of Chemical & Biomolecular Engineering

Matthew J. Realff
Associate Professor, School of Chemical & Biomolecular Engineering

What is the CoWeb?

The CoWeb (Collaborative Website) is a Web tool for collaborative activities that has been used in well over a hundred Georgia Tech classrooms since its introduction in January 1998. In a recent poll of Georgia Tech instructors regarding the use of classroom management tools, the CoWeb was the next most cited tool after WebCT. There are about a dozen CoWeb servers across campus that run CoWebs in LCC, French, Chemical & Biomolecular Engineering, Mathematics, Architecture, and Computing courses, among others.

CoWeb (also called Swiki for “Squeak Wiki”) is based on the WikiWikiWeb by Ward Cunningham. “Wiki” is Hawaiian creole for “quick.” Visitors to the Honolulu airport may recall the name of the inter-terminal shuttle as the Wiki Wiki bus. As Cunningham explains in his book The Wiki Way (with Bo Leuf, Addison-Wesley: 2001), the WikiWikiWeb arises from the question, “What’s the quickest way to create a large site on the Internet?” The answer is to allow everyone on the Internet to easily create and edit pages on your site through a normal Web browser. The WikiWikiWeb literally allows any user to edit any page, and from there, create new pages without knowledge of the Hypertext Markup Language (HTML). It’s an inherently democratic technological medium in use at thousands of locations, including the Wikipedia (http://www.wikipedia.org), a Wiki-based encyclopedia that was recently discussed on National Public Radio. The name CoWeb was first used in an NSF grant proposal to support much of the work at Georgia Tech in applying this software to collaborative learning.

The CoWeb was invented as a Wiki specifically designed for class use. It’s implemented in Squeak, a highly portable programming language and environment, so that it can run on whatever kind of computer a teacher might have available. It also contains several features that enhance its usability for educational use. Unlike the WikiWikiWeb, users (such as teachers) can lock pages so that others can’t write on them because classes really aren’t a democracy. While the WikiWikiWeb forbids users from entering HTML onto their pages, most University users know and want to use HTML, so the CoWeb allows integration of HTML. However, no knowledge of
HTML is required to produce creative web content. Other features of the CoWeb are designed to enable teachers and teaching assistants to easily navigate the CoWeb and set up pages for collaborative activities. Images and other types of files are easily uploaded for display and archiving on the CoWeb. Simply inserting a + symbol while editing the page will produce a web form in which students can type their comments to be automatically appended to the page.

CoWeb is an open source project—the source code is freely available for use and modification, with coordination of versions through a central source. There are over 100 participants on the developer list, discussing changes to CoWeb and submitting modifications that are vetted and supported by Jochen Rick, a Ph.D. student in the College of Computing. A search on Google today for “Swiki” turns up 190,000 hits, and a tour of the first couple hundred will show CoWebs in use all over the world, including installations in Japan, Germany, and Switzerland. Even if one cannot read the words, the icons and layout clearly indicate these sites are CoWebs.

CoWeb has been invented and developed as part of a research effort by the Collaborative Software Lab in the College of Computing. Documented cases exist where CoWeb use has had a positive impact on student learning in comparison with another group of students. For example, in two LCC classes taught by Lissa Holloway-Attaway, a CoWeb-using class developed stronger composition skills than those using non-collaborative versions of the same learning activities. However, the focus of the CoWeb on collaboration does not always guarantee that helpful collaboration will result as discussed below.

**CoWebs and Web-Based Collaboration at Georgia Tech.**

The most striking research finding on CoWebs in Georgia Tech classrooms has been the wide range of uses that inventive faculty have developed. In general, the history of educational technology is littered with tools that are rarely adopted and very rarely used to their potential. CoWeb is striking in how much it is not just adopted, but used to invent new kinds of activities that its developers never considered.

- Mindy Millard-Stafford in the School of Applied Physiology invented an on-line glossary activity (pre-dating the Wikipedia by several years!) where students describe and define terms relevant to the class—and successive classes have added on to the glossary over the years.
- Craig Zimring and Sabir Kahn in the College of Architecture have been using the CoWeb for several years to create on-line versions of Architecture studio practices such as design pin-ups and galleries. With the on-line versions, they can support design discussions in large classes (over 150 students) where face-to-face discussions would be impossible.
- Irfan Essa in the College of Computing uses a CoWeb in his project-based digital video effects course to support team management and “group memory.” Each team gets its own CoWeb page where the team members post work for discussion and review. The CoWeb pages support the team’s progress and serve as a way for the teacher to keep track of how each group is doing.

As a specific example of Coweb use in Engineering classes, the School of Chemical and Biomolecular Engineering has been using it on a widespread basis for the last two to three years. Our CoWeb server [http://swiki.che.gatech.edu](http://swiki.che.gatech.edu) has over 60 cowebs running which are devoted to numerous classes. The original concept was to have a single CoWeb for each course number and to have faculty teaching the course in a particular semester to use pages that reside in this central course CoWeb. In this way a
Architecture students were much more likely to engage in collaboration on CoWebs because they have a history of collaboration via a more open studio approach to learning. In contrast, many engineering or science students spend significant time in classes that teach fundamentals... (these) students often see collaboration as giving away an answer to a difficult calculation.

Comparing the use of CoWebs in Math and Engineering with those in other disciplines has uncovered an interesting dependence on CoWeb use on the particular discipline in which it is employed. Initial attempts at collaborative projects both within and between engineering and math classes found that students were reluctant to collaborate. This reluctance to engage in collaboration appears to be related to the culture of the particular discipline. In contrast, Architecture students were much more likely to engage in collaboration on CoWebs because they traditionally use a more open and collaborative studio approach to learning. Architecture students believe there are a variety of superior designs for a building, and therefore collaboration can only assist in fostering ideas that might be used in their own unique design. In contrast, many engineering or science students spend significant time in classes that teach fundamen-
tals with a more limited design component. Students often view a task in such classes as having only one single answer and see collaboration as giving away an answer to a difficult calculation. Even design classes in engineering contain projects that are more constrained in scope, which causes students to perceive collaboration as unhelpful. While some of this may be inherent to the discipline of science and engineering, much of it is due to the manner in which we teach engineers. The amount of collaboration in typical engineering and science research has increased significantly over the last two decades, yet most of engineering education lags behind this trend.

We have also found that in classes students perceive as highly competitive (e.g., students are convinced that the class is graded on a curve, even when we can show them on the syllabus where the teacher promises it won’t be), students will not engage in collaborative activities on the CoWeb. It’s only rational behavior—if the class is competitive, collaboration only gives up one’s “edge.” Similarly, we have found in these cases that some students exhibit what learning scientists call “learned helplessness.” Students may have decided that they aren’t learning the material, but that asking for help or trying to answer others’ questions will only prove that they are doing badly. As one student told us when asked why he didn’t participate in an exam review on the CoWeb, “I already know that my answers are wrong.”

In the above class situations, we now know that methods to actively engage the students in collaboration must be employed. These range from including web-based collaboration as part of the student’s grade to formulating projects in a puzzle form to better engage the students. We have recently used the CoWeb for collaborative engineering projects that involve no penalty for the posting of initial results or designs. Moreover, while students that fix errors in other’s posted results receive a bonus in their project grade that does not negatively impact the other students’ grades. This approach provides incentive for the students to teach and learn from each other. Additionally, engineering and science faculty must employ more open-ended design projects that foster the same sort of collaboration they themselves engage in during research. Prof. Tom Morley of the School of Mathematics has found that students are more likely to engage in collaborative analysis projects that utilize real data that is relevant to the student. His students were intrigued by the degree to which performance in Calculus class correlated with simple personal information about their fellow students. This approach avoids the boredom that typically accompanies the design problem of the generic widget.

Our findings to date indicate that the CoWeb is a very useful tool in rapidly generating web content for academic classes. The features of the CoWeb help it to foster open interaction that leads to helpful collaboration in many classes. However, the degree to which real collaboration occurs is instructor-driven. The more involved the instructor is in collaboration on the CoWeb, the more the students will engage in productive collaboration. In addition to instructor involvement, specific curriculum design is sometimes required to help engage otherwise reluctant students in collaboration. This is particularly true of fields such as Engineering that do not have a collaborative culture. Such curriculum design requires that the benefit of collaboration be clear to the student. However, we believe that benefits of student collaboration justify the effort required in curriculum design and the CoWeb is a useful platform for such collaboration. The Georgia Tech Office of Information Technology no longer supports the CoWeb, but the code may be downloaded from http://minnow.cc.gatech.edu/swiki for those interested in starting their own CoWeb server.
Criterion 4 required for accreditation by ABET requires a student to participate in a major design experience. Capstone design course offerings are a common avenue for engineering programs to meet this criterion. For many programs, the capstone design course consists of student groups working on industry-based projects under the supervision of a faculty member. The goals of such a course are to enhance a student’s technical writing skills, ability to work in teams, and ability to solve “real world” engineering problems, as well as to significantly benefit the industry sponsor.

During the curriculum redesign process and semester conversion at Georgia Tech (1999), it was decided that our capstone design course (called Senior Design) be converted to a 2-semester sequence. Since that time, there has been much discussion about the appropriateness of a 2-semester versus a 1-semester version. Critics of the current 2-semester version feel: i) the project length is too long and therefore not realistic, ii) it takes too many faculty resources, iii) group sizes have become too large, and iv) many potential project sponsors are unwilling to make a nine-month commitment. Proponents of the current version, on the other hand, argue that: i) it allows for sufficient time to do serious work, ii) it gives students more opportunities to develop the stated learning objectives such as communications skills, and iii) potential project sponsors prefer the 2-semester version. The arguments for and against the current version, however, are largely anecdotal.

In the spring of 2003, ISyE offered an experimental 1-semester version of the design course (concurrently with the second semester of the standard 2-semester offering) to evaluate if the additional resources consumed in the 2-semester course with higher faculty to student ratios (smaller groups) resulted in better outcomes. In addition we wanted to determine if the stated learning objectives (technical writing skills, presentation skills, and technical analysis) for the course were valuable to the company sponsors. Specifically, the following outcome measures were used to compare courses: i) company sponsor and student survey responses as to the appropriateness of class length and group size, ii) student survey responses on the course’s contribution to development of skills stated in course learning objectives, iii) company survey responses as to how well students accomplished learning objectives and the dollar value of the project to their firm, iv) external evaluation by outside faculty of the final project report, and v) the quantity of faculty resources consumed for each type of course offering. The student and sponsor surveys were conducted on the web site SurveyMonkey.com;
the results were anonymous and could not be traced to the individual. For the 1-semester section, there were 59 students working on 12 projects and for the 2-semester version there were 171 students working on 20 projects.

The findings of this experiment are summarized here. The interested reader may contact any author for a complete manuscript containing a more detailed discussion, the data, and the full statistical analysis.

Did the 2-semester version result in better outcomes?

We used data from the student survey to obtain student’s attitudes about the appropriate class duration and group size. Because the 2-semester version had both large and small groups whereas the 1-semester version had small groups only we stratified findings on class duration by groups size to avoid confounding. Students significantly preferred the 1-semester version of the class in terms of meeting the learning objectives and the overall value they assigned to the course. In addition, the 2-semester students felt there were too many reports and presentations and were less certain that their results would be implemented by their sponsor than students from the 1-semester class.

Sponsors also preferred the 1-semester version of the class. Sponsors of 1-semester groups were more likely to agree that the group’s analysis of the problem was correct and that presentations and reports were effective. In addition, sponsors of 1-semester groups were neutral about the shortness of the project duration, whereas their 2-semester counterparts disagreed that the course was too short. Dollar valuations of the project by the sponsor did not differ between the 1-semester and 2-semester versions of the class.

Finally, grades assigned to final project reports by outside faculty and an ISyE PhD student as to whether the report met stated learning objectives and the impact of the project did not differ by class duration.

Do smaller groups result in better outcomes?

Students preferred working in small groups. In particular, they felt that they worked better as teams, better managed their time, and developed better problem definition skills. It is interesting to note that students in smaller groups did not feel that they worked more than other group members as compared to larger groups. Sponsors did not have a definitive preference for group size. They were more likely to agree that large groups were too large and to disagree that small groups were too large. In addition, there did not appear to be a systematic relationship between group size and sponsor dollar valuation of the project per student.

How valuable are the stated learning objectives (technical writing skills, presentation skills, and technical analysis) to company sponsors?

One rationale for capstone design is to provide students with experience that will help them when they enter the workforce. We therefore thought it would be interesting to determine how valuable objectives established by ISyE (based on ABET criteria) were to employers. To do so we asked company sponsors to both assign a dollar value to the project and to grade the group as to how well its members accomplished the primary learning objectives of our program.
capstone design course — technical writing skills, presentation skills and technical analysis. We then calculated the correlation coefficient for the dollar valuation and each of the learning objectives. We found that dollar valuation was significantly correlated with only one of the learning objectives, technical analysis.

How much faculty resources could be saved going to a 1-semester course?

There are approximately 300 ISyE students that take senior design each year. Staffing the current 2-semester version is equivalent to staffing 16 normal class offerings (i.e., 16 faculty slots are used). Historically the average number of students per group is 8 and the number of groups assigned per faculty is 5. Since the median annualized faculty salary in the department is $90,000, the annual cost of running the class based on the current loaded Georgia Tech buyout rate is $414,480.

Changing the offering to a 1-semester version would lead to a significant reduction in resources. The total reduction of course depends on how many groups are assigned per faculty member and how large the group sizes are. One concern is that faculty members may need to spend more time per week with groups in the 1-semester version compared to the 2-semester version. We conducted a faculty survey and interestingly, the faculty in the 2-semester version reported spending 1.5 hours per week while the faculty in the 1-semester version reported spending only 0.9 hours per week with each group. Therefore assigning the same number of groups could actually reduce faculty workload under the 1-semester version.

Offering a 1-semester course with six students per group and six groups per faculty member could reduce the faculty workload assigned to Senior Design by 43%. This translates to savings of $178,226 per year. Reducing the group size to five students would lower the faculty workload by 38% and could potentially save $157,502 per year.

Conclusions

While there has been much work recently in teaching strategies (e.g., active learning techniques), little or no work has been done on group size or term length issues. In fact, we believe this is the first study to compare outcomes for capstone courses of different duration and with different group sizes. When designing an Engineering curriculum, it is not only important to determine course content but also the most cost-effective mode of delivery.

One significant finding of this research was that the 1-semester version strictly dominated the 2-semester version of capstone design— better outcomes for fewer resources expended. As a result of this study, the ISyE faculty recently voted to adopt a 1-semester capstone design course. Our findings on the impact of group size on outcomes do not provide a clear path for action. It is our impression that the prevailing belief about group size is that small is better. There is, however at present, little evidence to support this contention. Although students prefer smaller groups, companies are indifferent. In addition we do not yet know if the additional benefits to students attributable to smaller capstone design groups warrant the additional resources (i.e., foregoing smaller classes for other courses through multiple course offerings or increasing number of electives).

We also feel that course content should be evidence based. Engineering departments are being asked to expand their curriculum without a concurrent increase in resources. The major rationale for including the three learning objectives examined in this study was that they provided value to employers. Thus it is interesting that we found that one of the objectives, technical presentation, was not correlated with company valuation and that another, technical writing, was at best marginally significant. We are not suggesting basing all course content on maximizing a student’s value to employers; learning objectives, however, should be evaluated on their effectiveness in accomplishing the stated goals of the Engineering Department.
GROUP LEARNING: An Overview of the Literature

Sheldon Gen
Instructor, San Francisco State University
Doctoral Candidate, School of Public Policy
Georgia Institute of Technology

While the term “Group Learning” encompasses different forms of pedagogy and classroom engagement, and it often goes by different names, all of these schemes are similar in their requirement of having students interact with each other as a mode of their learning. Here is an annotated bibliography of the recent (about the last 15 years or so) literature on this rich topic. The organization is that the descriptions are first divided into the general topics of “Types and Definitions” [a background on definitions and theory], “Implementation” [tools for forming groups, planning for group work, and assessing group work], “Applications” [group learning in different disciplines], and “Effectiveness” [research into the effectiveness of group learning and its relationship to learning outcomes and student retention]. At the end, the full reference listing for each citation is given. Many of the references are available either in the main Georgia Tech library or in the CETL library in Tech Tower Room 17. If you need assistance finding any of these items, please feel free to contact CETL.

Types and Definitions

1. Collaborative and cooperative learning groups. There appears to be little consensus on their definitions, but there does seem to be much overlap and sometimes they are used interchangeably to described all sorts of group learning mechanisms. Common characteristics of them include an active role of students in learning (as opposed to passive roles), and the development of knowledge by the students (as opposed to the transfer of knowledge from the instructor). Sometimes distinct differences between them are described, but even these descriptions can be contradictory.

A. Collaborative learning

* It is “based on the idea that learning is a naturally social act in which participants talk among themselves” and share ideas (Gerlach 1994). It assumes that learning is an active process, requires students to solve problems and engage in higher reasoning, and exposes students to each other’s diverse ideas and experiences. For example, a history teacher might assign a group of students to determine the causes of the Civil War. Most collaborative learning share common characteristics: they allow time for group consensus to occur, they ask students to complete specific tasks, they allow members of groups to determine individual roles, and they teach respect for diverse and minority views.

* In a traditional course, the teacher holds knowledge and authority. Even in cooperative learning groups, the students still play the part of information receiver. In collaborative learning, power is transferred to the learner and they become creators of knowledge, not merely information receivers. The instructor creates the contexts in which knowledge can be discovered by the students. (Flannery 1994)

B. Cooperative learning

* Cooperative learning is “instructional use of small groups so that students work together to maximize their own and each other’s learning” (Smith and Waller 1997). It is more than just a traditional learning group, in that cooperative learning activities have high interdependence among group members, individual and group accountability, deliberately formed groups, emphasis on teamwork, and group processing of work quality.

* It is groups of students brought together to “teach each other the concepts of the class by reinforcing lecture and textual materials and subsequently are
evaluated as a group” (Sego 1991). Usually one or more students are designated to facilitate the group, and everyone in a group receives the same grade for group assignments.

* It is “the instructional use of small groups so that students work together to maximize their own and each other’s learning” (Johnson et al. 1991).

* Five defining characteristics of cooperative learning are positive interdependence, individual accountability, cooperative skills, face-to-face interaction, and group reflection and goal setting (Putnam 1997).

* Cooperative learning can take several forms including the learning together model, the structural approach, student learning teams, group investigation, and complex instruction (Putnam 1997).

2. **Informal learning groups** (Smith and Waller 1997, Davis 2001, Johnson et al. 1991): ad hoc temporary groupings of students (usually within a class period) formed to process information. They can take many forms including book ends on a lecture, focused organizing discussion, turn to your partner discussions, focused concluding discussion.

3. **Formal learning groups** (Smith and Waller 1997, Davis 2001, Johnson et al. 1991): teams established to accomplish specific tasks such as reports, labs, etc. This type requires specific inclusion of objectives, instructional decisions, thorough explanation of the tasks, monitoring progress, and evaluation of learning.

4. “**Cooperative jigsaw strategy**” (Smith and Waller 1997): dividing large lessons/units into smaller ones, each to be handled by different groups of students who teach each other.

5. “**Cooperative base groups**” (Smith and Waller 1997, Johnson et al. 1991) or “study teams” (Davis 2001): long-term, heterogeneous groups with stable membership, whose primary responsibility is to provide each student support, encouragement, and assistance to make academic progress. They review course material, critique work, prepare for tests, etc.

6. **Role playing and case studies** (Davis 2001): students are assigned characters they play in a hypothetical case. Originally developed for teaching law, it has been extended into courses in language, literature, planning, business, etc.

**Implementation**

1. **Planning and preparing for group activities**
   * General strategies for group work (Davis 2001): plan each stage, explain how groups will operate and how students will be graded, provide students with skills needed to succeed, consider written con-

   tracts, create group tasks that require interdependence and fit abilities, assign tasks that can be divided fairly, set up competitions among groups, consider group tests, avoid breaking up groups even when requested, monitor groups, evaluate individual performance, evaluate group performance, allow self evaluations of groups.

   * Planning for cooperative learning in a course requires the instructor to determine what activities can be assigned cooperatively, how many students should be in each group, how activities will be graded, and the balance between traditional classroom activities and cooperative activities (Sego 1991).

   * The benefits of cooperative learning methods do not magically appear when students are put into groups. They result from the instructor’s careful planning and implementation. Instructors must structure cooperation among the students. To be cooperative, students must have clear and positive interdependence (Johnson et al. 1991).

2. **Instructor’s role in group work**
   * In cooperative learning activities, the instructor acts as the idea person, the resource person, the mediator, and the supporter (Sego 1991).

   * In collaborative learning activities, the instructor becomes a task setter, classroom manager, and synthesizer (Gerlach 1994). The instructor creates the conditions in which collaborative learning can occur.

   * In collaborative writing activities, the instructor responsibilities are to form the groups, train the students in collaboration, and manage the groups (Speck 2002).

3. **Group Size**
   * In general the optimal size for a group is 4 to 5 students (Sego 1991). Two provides little peer pressure, three is volatile, and more than 5 become unwieldy. The optimal size also depends upon the task at hand.

4. **Group Formation**
   * Methods of group formation include students’ choice, instructor’s choice, random assignment, and assignment based on specific criteria or interests (Sego 1991). Caution must be used in letting students choose their groups completely: groups formed from friendships may prevent new students from assimilating, and new students will have no basis for selecting teammates.

   * In mathematics, one author found it advantageous to group students by the brand and model of calculator they owned. This helped students to learn how to fully utilize the functions of their calculators (Sego 1991).
5. Management of Activities
* Education technologies can assist collaborative learning, even if they were designed for the traditional individual learning (Sullivan 1994). Useful technologies include decision support systems, electronic classrooms, interactive video, and hypermedia systems.

6. Cooperative tests
* Cooperative tests are good teaching mechanisms as well as evaluative exercises. The key to their success is to give all students in a group the same grade. This will ensure that group members help each other understand the material (Sego 1991).

7. Considerations
* Diversity. In the US, 25% of school-children are ethnic minorities, 23% live below poverty line, and increasingly more have cognitive, physical, or behavioral disabilities. Implementation of cooperative learning activities must consider the heterogeneous mix of students in groups in order to make truly cooperative groups. Adaptations of cooperative learning activities to fit heterogeneous groups may include modifications to learning objectives, response mode, materials, workload, etc.
* Gender mix. Cooperative learning research shows that female students (from middle school to college) interact and perform better when participating in same-gender groups (Dillow et al. 1994).
* Today’s adult learners grew up on television and have attention spans directly related to the length of time between commercials. Thus, relying on lectures loses the attention of many students, while group activities can reinforce learning (Sego 1991).

8. Student Assessment
* Several tools can be used to assess student performance in collaborative learning activities (Cramer 1994). Assessments of group processes can happen through self-monitoring checklist, journal writing, and group member evaluation. Assessments of products can happen through exercises that range from independent to interdependent: student papers, research projects, short-answer examinations, group products, and collaborative examinations and assignments.

9. Student prerequisites
* Students need certain social skills for effective collaborative learning (Bosworth 1994). They include interpersonal skills, managerial skills, inquiry skills, conflict management skills, and presentation skills. Instructors can teach these skills through identification of skills, demonstration of skills, and feedback on student skills.

Applications
1. Mathematics (Emerson et al. 1994): student learning groups to work on homework sets, student- and teacher-generated problems and text, learning logs.
2. Literacy (Emerson et al. 1994): group project to interview seniors on literacy life experiences, student- and teacher-generated text, student learning groups.
3. Science (Emerson et al. 1994): replacing lectures with collaborative learning activities resulting in group oral or written products.
4. Writing (Speck 2002): students in groups produce multiple drafts on their way to creating a final, presentation-quality draft that is graded.

Effectiveness
Most of the literature praises group activities as a mode of teaching and learning, and most of the experiential and experimental data supports these claims. However, there are a few negative side effects.

1. Cooperative learning encourages student-student and student-teacher interactions, student decision making, problem solving, verbalization of methods and strategies, and positive peer relationships, all things that have been shown to improve learning (Smith and Waller 1997).
* The results hold true for men and women, first year and older students, majors and non-majors. The effects are significantly stronger for minority groups.
* The results hold true for all sorts of small group forms including cooperative, collaborative, and mixed form groups. That is, any kind of student interaction in learning is better than none.
* Small group learning also leads to greater self-esteem and more favorable attitudes toward the material, but it does not increase motivation.

2. A meta-analysis of 39 studies concludes significant positive learning effects from the use of small groups in science, mathematics, engineering, and technology courses (Springer et al. 1999).
* The results hold true for men and women, first year and older students, majors and non-majors. The effects are significantly stronger for minority groups.

3. An extensive review of research on cooperative learning – defined here as any small group learning exercise – concludes that the method has been and can be used to address 14 major issues facing higher education (Cuseo 1996). They include promoting active learning, increase academic achievement,
increase student retention, promoting critical thinking skills, enhancing writing skills, developing oral communication skills, increase student satisfaction, accommodating diverse learning styles, developing leadership skills, and preparing students for citizenship and the work world.

4. In traditional courses, students often seek the one "right" way to view the material. Through collaborative learning, however, they also learn about wrong ways to view it, and other ways when there is a plurality of views. In this way collaborative learning methods teaches critical thinking. (Nelson 1994)

5. Benefits of cooperative learning include helping students know each other, improving class attendance due to commitment to other group members, improving academic achievement, increasing student-initiated study groups outside of class, increasing active learning, increasing awareness of the complexities of decision making, increasing learning from peers in different careers and backgrounds (Sego 1991).

6. "Considerable research demonstrates that cooperative learning produces higher achievement, more positive relationships among students, and healthier psychological adjustment than do competitive or individualistic experiences" (Johnson et al. 1991).

   * Students may object to the seeming lesser role of the professor (e.g., students expect lectures and a passive role in class).
   * A group might not take the assignment seriously. Failing such a group on an assignment can motivate them for the next assignment.
   * Personality conflicts can be expected.

8. Collaborative learning requires students to participate actively and perform difficult cognitive and social tasks, so they do not always like the method. Group harmony is directly related to satisfaction, but inversely related to performance. Teachers must weigh performance, harmony, and satisfaction against each other (Miller et al. 1994).

9. There is some criticism of using cooperative learning methods with gifted students, essentially questioning the benefits of these methods for the gifted students themselves (Putnam 1997).

10. Jigsaw, a form of cooperative learning, shows the least achievement gains among various cooperative methods. Nonetheless, it a useful tool for covering and reviewing material (Foyle and Lyman 1989).
Group Learning

References


Fall 2003 Events

Faculty Development Seminars

September 18  BuzzPort, WebCT, and HorizonLive
October 16  Maintaining Passion For, In, and About Your Teaching
Panelists: Richard Catrambone, Nora Cotille-Foley, Andres Garcia,
Dana Hartley, Jianmin Qu
November 20  Demystifying Ethics Education
Dr. Robert Kirkman, School of Public Policy

Upcoming Spring Events

February 2 & 3  “GTREET”
(Georgia Tech Retreat Exploring Effective Teaching)

For more information on these events, visit the CETL website (www.cetl.gatech.edu)
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The Classroom

CETL
Georgia Institute of Technology
225 North Avenue
Administration Building, Suite 004-005
Atlanta, GA 30332-0383

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