Preparing Future Engineering Faculty through Active Learning

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Abstract

This paper describes the development, presentation, evaluation, student feedback, and recommendations of a graduate level course for engineering students titled "Active Learning in Engineering Education." The objective of the course was to provide engineering graduate students with information about the learning process and resources on teaching and academia to help them make informed decisions about teaching as a career and to help them be better teachers. We believe this course is unique because it provides a curriculum taught to graduate students by a graduate student. This work was funded by a Huckabay Teaching Fellowship, a program that provides support for teaching projects conducted by graduate students paired with mentors.[1]

I. Introduction

Preparing engineering graduate students for a future in academia should include providing methods and support for teaching as well as guidance in research. While research guidance is typically provided within a department via a research advisor, teaching guidance can be provided at the college or inter-departmental level. Even though many campuses provide the opportunity for graduate teaching development at the university level (e.g., through campus teaching centers), it is also useful to approach graduate teaching development within an engineering context. Specific engineering examples of active learning help teaching assistants and graduate instructors understand how active learning can improve engineering student learning. Bonwell and Eison define active learning as "instructional activities involving students in doing things and thinking about what they are doing."[2]

The work described here includes the development and presentation of a course on active learning for engineering graduate students. The course was developed with the support of a graduate teaching fellowship and the advice of mentors. Three of the motivating ideas inspiring the development and offering of this course in a graduate engineering curriculum are 1) to create a culture where talking about teaching is expected and useful; 2) to give engineering students access to a vocabulary for talking about education with members of other academic disciplines; and 3) to model active learning techniques and good teaching practices.

The Huckabay fellowship program is part of the larger Preparing Future Faculty (PFF) program at the University of Washington (see web links for more information[3,4]). The Huckabay Teaching Fellowship was proposed by and awarded to Bates. Linse (Associate Director of the

Center for Engineering Learning and Teaching, CELT) served as her primary mentor, with additional mentoring from Cindy Atman (Director of CELT and Associate Professor of Industrial Engineering) and Jennifer Turns (Assistant Professor of Technical Communication and CELT Faculty Affiliate).

The development phase of the "Active Learning in Engineering Education" graduate course involved interviewing engineering faculty from a range of institutions and a variety of disciplines including electrical, civil, and mechanical engineering, as well as computer science and engineering. The purpose of the interviews was to learn about some of the teaching challenges engineering faculty and students face and to identify when and how they use active learning methods. The graduate course had two primary components: 1) activities to encourage discussion among the course students about teaching in general and active learning in particular, and 2) development and implementation of active learning modules applicable to undergraduate engineering courses.

In the remainder of this paper we discuss the state of active learning in engineering education, the faculty interview process and outcomes, and finally, the graduate course on active learning in engineering. We provide an overview of the course content, our goals for each topic, details of the course, and a sample of student comments about the individual classes. The paper concludes with some observations about the value of this course in graduate engineering education and recommendations for presenting a similar class.

II. Active Learning in Engineering

In engineering, active learning includes such things as supervised problem solving, discussions of the process and the result, and collaboration between students. While great strides have been made in engineering education reform over the past decade, the shift toward learner-centered teaching (and away from dependence on the traditional lecture) is still in the developmental stages. For example, over 87% of polled engineering faculty report that they use lecture as their sole or primary instructional method.[5]

Active learning has been shown,[6,7] to improve functional understanding and retention of physical concepts, but since most engineers are not taught this way, we need to learn how to do it before it can be incorporated into our own teaching. Important aspects of engineering such as problem solving and creativity can be better fostered through active learning than by passive listening to lectures. To make active learning more accessible for engineering educators, we need to forge links between the extensive research on active learning and practical implementation of active learning methods. Personal experience indicates that engineering instructors find specific engineering examples of active learning most useful for understanding and implementing active learning in their own courses. Engineering-specific examples of active learning in classroom contexts are not easy to find. However, experienced professors provide a rich source of examples.

III. Faculty Interviews

In this section, we describe the process of data collection from different engineering and computer science faculty members at three different types of institutions: a large research

university, a small religiously affiliated liberal arts college, and a small women's liberal arts college. One of the goals for interviewing faculty members from many different disciplines was to learn about the varying culture across engineering fields. This aids communication and teamwork in smaller schools with fewer faculty or broader departments (e.g., joint physics and electrical engineering departments). Examples and ideas accumulated through these interviews were used in the graduate course.

At the beginning of their faculty careers, new professors typically develop courses with the help of sample syllabi, notes, and texts from previous offerings of the course. Many new faculty would also like to investigate alternative teaching methods to ensure that the curriculum is actually learned by their students effectively. While many graduate students have experience working with a variety of courses and associated material, they are generally less familiar with a wide range of teaching methodologies. Talking with professors, both new and experienced, about how they made the transition from graduate school to a teaching position and about their "best practices" in the classroom, provides graduate students with guidance on the transition and eases the task of developing their own teaching style and philosophy. Faculty were interviewed at two stages in this project: 1) prior to the course (to gather active learning examples) and 2) during the course, by students, to encourage conversation between graduate students and faculty about teaching. During the first stage, faculty with a wide range of experiences were interviewed individually by one person. During the course, each student interviewed a faculty member "whose teaching they admired." This also resulted in interviews with a range of faculty and the collective wisdom was shared via discussion in class.

The following questions guided the first author (Bates) in her development of the faculty survey questionnaire:

What can I learn from faculty?
How can I get faculty to articulate useful information?
How can I standardize vocabulary?
How can I encourage faculty to talk about active learning if they do not think about it in those terms?

The resulting interview questions were:

a) What is your biggest challenge in your classes?
b) What are the biggest challenges facing your students in the courses you teach?
c) What do you do to meet the challenges and help your students meet them?
d) In your large lecture courses (N>50), what do you find most useful for engaging students?
e) Is this different from what you would do in a smaller course?
f) What do you see as your responsibilities in your classes?
g) What are your expectations of students in your classes (i.e., their responsibilities)?
h) How do they know these?
i) How do you help students achieve these expectations?

Faculty who teach large courses at the University of Washington were invited to participate in the interview process. They were told it would take at least 30 minutes for the questions. While it was possible to ask and answer the questions in this time frame, many of the interviews took closer to 60 minutes and some took as long as two hours. Many experienced faculty were very willing to talk about their difficulties with teaching as well as their experiences addressing them.

Many faculty members had found solutions over the course of many terms through trial and error. They also felt that knowing more at the beginning of their careers could have helped them avoid frustration and prevented the need for a lot of trials. It was less easy talking with junior faculty who were experiencing difficulty teaching. They were often reluctant to be interviewed or even to talk about their experiences casually. This may be because the interviewer was a graduate student or it may be because of discomfort with the topic. Ongoing research at the Center for Engineering Learning and Teaching (CELT) and the newly funded NSF Center for the Advancement of Engineering Education will provide additional insight on engineering teaching concerns.[8]

The information gathered in the interviews was used to inform the selection of course topics as well as for the compilation of examples presented in class meetings. The model of interviewing faculty by graduate students is also a way to insure conversations about teaching with potential mentors.

IV. The Course: Active Learning in Engineering Education

IV.a. Course Logistics

The graduate course was offered as a two-credit class, meeting for two hours once a week for an academic quarter (ten weeks). The course website is:

http://ssli.ee.washington.edu/courses/GRDSCH630.html.[9]

Materials described in this paper are available from the site. Participating students were self-selected, interested in the topic, and motivated to learn based on their future goals. All students had some sort of teaching experience as graduate teaching assistants or lecturers. While it could have been presented as a four-credit course, the decision to limit the credits was made in consideration of the limitations of graduate student schedules and pressure to focus on their dissertation research. In addition, other PFF courses offered at the University of Washington are also 2-credit courses. Ultimately, the particular graduate students who registered for the course would have been interested in a course that met twice per week. End-of-term student evaluations stated a desire for more time to discuss course material.

IV.b. Course Development

Before putting together the course topics, the course goals were developed. While the original intent was to teach about active learning, good teaching practices in general also informed the content since this would be the first exposure to education ideas for some of the students. Many of the course topics fell outside of the active learning definition but were considered important for meeting the goals of providing a vocabulary for talking about education and creating a culture where talking about teaching is common practice. Active learning was used throughout the course to provide situations where the participants could experience learning in ways that may be unfamiliar. The intention of the course and each of the classes was made transparent to the class so that students would be able to identify their own learning and progress. The following goals statement was included on the syllabus and discussed the first day of class.

> Course Goal: This course introduces graduate students with some teaching experience to education theory and methods. It is hoped that students will be able to use their own

experience to come to a deeper understanding of teaching methods introduced in the course. Students who complete this course should expect to:

1) develop a greater awareness of teaching as a learned, and improvable, activity;
2) learn about available teaching resources;
3) be exposed to different teaching methods, including knowledge of the vocabulary used in engineering education research literature;
4) experience learning about engineering in an active learning environment;
5) prepare engineering material for their own students using different teaching methods.

Topics included: an Introduction covering active learning and the course goals, Student Learning, Talking about Teaching, Active Learning, Using Technology in Teaching, Classroom Assessment Techniques and Group Learning. The class concluded with a session to plan active learning modules and two sessions to present the modules to the class. Thus, every student participated in the development, implementation and learning stages of a learning activity. Guest lecturers were used frequently to build familiarity with campus resources and to help students build a network of contacts for education information.

The order of the classes was obvious in some cases, such as the introduction and discussion of student learning, but less so for some intermediate topics. For example, the Classroom Assessment Techniques, Group Learning, and Active Learning sessions could have been presented in almost any order. The order used made sense for the guest lecturers and material covered in this class. (The class schedule with associated readings and assignments is attached as Appendix A and is also available at the course website.) Whenever possible, the use of active learning was highlighted for teaching by using active learning in this class. Many of the techniques described in the classes or readings such as small group work, two-minute reflection papers, think-pair-share, and brainstorming were implemented in the course. (Further information on these techniques can be found in Angelo and Cross (1993),[10] Lymna (1981)[11] and various weblinks[6,12] as well as the links presented in Appendix A.)

IV.c. Class Meeting Details and Student Feedback

This section contains detailed information about each course meeting, including the class topic, activities and feedback. Throughout the course, active learning methods were used to illustrate the particular topic. Unattributed quotes in this section all come from written feedback from various students in the course.

1. Introduction

In this class, we discussed definitions of active learning to insure that all class members had a similar starting point, as well as to expand the idea of learning for students who may not have been thinking about it in the terms used in this class. We used the syllabus for this course to talk about the creation of student-centered syllabi. While the goals developed for the class were presented, no objectives were presented. This allowed for discussion of the differences between goals (course expectations) and objectives (measurable student behaviors). The students in the class worked in small groups to develop lists of possible objectives. Some of the objectives were incorporated into the class syllabus, although this had to be balanced with the fact that it was only a two-credit course. The entire set of objectives is available online.[13] During the first class, the students were told about a "hidden agenda": the students should learn to be focused on

students and students learning the content rather than on the content itself. Another ideal was to provide a foundation for a habit of being reflective about their teaching, i.e., critiquing rather than criticizing. To this end, every class ended with five minutes spent answering the questions "What went well?" and "What could be better?" about the class (as feedback to the instructor) and also about their own participation in the class (as self-reflection). In a sense, all of the explicit goals have this underlying agenda. Student feedback will be discussed further below.

2. Student Learning

After the concept of ABET (Accreditation Board for Engineering and Technology) learning outcomes was presented, and connected with the idea of measurable course objectives, most of the class was a presentation by Dr. Cindy Atman and Dr. Jennifer Turns. They discussed ways to put into practice some of the ideas from the wide range of research on learning, and addressed the question of how we can actually design activities that do what we want. Showing students how to connect research with practice will allow them to continue to improve their teaching throughout their careers. The students were very interested in the material, and this topic was one of the most praised in the class. When developing a similar class, if engineering education researchers are not available as guest speakers, there are useful sources of information for showing the connections between research and practice.[14,15]

3. Talking about Teaching

During this class, information about the broad range of student learning styles was presented along with information about how to teach to reach as many learning styles as possible. Student preparation included taking a learning style inventory and reading about learning styles, as well as reading about mentoring, and how mentors differ from advisors. Given this information about students, the next step was to see how faculty perceived their students and thought about their own teaching. The primary questions asked in this class were:

What can we learn from faculty?
What questions can we ask as graduate students about teaching?

Two separate interview results were presented from the earlier portion of this work to spark discussion about what kinds of answers are elicited by different types of questions. The students then worked in small groups to generate lists of questions for experienced faculty members. As a large group, the questions were narrowed down to a representative sample that could be used by all members of the class for interviewing one faculty member. The final questions selected by the class were:

1) How did you become interested in teaching?
2) Tell me about your students.
3) How do you engage students?
4) How do you figure out what concepts are troubling for students and what concepts they understand?
5) How do you prepare to teach a class for the first time?
6) What resources do you draw upon when teaching a class for the first time? What kind of support is there for your teaching within the department, college, and university?

In this class, students were reminded that they cannot change their personality and that will affect how they teach. Students were told to think about their best learning experiences to remind themselves which aspects of teaching were key. If the most important thing is that

students were engaged, then it is important to figure out how we as teachers can engage students in learning. Class members reported on the results of their interviews in the next class.

4. Active Learning
This session was facilitated by Linse and involved a general discussion of the research supporting active learning. A few of the students were skeptical, as are many faculty. Additional questions revolved around how to balance the additional class time that activities require with the curricular expectations that certain material will be "covered" in required courses. Students were provided with a variety of materials that ranged from simple, short term activities to activities that would last an entire class session. These materials were provided to guide students' future adoption and adaptation of various active learning strategies for engineering courses. Discussion was lively as class members discussed techniques they had tried or experienced and were given advice about how to deal with troublesome situations that may arise in class.

5. Using Technology in Teaching
This class was taught by a substitute guest lecturer who had not been fully briefed on the composition of the class or its objectives. A lot of time was spent on introductions to specific technologies available at the University of Washington. It was most useful for students who were not aware of available resources. These students gave positive feedback for this session and easily made connections with how the technology could be used in classes to promote discussion, increase student access to course staff or make additional resources available. For students who were already aware, "it would have been better to have a really brief intro to the tools and then have a discussion of how to use this technology - when are online tools appropriate and helpful, how can we best make use of them in the kinds of classes we're likely to teach, etc."

6. Classroom Assessment Techniques (CATs)
This session was led by Wayne Jacobson of the Center for Instructional Development and Research at the University of Washington. Discussion focused on the connection between assessment tools and learning tools. Because the class had been writing two-minute papers at the end of every class, they were familiar with one type of classroom assessment. The readings and discussions generated other ideas. Student experience with different types of CATs was used to disseminate information about implementation pros and cons. This discussion showed how good learning is often related to the experiences brought into the classroom by students. The fact that several course members had used CATs in their graduate student teaching improved the discussion in the class and provided examples of peer-to-peer teaching for the students.

7. Group Learning
The key concept presented in this lecture is that independence and interdependence are essential to functioning groups. Group work can be very helpful to learning but it is not necessarily easy to set up groups so that they function. First, it is important to make sure that group work is appropriate for meeting the course objectives. Next, the question of how to set up functioning groups can be addressed. Typical complaints about group learning are that some people do not do their full share of work or that a single person controls all aspects of the work. An exercise

to help students define what ground rules should be used in group work was presented in this class (and could be used in any class with group work). Students brainstormed to identify "good" behaviors and to think of ways of heading off "bad" behaviors in groups. This class was preceded by observation of a sophomore-level mechanics course that had a combination of term-long groups for homework discussion and lab work. There were three two-hour classes available for observation and the 12 students in the active learning course went to different sections. We were able to watch effective learning in group situations. In the class feedback, some students saw the class as being disorganized and chaotic but it was also clear that the class was learning, engaged, and interested in the material. One student felt this class showed "that a great amount of thought and creativity can go into some of the most disorganized looking class time."

8. Active Learning Module Planning (1 session) and Presentation (2 sessions)
In developing the modules, course participants were asked to prepare a module that would take no more than 20 minutes of class time, allowing for 10 minutes of feedback. Each facilitator presented information about who their students would be (year, level of experience with topic) so that the other members could step into the appropriate student role. For most students in the course, this was the most useful in-class exercise for their learning, partly because of its culminating role in their own learning about education. The experience of conceiving, planning, and implementing the modules, coupled with the experience of active participation, helped the students connect the information presented in the course with how it can actually be used in an engineering classroom. It should be noted that not all of the modules worked well. Analyzing what went wrong was equally useful for the students since it prompted discussion about how to do things better the next time. Students also developed a better feel for how much preparation it takes to do different types of active learning in the classroom.

IV.d. Student Feedback

Performing student evaluations (or two-minute papers) during every class may be too much for a typical undergraduate class. But in this course, where there were typically no writing assignments outside of class and where there was an underlying goal of encouraging reflection about teaching, this feedback was useful for both the students and the instructor. After the final meeting, students were asked to respond to a final evaluation that helped them inventory and reflect on their learning over the course of the quarter. The questions used were based on a final exam question used for student self-evaluation of learning developed by Jennifer Turns. The questions used in this course are included in Appendix B. They can be extended for other types of engineering and computer science courses so that students can identify their own learning while letting the instructor know in a detailed fashion what works well in a course.

One of the key results from the evaluations for this course is that coursework could easily be extended by facilitating more discussion. This may be due in part to the self-selection of students (i.e., interested and motivated in learning about education). Common student feedback was that more discussion time would have been beneficial for getting a deeper understanding of the topics. It would be relatively easy to extend the course with an extra discussion meeting each week. This would be treated as unstructured time in which students could explore material in greater depth and discuss its implications, rather than being led in a particular direction by

having a set agenda for each discussion meeting. Additionally, more time could be spent exploring current research to build experience connecting available research findings with teaching practice.

V. Example Active Learning Modules Developed by Students

The following is a list of some of the modules developed by students in the course. The planning of these modules typically took less than 5 hours.

- Role-playing to learn about transportation safety. Roles included: urban planner, bicyclists, drivers, environmentalists, construction contractors and historians, with the "teacher" playing the expert role of transportation engineer. While senior design students may practice their skills on this type of problem, role-playing will allow them to stretch their imaginations about broader aspects of the problems they will need to solve. Role-playing with this type of problem will allow first and second year students to think about what types of tools they may need in order to solve a particular problem. This type of problem solving may also capture the imaginations of students and become motivational as students progress through an engineering program. This type of activity could be used to structure course sections as well as a stand-alone activity. More time to "play" may have a stronger impact on student learning.
- Illustration of free body diagrams. Students feel or see how the forces actually work between connected masses; in teams of three, one person labels with post-it notes all the possible forces on two people holding a rope. This is useful for first year physics students or mechanics students and results in a great deal of discussion about possible forces among the participants. The ability to both feel the forces and see their labels should deepen student connections with the material.
- The Monty Hall problem: Students gain a better understanding of Bayes' and Total Probability Theorems by proving that one should always change doors if a "wrong" door is revealed. Repetitive flipping of a coin to generate the outcomes can also lead to a new appreciation for the use of probability functions rather than physical testing of all outcomes. The audience for this would be students in a first probability class, which could include any level of undergraduate student.
- Acting out of network routers. Imagine sending a novel from an island to your publisher and you can only write on postcards. How do the postcards get from the island to the publisher? How do they get composed into a novel? What if a natural disaster or computer failure changes the route? How is redundancy built into the system? Students act as routers connected by string and pass index cards from one location to another. This example would be useful in for an introductory computer science or computer science literacy course.

The class participants played all student roles and in many cases, learned about an aspect of engineering that was unfamiliar to them. However, because students were thinking about learning differently, they were able to do meta-cognition about their own learning process and notice when the activities were useful or confusing, and whether the activities fulfilled the learning objective or not.

VI. Conclusions

The short-term success of the course, measured in positive feedback and continuing discussion of teaching methods as seen in both email and casual conversations between the students, shows that peer-training of graduate students is a viable option for increasing the amount of teaching development in engineering graduate education. One of the benefits of this course for the students was that it encouraged discussions across engineering disciplines, making it possible to see how what is useful in mechanical engineering may also be useful in electrical engineering. While experienced faculty were very willing to talk about teaching and their struggles, some newer professors found it difficult to express their struggles. This may also mean that it is difficult for them to ask for help in their teaching. By creating a culture where talking about teaching is common and where engineering educators can ask for help, through classes like this one, it is our hope that junior faculty (as well as senior faculty) will be on a path where they can continually improve their teaching. We believe this course, focused on engineering education, will help address this issue.

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References

1. *Huckabay Teaching Fellowships*, 4 February 2003, University of Washington, 22 March 2003 <http://www.grad.washington.edu/pff/huckabay.htm>.
2. C.C. Bonwell and J.A. Eison. *Active Learning: Creating Excitement in the Classroom.* ASHE-ERIC Higher Education Reports. Washington, DC: School of Education and Human Development, George Washington University, 1991.
3. *The Web Site for the Preparing Future Faculty Program*, Preparing Future Faculty National Office, 22 March 2003, <http://www.preparing-faculty.org/PFFWeb.Contents.htm>.
4. *Preparing Future Faculty*, 16 August 2002, University of Washington, 22 March 2003, <http://www.grad.washington.edu/pff/pff.htm>.
5. Staff of the U.S. Department of Education. Section V: The Context of Postsecondary Education. In *The Condition of Education 2001*, NCES 2001072, pp. 74-84, National Center for Education Statistics, U.S. Department of Education, Washington, DC, 2001.
6. K. Smith, *Resources for Cooperative Learning*, University of Minnesota, 22 March 2003, <http://www.ce.umn.edu/~smith/>.
7. R.M. Felder, D.R. Woods, J.E. Stice, and A. Rugarcia, "The Future of Engineering Education II. Teaching Methods that Work." *Chem. Engr. Education,* 34(1), 26-39, 2000.
8. The Teaching Challenges of Engineering Faculty: Insights from a Model Instructional Development Program (National Science Foundation grant EEP-0211774), Center for the Advancement of Engineering Education (ESI-0227558), PI: C. Atman.

9. R. Bates, *Active Learning in Engineering Education Course Website*, 26 May 2002, University of Washington, 22 March 2003, <http://ssli.ee.washington.edu/courses/GRDSCH630.html>.
10. T. Angelo and K. Cross, *Classroom Assessment Techniques: A Handbook for College Teachers*, (2nd Ed) San Francisco: Jossey-Bass, 1993.
11. F. Lymna, "The Responsive Classroom Discussion." In A.S. Anderson, (Ed.), *Mainstreaming Digest*, College Park, MD: University of Maryland College of Education, 1981.
12. A. Ellis, *et al*., *Doing Collaborative Learning*, 1 November 1997, National Institute for Science Education, 22 March 2003, <http://www.wcer.wisc.edu/nise/CL1/CL/doingcl/DCL1.asp>.
13. R. Bates, *Active Learning in Engineering Education Course Website: Objectives,* 3 April 2002, University of Washington, 22 March 2003, <http://ssli.ee.washington.edu/courses/grdsch630/objectives.html>.
14. K.M. Bursic and C.J. Atman, "Information Gathering: A Critical Step for Quality in the Design Process," *Quality Management Journal*, vol. 4, no. 4, pp. 60-75, 1997.
15. J. Turns, C.J. Atman, and R. Adams, "Concept Maps for Engineering Education: A Cognitively Motivated Tool Supporting Varied Assessment Functions," *IEEE Transactions on Education*, Special Issue on Assessment, May 2000.

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Appendix A: Class Schedule

This is the annotated class schedule. Each week includes assignments and readings for the following week. It can be found online at http://ssli.ee.washington.edu/courses/grdsch630/class-sched.html.

Week 1: Introduction
- Class introductions
- Discussion of active learning definition
- Discussion of syllabi: Goals vs objectives

Assignment: Post to E-Post (a web-based discussion center at the University of Washington).
Readings: CIDR's inclusive teaching web site (http://depts.washington.edu/cidrweb/inclusive/).
How People Learn: Bridging Research and Practice, Ch. 2, (pp. 10-24), National Research Council (http://books.nap.edu/html/howpeople2/ch2.html).

Week 2: Student Learning
- ABET Learning Outcomes
- Data on learning: How can research on engineering students help in designing teaching activities?

Guest Speakers: Cindy Atman, Director, CELT, Jennifer Turns, Asst. Prof, Technical Communication
Assignment: Take learning style inventory on web and email scores to instructor. We will look at the

aggregate class information. Felder's Learning Style Inventory (http://www2.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/ilsweb.html)
Readings on mentoring:

- CIDR Mentoring Bulletin (http://depts.washington.edu/cidrweb/TLBulletins/4(4)Mentoring.html)
- "Guidelines for Good Practice in Graduate Education," University of Washington.
- Mentoring notes and resources from Angela Linse. See course webpage for links.

Readings on learning styles:

- "Descriptions of the Learning Styles" (http://www2.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/styles.htm)
- "Reaching the Second Tier: Learning and Teaching Styles in College Science Education" (http://www2.ncsu.edu/unity/lockers/users/f/felder/public/Papers/Secondtier.html)

Week 3: Talking about Teaching

- What can we learn from faculty? What questions can we ask as graduate students about teaching?
- Create a list of questions to get faculty to describe how they teach.

Assignment: Ask one faculty member whose teaching you admire the questions your group designed.
Readings & Handouts: CIDR's Active Learning links (http://depts.washington.edu/cidrweb/AltTools.htm)
3 Handouts: Teaching Strategies, Active Learning Guidelines, Interactive Learning Strategies available by June 2003 through a link on the CELT website http://depts.washington.edu/celtweb/ under Teaching.

Week 4: Active Learning

- Report on Faculty Q & As.
- Active learning techniques: Evidence for, experience doing.

Guest Speaker: Angela Linse, Faculty Consultant, CELT
Readings: Catalyst web site (http://catalyst.washington.edu/).
Focus on the teaching/integrating technology pages (http://catalyst.washington.edu/method)

Week 5: Using Technology

- Meet at CTLT Center, 2nd Floor, Odegaard Undergraduate Library
- Technology in teaching: not just classroom uses

Guest Speaker: Mark Farrelly, Outreach and Special Projects Coordinator, CTLT
Readings: Explore the CIDR Classroom Assessment Techniques webpage (http://depts.washington.edu/cidrweb/CATools.htm). Focus on "Do you know where your students are?" (http://ctl.stanford.edu/teach/speak/stwin93.pdf).
Speaking of Teaching, 4(2), from the Center for Teaching and Learning at Stanford University

Week 6: Classroom Assessment Techniques

- The connection between assessment tools and learning tools

Guest Speaker: Wayne Jacobson, Associate Director, CIDR
Readings: Spend one hour exploring the Active/Cooperative Learning: Best Practices in Engineering Education website (http://clte.asu.edu/active/). As a resource, you may want to explore: "Active Learning: Cooperation in the College Classroom," by Johnson, Johnson & Smith, available at the CIDR library. Some of the information from this book is online. For example, you may find "Basic Elements of Cooperative Learning" (http://clte.asu.edu/active/Artc2_PDFs/BasElemCoopTms.pdf) useful.

Week 7: Group Learning

- How to set up groups so they work.

- How to know when group work is appropriate.
- Activity: Talk about group experiences, how could the TA/professor have made things better?
- Course case study: CEE 220, EE 215

Assignment: Think of how the techniques discussed in class could apply in your own field.

Week 8: Active Learning Module Planning
- Build teams and ideas for activities/reports

Week 9: Active Learning Module Presentation
- TA Reports/Activities

Week 10: Active Learning Module Presentation
- TA Reports/Activities
- Wrap-up: What we have learned.

Appendix B: Final Evaluation Questions

Self Evaluation of Learning

The aim of this exam question is to get you to reflect on (and document) your learning in this course. Specifically, the question asks you to identify courses activities that contributed to your learning in specific ways. Each of your responses should clearly indicate:

Choice: The course activity (e.g., the citation for the reading, a short description of the design exercise, etc.) that you have chosen as contributing to your learning in the specific way indicated, and

Explanation: An explanation of your choice (e.g., How does your choice fulfill the criteria? Why did the activity work as it did for you? What features of the choice are relevant? What was the significance of the activity for you personally?).

The Context: GRDSCH 630 has been designed to introduce education theory and methods to you given the context of your own experience in the classroom. Students who complete this course should expect to have:

1. Developed a greater awareness of teaching as a learned, and improvable, activity.
2. Learned about available teaching resources.
3. Been exposed to different teaching methods, including knowledge of the vocabulary used in engineering education research literature;
4. Experienced learning about engineering in an active learning environment;
5. Prepared engineering material for their own students using different teaching methods.

As a student in the course, you engaged in a number of course activities chosen to promote your learning in the above areas: These activities included readings (e.g., website pubs, journal articles, etc.), class exercises (e.g., designing course objectives,), class project activities (e.g., do your own project, participate in others projects) and class discussion exercises (e.g., active learning and classroom assessment discussions).

The Prompts: To complete this reflection, please identify a specific course activity that meets each of the criteria below (a total of 10 activity choices). In your responses, document your choice and provide an explanation for your choice (as described above):

1. The in-class exercise through which you learned the most
2. The in-class exercise through which you learned the least
3. The in-class exercise through which you found to be the most rewarding
4. The out-of-class activity or reading through which you learned the most
5. The out-of-class activity or reading through which you learned the least
6. The course activity (generally) that most contributed to your achievement on course goal 1
7. The course activity (generally) that most contributed to your achievement on course goal 2
8. The course activity (generally) that most contributed to your achievement on course goal 3
9. The course activity (generally) that most contributed to your achievement on course goal 4
10. The course activity (generally) that most contributed to your achievement on course goal 5

Notes: There are no right or wrong responses to this part of the exam. However, there are both well-explained and poorly-explained responses. To achieve full credit, your responses need to be well explained. Also, your complete response to this reflection should be no longer than 2 single spaced pages.

Question: Are you satisfied with your initial definition of active learning? If not, how would you change it? (Feel free to post your response to Epost.)