Aligning Foundation Coalition Core Competencies and Professional Development Opportunities: A University of Wisconsin - Madison Case Study in Preparing a New Generation of Engineers

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Abstract

Faculty within the Foundation Coalition (FC) are working together to prepare a new generation of engineers by strengthening both undergraduate and graduate students' educational foundations and helping them develop core competencies. The coalition links together six institutions: Arizona State University, Rose-Hulman Institute of Technology, Texas A & M University, University of Alabama, University of Wisconsin-Madison, and University of Massachusetts-Dartmouth. Partner institutions are diverse in terms of size, age, public/private, student body characteristics, and experience in educational reform, but all share a commitment to the improvement of engineering education. With the goal of student learning in mind, the Foundation Coalition defines core competencies to be the abilities that educators must develop, continuously improve, and use in order to "create a new culture of engineering education that is responsive to technological changes and societal needs" – the FC vision. The core competencies are curriculum integration; cooperative and active learning; utilization of technology-enabled learning; assessment-driven continuous improvement; recruitment, retention, and graduation of women and under-represented minorities; teamwork and collaboration; and management of change. The University of Wisconsin-Madison helps faculty, staff, and teaching assistants develop and use these core competencies in myriad ways.

This paper describes two professional development opportunities at the University of Wisconsin-Madison, College of Engineering: the New Educators' Orientation (NEO) and the Teaching Improvement Program (TIP). While NEO introduces the core competencies, each TIP workshop incorporates one or more of the FC competencies. The program director and graduate student co-chairs use the competencies to guide workshop selection and design. This paper traces the development of both NEO and TIP; the incorporation of the FC core competencies, vision, mission, student outcomes, and objectives; the impact on curricula as reported on evaluations; lessons learned; and plans for future professional development opportunities. Four case studies illustrate how graduate students, the next generation of engineers, develop the core competencies through professional development opportunities including TIP and NEO.

An Historical Perspective

In 1990 an Education Committee of the University of Wisconsin-Madison College of Engineering determined that training of teaching assistants (TAs) was vital to improving engineering education. With approximately 125 teaching assistants in 8 different engineering departments affecting both undergraduate and graduate education, the College began offering workshops in basic teaching concepts. For the first three years, new and continuing TAs attended workshops of their choice at the beginning of the semester. However, it soon became evident that new TAs and continuing TAs needed different workshop content. In 1993, the College instituted the New Educators' Orientation (NEO) for new TAs and the Teaching Improvement Program (TIP) for continuing TAs. These programs were also open to all faculty and instructors in the College.

The mission of both programs is "to improve the quality of undergraduate and graduate education through a series of workshops that enable teaching assistants to develop professionally and to continuously improve those skills needed to enhance student learning." The focus of NEO is "to develop basic skills and to generate enthusiasm and excitement about teaching and learning." NEO exposes participants to basic educational theories, provides practical suggestions to help engineering educators with their classroom responsibilities, and emphasizes their value and importance of their role as a teacher. Additionally, NEO consists of four workshops: 1) First Day Concerns and Solutions; 2) Creating Effective Teaching and Learning Opportunities With Our Cultural Perspectives; 3) Cooperative & Active Learning and Assessment; and 4) Presentation Skills. In the presentation workshop, each person presents a four minute topic which peers critique.

The focus of the TIP program is continuous improvement and to develop teaching and learning environments that prepare future engineers. Since the audience already has attended the NEO program and has one or more semesters of teaching experience, the focus of these workshops is on more advanced teaching skills and new teaching philosophies. Usually a theme weaves together eight to ten workshops; "Unleashing Creativity in Research and Teaching" and "Teaching and Learning with Technology" were two recent themes. Each participant chooses two workshops to attend based on his/her teaching needs and recent teaching evaluation reports.

While NEO is a two day program, the second day overlaps with TIP to guarantee interaction of new and experienced engineering educators. All participants in both NEO and TIP workshops end the professional development programs together by attending a College-sponsored workshop luncheon whose goals are to 1) establish community among TAs, faculty and instructors; 2) provide a forum for informal discussion; 3) disseminate other useful information; and 4) present teaching activity in a fun atmosphere.

To help facilitate these programs, two graduate student co-chairs are chosen for TIP and one for NEO. These are TAs who are interested in improving teaching and learning. The co-chairs, who receive a small honorarium, comprise the management team along with two administrative staff. They determine the workshop programs and find TAs from engineering departments to help coordinate details and speakers for workshops. Most speakers are faculty, staff or TAs from the Engineering College or University, but at least once a year, visiting scholars from other

campuses are featured speakers.

Workshop Topics Align with Core Competencies

Over the years about twenty issues have emerged as critical to helping students learn and to developing confidence in teaching. Faculty and graduate students have identified the issues through their own evaluations, focus group discussions, workshop assessments, ASEE conferences and publications, and work of the National Institute for Science Education (NISE). These issues became workshop topics that are rotated to enable TAs who teach for several semesters to attend a new workshop each semester. Each workshop is one and one half hours and is interactive. With recent involvement of the Foundation Coalition, the management team decided to compare their extensive list of topics with the FC core competencies. Not surprisingly, the workshop topics align well with the core competencies that educators need to develop to become more effective teachers enabling students to learn. NISE has provided a number of excellent resources that parallel FC competencies and that TIP and NEO have incorporated. Based on substantial educational research, specific NISE resources include those for cooperative and active learning (http://www.wcer.wisc.edu/nise/CL1)[2,5], assessment-driven continuous improvement (http://www.wcer.wisc.edu/nise/cl1/flag)[6], and recruitment, retention, and graduation of women and under-represented minorities[1].

Figure 1 shows TIP workshops with a theme of creativity and identifies how each workshop incorporates at least one of the following seven core competencies:

a. curriculum integration
b. cooperative and active learning
c. utilization of technology-enabled learning
d. assessment-driven continuous improvement
e. recruitment, retention, and graduation of women and under-represented minorities
f. teamwork and collaboration
g. management of change

Workshop	**a**	**b**	**c**	**d**	**e**	**f**	**g**
Creative Approaches to Research and Teaching	x	x	x	x	x	x	
Managing Time		x					x
Different Students, Different Learning Styles		x	x	x	x	x	
Assessment of Learning				x	x		x
WebCT			x				
Lab Creativity		x	x	x	x	x	
Creating Dialog in the Learning Environment	x	x			x	x	
Teamwork		x		x	x	x	

Figure 1. TIP workshop alignment with FC core competencies

Case Studies

The following case studies illustrate how graduate students develop professionally as engineering educators and practicing engineers; in the process, they develop the core

competencies through professional development opportunities including TIP and NEO.

Case Study: Jacob

Besides the blistering cold winters, Jacob's first recollection of Wisconsin, having left his home in the tropics, is one of culture shock. Here he was placed in a foreign land, with a people of very different habits, sensibilities and values. It was this that caused him to be anxious of his first assignment to lead a group of young electrical engineering students (juniors) through their required course in "Advanced Lab." To his relief the University provided their new TAs with an orientation and training program. Some of the key points that prepared him for his first experience as an educator were the diversity workshops and the preparation skills workshops. The diversity workshop exposed Jacob to the cultural differences and nuances and provided the "how to's" and resources available for overcoming the cross-cultural barriers. The preparation skills workshop made him aware of the subtleties of preparing (even familiar material) for lectures and on methodologies in conveying the relevant information most efficiently. One of the key elements of this workshop was that it fostered an atmosphere of peer mentoring. It gave him the opportunity to meet with experienced TAs in the same area, to hear their experiences, and to connect with them.

Through his first semester of teaching, the continued departmental focus on teaching improvement and their encouragement, coupled with that of the staff and peers, influenced him greatly. He strived to improve his teaching techniques through student evaluations, videotaping sessions and peer feedback. Through his experience he learned that teaching was a process that one continued to work on improving. At that point he got actively involved in the teaching improvement workshops of the College of Engineering. The following semesters were an explosion of ideas for improved teaching, starting with TIP at the beginning of each semester. He learned about various teaching and learning styles and several methodologies of teaching that would enhance and improve classroom learning.

His implementation of these ideas to the classroom was well received by the students, and they constantly gave him some of the best teacher evaluations. Three highlights of his teaching techniques were that he encouraged teamwork, cooperative and active learning, and assessment-driven continuous improvement, each of which had a base focus from the various TIP workshops. For example, in a conceptual systems engineering lecture, after introducing a new concept, he would divide the class into smaller groups. Each group would be assigned a problem based on the lecture and had to work as a team to produce a result that all members of the group agreed upon. This idea of assessment-based cooperative learning was enthusiastically received by the students and this was reflected in both the student evaluation (exam) and teacher evaluation. The second idea he implemented by being accessible to his students, and he transcended the cultural barriers by being friendly. Even today Jacob volunteers at opportunities to teach, and he attributes many aspects of time management and research resources to the TIP workshops and the atmosphere that the university's teaching culture set up.

Case Study: Nana

This case study illustrates the impact of the NEO program on new teaching assistants like Nana Murugesan.

In Spring 2000, Nana became both a graduate student and a teaching assistant in the Department of Electrical and Computer Engineering (ECE) at the University of Wisconsin-Madison. He recalls that initially he had a few concerns since he hailed from a country where the teaching and assessment techniques and the whole teacher-student interaction seemed to be different. Initially, he felt that he might experience a lot of non-academic difficulties while teaching the undergraduate students at Madison. Nana had been assigned to assist in teaching two courses, Advanced Laboratory (undergraduate level) and Computer Aided Design for VLSI (graduate level). Nana knew that he would need to deal with several teaching issues in the undergraduate level lab course since it involved more responsibilities such as lecturing, proctoring, and grading quizzes and projects. The graduate level course involved creating a course website, holding discussion sections, and grading. The Advanced Laboratory course was new to Nana since he had not done a similar course in his undergraduate studies. He chose to use peer mentoring, which was encouraged by the College and emphasized in the NEO training program. Nana worked with Jacob (an experienced TA for that particular course) to get acquainted with the requirements and expectations for the course from both the student and the instructor perspective. Nana used a candor grading system, which enabled the students to be aware of their current grades and the expectations during the semester. During the end of the semester evaluations, Nana secured an evaluation rating of 4.4/5. This was well above the average for new TA's. He attributes his successful teaching experience to the NEO workshop training and also to the rapport he developed with his students.

In the following semester (Summer 2000), Nana chose to teach the Advanced Laboratory course again. He also lectured a Computer Science course for African/Latino/Native American high school students in the Engineering Summer Program (ESP). Nana feels that the NEO diversity workshops helped him to do well as an instructor for the ESP. He used creative teaching methods such as web-enabled teaching tools and encouraged active/cooperative learning in students in the Advanced Laboratory course. Nana's evaluations increased to around 4.6/5, apparently indicating that the techniques he was exposed to in the NEO program and his improvements were well received by his students.

Nana continues as a teaching assistant in the ECE Department and volunteers to organize the teaching workshops for new and continuing TAs. He feels that his experiences as a TA have helped him while interviewing for jobs in industry, and given him more confidence during presentations and while interacting with a diverse group of people. He also believes that the NEO and TIP programs help graduate students in the long run.

Case Study: Jodi

The NEO and TIP workshops were springboards for academic professional development for Jodi Reeves, a TA in Materials Science and Engineering. The TIP workshops on cooperative and active learning were instrumental in changes she implemented in her introductory materials science course. For example, instead of the instructor doing a follow-up lecture on steel following the laboratory activity, she instead had the students take turns presenting their group's lab results in front of the class. The class was encouraged to ask questions of the presenters as well as discuss how the specific results illustrated broader trends in the experiment. This activity fostered a sense of teamwork in the class as well as enhanced the communication skills of the students. However, this change in teaching style was initially difficult for both Jodi and the

students to get used to. With active and cooperative learning, there is sometimes a danger that chaos, and not learning, may ensue. Especially the first time Jodi tried this new teaching method, she felt that she was not as "in control" as she felt during a lecture. At first, the students felt that the teacher was being lazy, in a way, since **they** were doing the hard work of presenting and discussing experimental results. As the class went on, and as active and cooperative learning activities continued to be used, the instructor and students became more comfortable with the new teaching and learning style. The end result was that the students worked better in teams, produced better final projects, got more out of the class, and gave better TA evaluations than in previous semesters.

In addition, NEO and TIP workshops on diversity gave new instructors practical ideas to use in their classroom in order to encourage recruitment and retention of women and minorities. In materials science, typically only a few women enroll in introductory courses, so attracting and keeping good female students is a high priority. One TIP workshop introduced ideas from Elaine Seymour[4] about the differences in learning styles between men and women. By understanding these differences, instructors can adapt their teaching style to help all students learn.

NEO and TIP are the foundation of a cycle of continuous professional development: new ideas are learned in NEO and TIP, the ideas are implemented and improved while being a TA, then these "lessons learned" can be shared in subsequent TIP workshops or in other educational forums on the department, college, university and national level. Jodi's professional development activities included implementing the course portfolio project [8] as a College of Engineering TA Fellow, attending the national Science and Engineering Education Scholars Program (SEESP) [9], and becoming president of the UW-Madison graduate student chapter of the American Society for Engineering Education [7]. In many ways, these additional professional development activities are just an extension of NEO and TIP, and therefore, incorporate FC core competencies as well. For example, the SEESP hosts thirty new professors and academic track Ph.D. students each summer for a week. SEESP consists of presentations by nationally and locally recognized faculty, staff, and administrators. Workshops and discussions helped participants bridge the gap between theory and practice to help improve their teaching and learning. Specifically, participants learned to develop or revise a course in terms of objectives, outcomes, activities, and assessments. Often the SEESP topics are the same as in the NEO and TIP workshops, just explored in more depth with participants from around the country.

Case Study: Dan

Dan arrived at UW-Madison with a bachelor and master of science degree in electrical engineering from different universities. His teaching experience as an undergraduate was through tutoring a few hours a week. As a TA, while seeking the master's degree he taught drafting, FORTRAN and design laboratories. The institution where he attained the master's degree did not have the amount of teaching preparation that the College of Engineering provides. Although he believes his teaching then was effective, he also believes the exposure to semester workshops of NEO and TIP, as well as a large number of other teaching effectiveness seminars and talks on the UW campus, have modified his style and made him a better educator. His TA experience was weekly discussion sections and office hours for a variety of core undergraduate signal processing courses. For this reason, we focus on his development of lecturing and office hour effectiveness.

His initial teaching philosophy teaching was to present as lucid a lecture as possible, or to give as clear a presentation to solving an engineering problem as possible. Certainly, being lucid and clear is one important element of teaching. However, through TIP workshops he realized that there are ways to enhance one's communication skills, especially regarding engineering problem solving skills. The most notable influence was a 1993 workshop which presented many of the ideas from "Learning and Teaching Styles in Engineering Education" by Felder and Silverman [3]. A short test of the participants own learning styles with the opportunity to see the mixture of different styles for people there in the workshop made him realize that trying to make all students understand his viewpoint, albeit lucid and clear, was perhaps not the most effective teaching method. Furthermore, a discussion with an invited presenter during the Science and Engineering Education Scholars Program [9] convinced him that the teaching style of his undergraduate professors that inspired himself to seek a graduate degree probably was **not** the most effective teaching style to reach the majority of undergraduates in the class room.

Much of Dan's development as an educator was to learn and become comfortable with the teaching styles, and then to mix the different styles in lectures and problem solving sessions. For example, early in the semester he would present problem solutions to the class trying to show the students the thought process he used. Then gradually he would ask for more input from the students, bringing their thought processes to light and proceed solving the problem from there. Near the end of the semester he would have students work in groups and choose a student to present the group's solution. Of course, the degree of these types of activities is based largely on the lecture instructor's weighting for homework in the students' final grade. A larger weighting for homework probably requires more individual work on part of the students, while a lesser weighting on homework allows for more flexibility in the discussion activities.

Surprisingly, sometimes the students don't rate Dan too highly when doing this sort of thing. He gets comments like "We have to teach him the stuff." This doesn't bother him because he believes that he is being more effective, whether or not the students are comfortable with it.

During office hours, Dan learned to match the teaching style with the learning style of the student. This was done by first letting the student present their attempt at solving the engineering problem, assuming they did already try. This gives one a feeling for how the student thinks and gives the student more confidence in formulating a solution. Dan then tries to get in tune with the student's learning style and proceed by guiding the student to the final "correct" solution. He never lets the student leave with any doubt about the solution, even if the method the student has chosen to arrive there may not be the most direct.

The significant change in Dan's philosophy is to now approach the problem of educating students as he would any other type of engineering problem. The first step is to gather information about your audience, then formulate the best approach to using different learning styles to communicate ideas, as clearly exemplified in the discussion of office hours. However, this is also the case for discussion and lecture. Dan decides which background courses are relevant to the course, then constructs a questionnaire handed out at the beginning of the semester to find out how strong the students are in the material from the background courses. Also, on the questionnaire he will ask students to write down what they think their own learning styles are after Dan gives examples within the five categories. Dan still tries to be lucid and clear, of

course.

Conclusion

Faculty in the College of Engineering at the University of Wisconsin-Madison, a partner in the Foundation Coalition (FC), are working with graduate students to "create a new culture of engineering education that is responsive to technological changes and societal needs" – the FC vision. Every semester they collaborate with a management team in the Engineering Learning Center to sponsor both the New Educators' Orientation (NEO) and the Teaching Improvement Program (TIP). Within the workshops, they integrate the core competencies, that is, the abilities that educators must develop, continuously improve, and use in order to prepare this new generation of engineers. The core competencies are curriculum integration; cooperative and active learning; utilization of technology-enabled learning; assessment-driven continuous improvement; recruitment, retention, and graduation of women and under-represented minorities; teamwork and collaboration; and management of change. Four case studies illustrated how graduate students, the next generation of engineers, develop the core competencies through these professional development opportunities.

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