AC 2007-1313: MULTIPLE PERSPECTIVES ON IMPLEMENTING A TEAM-TEACHING MODEL

Jenny Lo, Virginia Tech

JENNY LO, assistant professor in the Department of Engineering Education at Virginia Tech, has interests in freshman curricula, engineering ethics, increasing diversity of the engineering population, and promoting undergraduate research.

Vinod Lohani, Virginia Tech

VINOD LOHANI, associate professor in the Department of Engineering Education at Virginia Tech, has research interests related to freshman curricula, predictors of student success, international study, and sustainability.

Michael Gregg, Virginia Tech

MICHAEL GREGG, associate professor in the Department of Engineering Education at Virginia Tech, has interests in green engineering, computer aided design, and improving the diversity of the engineering population.

Richard Goff, Virginia Tech

RICHARD GOFF, assistant department head of the Department of Engineering Education at Virginia Tech, has interests in better understanding and improving the instruction of engineering design as well as increasing diversity of the engineering population.

Multiple perspectives on implementing a team-teaching model

Abstract

Multiple perspectives from two pairs of faculty that used a team teaching model for freshman engineering courses at Virginia Tech are presented. The first group (Goff and Gregg) taught a set of introductory engineering courses to a select group of 15 rising freshmen in the summer of 2002. The second group (Lo and Lohani) have team taught an introductory engineering course "Engineering Exploration" to multiple 150+ seat sections in spring 2005, fall 2005, and fall 2006. Content of these engineering courses include design, problem solving, ethics, graphing, technical communications, engineering graphics, and computer programming.

Some notable sample experiences are based on gender, age and educational background differences of participating faculty. In addition, these two pairs provide an interesting contrast due to the size of the class sections that were team taught as well as classroom environment. Goff and Gregg taught a special study abroad offering that included using classrooms in both the United States and Europe. Lo and Lohani taught in large, stadium style classrooms at Virginia Tech. The paper reports the advantages and disadvantages to team teaching and presents faculty perspectives that can be useful to faculty who are considering a team-teaching approach.

Team-Taught Courses: Background

Virginia Tech requires that incoming engineering students take a set of required introductory-level engineering courses during the first year of studies. Faculty in the Department of Engineering Education (EngE) are responsible for the first year engineering courses. The first semester course, Engineering Exploration EngE1024, involves ethics, problem solving, algorithmic development, programming, graphing, teamwork, design, and technical communication. The second semester course primarily focused on the design process, technical communication, project management, teamwork, sketching, and computer aided design. In 2005, the second semester course was reformulated into two tracks. One track focuses on introductory design related needs for students bound for electrical and computer engineering as well as computer science. The other track covers introductory design related skills required for remaining nine engineering departments at Virginia Tech.

Prior to spring 2005, the two introductory-level engineering courses were taught as 50-minute, 32-seat lectures that met twice a week and were taught by EngE faculty. A format change was piloted in spring 2005 by Lo and Lohani for EngE1024, primarily due to increased research responsibilities for faculty as well as the introduction of graduate teaching assistants to the pool of available teaching resources. This change included piloting: a weekly 50-minute, 150-180-seat lecture led by faculty with a weekly 90-minute, 32-seat workshop led by a graduate teaching assistant. In fall 2005, this new format was successfully implemented for the entire freshman engineering class of approximately 1200 students[1].

In summer 2002, the university implemented a special pilot offering of a 4 credit hour class, based on a combination of the two aforementioned introductory engineering courses. This recruitment effort was in its earliest formative stages in late fall 2001. The course, led by Goff

and Gregg, was envisioned as an intensive, hands-on, four credit hour class combining two weeks of classroom and laboratory work on the Virginia Tech campus with an equal duration at the University's Center for European Studies and Architecture (CESA) facility in Riva San Vitale, Switzerland. Teamwork issues associated with this venture were ad hoc. Academic issues were dealt with by the authors Goff and Gregg; however the difficulties of itinerary and logistics were handled by a senior staff member from the Dean's Office. This course, Enhanced Engineering Design and Problem Solving, was aimed squarely at those prospective engineering students with extraordinary credentials who had not yet committed to Virginia Tech. With high levels of AP, IB and dual enrollment credit, many first-year students are in a position to take sophomore level engineering courses but cannot not enroll in these sophomore level courses due to failure to meet pre-requisite requirements, namely successful passing of the first-year introductory engineering courses. The pilot offering was an attractive venue for allowing these advanced students to begin studying the first-year engineering content in the summer and then take the sophomore level engineering courses upon entry in the fall.

This paper presents experiences of four faculty (Lo, Lohani, Goff, and Gregg) who were involved in team-teaching above courses.

Experiences by Lo and Lohani

Teaching advantages

Lo and Lohani implemented a major change in the delivery format of the 2-credit EngE1024 in spring 2005. The new format involved a 50-min lecture in a large classroom (~150 seat) followed by a hands-on workshop in a 32-seat classroom[2]. The authors team-taught the large lecture class and supervised development of hands-on activities for the workshops. As far as the authors know, this was the first major change in the delivery format of this required engineering course in the 35+ year history of General Engineering program at Virginia Tech. The new format has now been existence for the last four semesters, and other freshman engineering courses in the General Engineering program at Virginia Tech are being transformed to follow a similar 1-lecture, 1-workshop per week format. The team-based approach helped to successfully implement the new delivery format of the course. Lo and Lohani shared responsibilities for developing lecture and workshop material as well as managing personnel including graduate and undergraduate teaching assistants and graders. In spring 2005, there were 4 graduate students who taught the workshop sections. In fall 2005 and 2006 semesters, the authors managed 14 graduate students who were involved in teaching the workshops. The new format has been by and large a successful experience. Some other advantages are noted below.

Multiple faculty could provide multiple perspectives to engineering freshmen. For example, one of the objectives of EngE1024 is to introduce freshmen to engineering profession. Students are taught about P.E. licensing and given information regarding a variety of engineering disciplines. Lo, who received educational training in chemical engineering in the U.S., and Lohani, who received educational training in civil/agricultural engineering in India, Thailand and the U.S., were able to present different educational experiences, particularly focusing on differences in culture and disciplines. In addition, Lo and Lohani represented two different genders, allowing

students to see representation from both genders among engineering faculty as part of their very first engineering course.

In some situations, one faculty member could relate an experience to the students that would lead credibility to the other faculty member's statement. For example, Lo often made references to her husband's (also an engineering faculty) experiences in industry about expectation of neat and organized work while Lohani discussed the engineering format requirement for writing homework solutions.

With two faculty members, it was easier to reduce time wasted due to implementation of formative assessment tools such as clickers (also known as student response pads) and unanticipated technical problems. While one faculty member focused on speaking, the other faculty member could engage the software and hardware necessary to allow for clicker use. In the case of technical problems involving laptops or projectors, one faculty could continue to lecture while the other faculty could focus on solving the problem.

With a large classroom, the use of two faculty can help to keep students engaged. As one audience member noted, changes from one voice to another voice seemed to be effective at regaining student attention. It may be mentioned that engineering students are required to own a laptop (a Tablet PC since fall 2006) at Virginia tech and instructors often require students to bring computers to class. Lo and Lohani took turns to circulate around the room while the other faculty is speaking at the front. With the knowledge that a faculty member was monitoring behavior, some students appeared to respond by reducing use of non-classroom related software (i.e., instant messenger, games, videos, etc.). Also, the circulating faculty member could address a particular student's question without interrupting the lecture for the entire class.

Another advantage to having a second faculty monitor student behavior is that the second faculty could quickly survey student progress and report this to the other faculty member. For example, in a object-oriented programming class involving students use of laptops while Lohani went through a step-by-step programming exercise, Lo went around the room and assessed that about 50% of the students were only able to follow half of the material. This allowed the two faculty to regroup and alter subsequent workshop and lectures based on this information.

Shared responsibility in writing tests, exams, quizzes, assignments, and other course documents helped both instructors. One faculty member might be primarily responsible for writing one half of a test while the other member would write the other half. Then both faculty members could review each others' work for accuracy and fairness.

Additionally, Lo and Lohani used their respective strengths in delivering course material. Lohani had expertise in object-oriented programming and elected to teach much of the lectures related to programming concepts. Lo emphasized the key concepts associated with engineering ethics instruction.

Lo and Lohani discovered that many students waited until the class period was over before approaching the faculty to ask questions. The sharing of responding to student questions reduced the time students had to wait to have their personal questions answered.

This model also allowed absences by either faculty member to easily be covered. On a few occasions, one faculty member could not be present. In this case, the remaining faculty member taught alone rather than canceling class or leaving students with a substitute faculty member who might not be as familiar with the course. Lo and Lohani also maintain that the students were able to see an example of teamwork, not just being preached in lecture, but in action.

Classroom Disadvantages/Challenges

Also, teaching together requires that faculty can smoothly transition from one to another. It also requires some planning to determine who will take the lead for each topic in a particular lecture. There will also be times where one faculty may need to correct the other or when one faculty wants to interject a statement. This has to be done in a way that does not undermine the authority of the primary speaker. The faculty must address these possibilities ahead of time and establish a protocol.

Lo and Lohani also noticed that some students were initially confused as to which faculty they should approach outside of the classroom for help. However, other students appreciated being able to access the office hours of multiple faculty.

At Virginia Tech, each faculty member is evaluated by the students. There was some question as to whether faculty members should be evaluated together or separately, especially for use in the promotion and tenure process. In this case, Lo and Lohani decided to be evaluated as a team.

One other consideration was the teaming of a tenured and non-tenured faculty member. In some cases, the relationship between tenured and non-tenured faculty can be strained with non-tenured faculty restraining opinions due to perceived hierarchical differences. While a challenge, it was important that the faculty respect each other so that opinions could be freely shared. In several instances, it was helpful to have multiple opinions to decide upon appropriate levels regarding expectations for graduate student load, the amount of homework assigned to students, pace of material being delivered, and course content.

Some might argue that the team teaching approach requires additional resources in the form of faculty time; perhaps the second faculty could be doing something other than spending time in the classroom. However, Lo and Lohani feel that the advantages outweighed the disadvantages.

Research Productivity

The collaborative efforts that started in transforming EngE1024 have resulted in developing research collaboration among the authors, particularly Lo and Lohani. Since creation of Department of Engineering Education (EngE) at Virginia Tech, engineering education research has become an important mission. A NSF project titled "Bridges for Engineering Education – Virginia Tech (BEEVT)" [3]laid the foundation of an engineering – education collaborative at Virginia Tech in 2003. The BEEVT investigators (engineering and education faculty) proposed to reformulate engineering curriculum using a spiral approach. This approach is adopted in a 4-year (2004-2008) implementation grant under a Department-Level Reform (DLR) program of

the NSF (hereafter referred to as DLR project) (www.dlr.enge.vt.edu). As part of the DLR project, a number of EngE faculty members are collaborating with faculty from other engineering departments and the School of Education to reform the freshman engineering program within the EngE and the bioprocess program within the Biological Systems Engineering department using a theme based spiral curriculum approach[4]. All authors of this paper are participating in the DLR project. Particularly, authors Lo and Lohani have brought out a number of conference papers as a result of their collaborative efforts in implementing the new delivery format of the first semester engineering course. These have been presented at major engineering education conferences like Annual conference of ASEE, Frontiers in Education (FIE), International conference on engineering education (ICEE), and 5th ASEE Global Colloquium in Engineering Education. The number of publications that have been brought out collaboratively by Lo and Lohani, related to the first semester engineering course, in last 2 years has been unprecedented. A journal paper has also been published in the Computers in Education journal (July – Sep. 2006 issue) of the ASEE by Lohani and Lo[5]. Manuscripts for two other journal papers are in preparation.

In addition to the conference and journal papers, authors Lo and Lohani have collaborated in submitting proposals to various programs of the NSF including the Course Curriculum and Laboratory Improvement (CCLI), Research in Gender in Engineering, Advanced Technological Education, and Partnership for International Research. In addition, to the DLR project, they are working together on a CCLI phase II grant, along with three other EngE faculty, that involves research work in EngE1024 course.

Experiences by Goff and Gregg

As described earlier, in the summer of 2002, two faculty members in the Division of Engineering Fundamentals (now the Department of Engineering Education) at Virginia Tech collaborated to develop and deliver an introductory engineering course in the period of a month to a group of 15 new outstanding high school graduates in the summer. Half of the course was taught on the University campus in the U.S. and half of the course took place at the University campus in Europe. Students applied to be in this course and those with requisite Advance Placement credit, design experience and very high (above 1500) SAT scores were accepted. Professors Goff and Gregg spent the spring semester preparing this course which would be a combination of the two independent courses with several field trips and demonstrations added.

Goff and Gregg prepared and taught the course. A staff assistant from the Dean's office provided support helping with recruiting, applications, and screening of applicants as well as arranging for local housing for the students and travel arrangements for the trip abroad. The course started with 6 hours of class each day for two weeks. This was supplemented with field trips to local companies, social events, and hikes.

Professors Goff and Gregg share similar backgrounds combining both academics and industry/commerce driven engineering issues. Team teaching in this context obviously did not involve widely different areas of expertise or disciplines. Neither did it generally involve a blanket separation of teaching duties, e.g. one teaches programming and the other teaches design. This approach might have been less resource intensive, however the authors opted to co-teach

most topics. With minimal formal training in team-teaching, but with a wealth of collaborative experience gained over the course of their respective careers, the two faculty members approached the design and delivery of the course from the standpoint of 'what will work best for these students?'. Goff and Gregg both had taught the material individually as colleagues in the department; team teaching involved dividing the responsibility for delivery of technical content based on shared preferences, and also providing individual engineering insight based on their respective backgrounds. The students benefited from this co-teaching method not only because faculty opted to present that particular material (and thus had an abiding interest in it), but also because the other faculty member provided tangential insights to the subject at hand.
They both usually had good comments and additions to the other's presentation of the material. It is critical that faculty team-teaching in this way have similar levels of comfort with the degree of preparation and flexibility with interaction in the classroom. They also need to have a relaxed relationship with a good sense of humor.

Goff's experience of team-teaching with Gregg was very positive. Both professors seemed to complement each other in knowledge and style. Student reaction and participation was very positive as well.

An effort was made to have the same number of classroom contact hours as the two courses normally had. In addition, many field trips were planned. The two weeks at the U.S. campus included several field trips to area industry and recreational sites as well as classroom work. In addition to village living and classroom work for two weeks in Europe, the students were exposed to European companies, engineering marvels and cultural landmarks during their stay. International ethical, environmental and organizational themes were explored. The field trips to several manufacturing companies in and around the U.S. campus, a recreational hike and 4th of July social at Goff's house were huge hits with the students. The field trips throughout Europe were certainly the highlights of the course with trips to companies, universities, the Last Supper, a cog rail trip, dinner cruise on Lake Geneva, visit to a university robotics lab, Castles in Bellinzona, the Gothard Tunnel construction in Switzerland and to the Tour de France.

These students had a higher grade point average after first semester at Virginia Tech than did their scholarship peers. Most of these students double majored and graduated with honors. The strong bond that was formed between the faculty and these students continues even today though there was not much contact during the regular academic first year or in subsequent years. Although, some of the now graduated students, still reflect on the great educational experience they had in 2002. Goff and Gregg had major life changing experiences as a result of this collaboration and team-teaching experience.

Conclusions

The success of the team teaching approach discussed in this paper highly depends on the professional and personal relationship between team members. It does not work for every faculty pair[6]. The literature cites numerous examples of successful team teaching in non-technical areas, but few in technical ones[7,8,9].

It is conjecture based on experience, but it is Gregg's contention that the more technical the subject matter the more difficult it is for a faculty member to relinquish the dais.

The authors found that the main advantage of the team teaching method is allowing for multiple perspectives on a topic in a classroom and maintaining student engagement in a large classroom. One action that the authors believe provides a great return is the creation of an active classroom that consists of one teaching partner circulating among the students while the other is directing or coaching the activity. To make team teaching work, it helps to have teaching partners who are flexible and who welcome comments and input before, during, and after class. Also, faculty should consider working with someone who he likes to be around and who has similar levels of comfort with planning, preparation and spontaneity. The authors (mainly Lo and Lohani) had positive experiences in implementing formative assessment schemes for assessing students' prior knowledge and learning experiences. While the authors note that some might argue that a team teaching approach is not an effective use of resources, the authors had a positive experience with this approach. In fact, Lo has been assigned to co-teach another course in spring 2007 with a different faculty member, and plans to continue experimenting with a team-teaching approach.

References

[1] Lo, J.L., Lohani, V.K. and Griffin, Jr., O.H., "Full Implementation of a New Format for Freshmen Engineering Course," Proceedings of the 2006 ASEE Annual Conference and Exposition, Chicago, IL, June 18-21, 2006.

[2] Lo, Jenny, Vinod Lohani, Richard Goff, O. Hayden Griffin, Jr. "Work in Progress: Pilot of Foundation Engineering Education Course", Proceedings of the 35th ASEE/IEEE Frontiers In Education Conference held October 19-22, 2005 in Indianapolis, IN.

[3] Lohani, Vinod K., Mark Sanders, Terry Wildman, Jeff Connor, Kumar Mallikarjunan, Theo Dillaha, John Muffo, Tamara W. Knott, Jenny Lo, G.V. Loganathan, Greg Adel, M.L. Wolfe, Richard Goff, Mike Gregg, Mike Chang, Foster Agblevor, David Vaughan, John Cundiff, Ed Fox, Hayden Griffin, and Sue Magliaro, "From BEEVT to DLR – NSF Supported Engineering Education Projects at Virginia Tech", Proceedings of the 2005 ASEE Annual Conference and Exposition, Portland, OR, June 12-15, 2005.

[4] Bruner, J (1960). *The Process of Education*, Cambridge, Mass.: Harvard University Press

[5] Snook*, J., Lohani, V.K., Lo, J.L., Sirvole*, K., Mullin*, J.S., Kaeli*, J.K., and Griffin, O.H., "Incorporation of a 3-D Interactive Graphics Programming Language into an Introductory Engineering Course," Computers in Education Journal, Vol. XVI, No. 3, July-September 2006, pp. 63-72.

[6] Dennis et. Al, *Team Teaching, Team Learning,* The Chronicle of Higher Education, April 16, 2004.

[7] Bartlett, T.: *Students Become Curricular Guinea Pigs*, The Chronicle of Higher Education, May 10, 2002

[8] Gregorian, V.: *Colleges Must Reconstruct the Unity of Knowledge*, The Chronicle of Higher Education, June 4,2004

[9] Bollag, B: *A Course on Conflict Resolution Is Personal for the 2 Professors Who Team-Teach It*, The Chronicle of Higher Education, September 22, 2006