Promoting Pedagogical Innovation in the School of Electrical and Computer Engineering

Cordelia Brown, Mark C. Johnson, Joanne Lax
School of Electrical and Computer Engineering
Purdue University, West Lafayette, IN 47907

Introduction

In recent years the demand for advancement in the practice of engineering education has been growing tremendously for all manner of institutions. This demand is coming from many directions. A number of agencies, corporations, and foundations with an interest in engineering education has provided funding, disseminated documents, and offered recommendations. The National Science Foundation has placed a strong emphasis on having educational components integrated into the research proposals it receives. The National Academy of Engineering has published several documents with recommendations about attributes of the future engineer and educating the future engineer[1,2]. The Accreditation Board of Engineering and Technology, through EC2000, mandates that undergraduate engineering programs demonstrate that their students have a certain skill set through an outcomes-based assessment[3]. Many corporations, such as Hewlett-Packard, also have offered grant opportunities to engineering educators to focus on evolving instructional innovations. All of these incentives are causing institutions to look for ways to meet the demand for instructional innovation.

Several models exist for integrating educational innovations into traditional engineering disciplines in universities. To facilitate the integration, there are some colleges or schools of engineering which have pioneered efforts to lead this effort, as well as to address other pressing needs in engineering education. One of the earliest models involved the creation of research centers that focus on engineering education within a traditional engineering discipline, such as Vanderbilt University's National Science Foundation-sponsored research center, VaNTH, founded in 1999 to focus on bioengineering education[4]. Later models established independent entities for engineering education. As examples, Purdue University created a School of Engineering Education (ENE)[5] in 2004, Virginia Tech created a Department of Engineering Education[6] lemson University started its Department of Engineering and Science Education[7] in 2006, and Utah State established its Department of Engineering and Technology Education[8]. Finally, Purdue's School of Electrical and Computer Engineering (ECE) has used a slightly different model in forming an internal committee, the Instructional Innovation Group (EI2G)[9], which focuses on innovations in engineering education specifically in ECE, and also creating an education research area within the School.

There are valid reasons for ECE's decision to establish the EI2G. First, ECE has a large number of full-time faculty (approximately 86) covering nine research areas, from Automatic Control to VLSI and Circuit Design. Moreover, faculty offices are spread throughout several buildings on Purdue's sprawling campus, including the newest building, the Birck Nanotechnology Center, which is nearly a mile from the main office building. Thus, despite the easy access to all sorts of electronic communication, faculty members in different research areas rarely have the

opportunity to discover the types of educational innovations their colleagues may be implementing in their courses. For an academically and spatially dispersed faculty, the monthly EI2G meetings provide a central forum for faculty with a common interest in education.

Implementation of EI2G

When the last ECE head joined Purdue in 2003, he sought to advance pedagogy within ECE and encourage faculty and staff take a leadership role in ECE education nationally. An important step in reaching this goal was the formation of the EI2G. During the fall of 2004, a group of faculty and staff was organized and recruited to achieve this purpose. On December 1, 2004, the first meeting of EI2G took place, attended by ten ECE faculty and administrators, in which participants outlined their teaching interests and discussed what they would like to see ECE accomplish in the areas of pedagogy and applications of instructional technology. In the next meeting, EI2G outlined actions to take: 1. explore, implement, and assess the use of personal response units; 2. implement and test online outcome testing; 3. get ECE to mandate WebCT (course management system) training for teaching assistants; and 4. initiate collaborations with the School of Engineering Education. Out of this list, the second and third actions were not pursued, but numbers one and four become two signature areas for EI2G, as will be reported in the next section.

Membership in EI2G is entirely voluntary, but over the past four years, the participation level in meetings has remained at approximately ten to twelve people. The core group includes two undergraduate laboratory coordinators, the technical communications specialist, the head of ECE, two faculty on joint appointment between ECE and ENE, the director of the ECE undergraduate advising office, and a mix of faculty ranging from young assistant professors to well established faculty who have taught for thirty to forty years. In addition to the core group, there are faculty in both ECE and ENE who periodically collaborate with members on EI2G-related projects.

EI2G has grown to fill several roles within ECE, including the following:

- Bringing in guest speakers to ECE to discuss instructional innovations.
- Incorporating instructional innovations into ECE classrooms.
- Collecting and publishing data on instructional practices in ECE.
- Interviewing candidates for joint faculty positions in ECE and ENE.
- Giving input to ECE administration and other committees on instructional issues, in particular the most recent ECE strategic plan.
- Providing a venue for faculty and instructional staff to learn of each other's efforts in teaching.
- Disseminating information about educational grants and conferences.

The most visible function within ECE is the organization and conduct of workshops on pedagogy and instructional technology as part of the annual ECE faculty retreat in August. Sessions have included a workshop by a professor in the School of Chemical Engineering on active learning and community building in the classroom, presentations by ECE faculty regarding their own experiences with best and worst instructional practices, discussion of possible plans for the hiring of instructional faculty, and collection of data from ECE faculty regarding their own instructional practices.

One of the most positive influences on ECE has resulted from interviewing and hiring recommendations for joint appointments in ECE and ENE. In 2005 and again in 2008, EI2G was instrumental in hiring two faculty members with joint appointments. In addition to these more visible roles in ECE, an important function of EI2G is to provide a place for faculty and staff with a special interest in instructional innovation to learn about each other's work and trigger collaborations within ECE. This, together with the hiring of ECE/ENE joint faculty, has led to some very productive collaborations on instructional innovation reported in the next section of the paper.

Perhaps the least visible but most consistent function of EI2G has been in providing a venue for faculty and staff to learn from each other and from invited speakers about instructional methods, innovations, and technologies. The group meets monthly throughout the academic year and on an as-needed basis during summers. Typical meetings last 90 minutes, with the first 30 minutes allocated to business and eating, and the remainder to a presentation and discussion. During the past four years, speakers have come from throughout the university and beyond, including the Department of Biological Sciences, the Discovery Learning Center, the School of Engineering Education, non-EI2G faculty within ECE, EI2G members, and commercial instructional technology vendors. Most of the speakers have been suggested by EI2G members who were aware of the formers' work in educational innovation. Often, these presentations have sparked discussions that led to ideas for other speakers or collaborative work within and outside the group, just a few of which are reported in the Results section.

Results

In this section, we highlight several projects that demonstrate the spirit which characterizes the openness and collaborative nature of the group. The EI2G website provides a more complete picture of the group's projects and publications[9].

Directed Problem Solving (DPS)[10]

Students enrolled in a number of Computer Engineering courses are presented with several of innovative education options. One option in the Introduction to Digital System Design course offers students a choice of course format: the Directed Problem Solving (DPS) division or the traditional division. Since students can select the course format that best fits their learning style preferences, they are asked to take the Index of Learning Styles Inventory (ILS) on the first day of class. From the ILS tool, professors make recommendations to students about which division may be more effective according to the latters' learning style preferences. The course formats are the inverse of one another. In the DPS division, students are expected to view the lecture online before participating in problem-solving sessions in class. In the traditional division, students attend a live lecture and do practice problems outside of class. Data have been collected on the effectiveness of each format since fall 2005[10,11]. Personal Response Units ("clickers") are used to engage students, and to present formative feedback for the student and the instructor[12]. Data suggest that there are no significant differences in student performance in either division. Further exploration is planned to examine the effects of learning styles on course format. DPS and its faculty implementers were awarded the Electrical and Computer Department Heads Association (ECEDHA) 2008 Innovative Program Award and the Purdue University Class of 1922 "Helping Students Learn Award" for 2008. These faculty members also have been awarded two Purdue University "Teaching and Learning with Technology" grants in 2006 and 2008.

Tablet PCs for Senior Design Notebook Capture

A collaboration of EI2G members resulted in grant of 21 tablet PCs from Hewlett-Packard in 2007 for the purpose of design notebook capture in the digital systems senior project course. One or two tablet PCs have been made available to each design team. Design notebook evaluations from before and after the grant have continued been collected as well as surveys of students regarding their use of the tablet PCs. Before the tablet PCs arrived, students had been keeping design notebook data online, but this process generally required the students be at a networked computer to post the data. The use of non-tablet PCs also did not facilitate capture of hand-drawn notes or illustrations. Preliminary results were reported based on data collected through January 2008. There was not a clear improvement in design notebook quality, but curiously the change coincided with an improvement in overall achievement on project outcomes[13]. The tablets were used extensively to run design and development software, enabling students who did not own laptops to complete work in a wider range of locations. An aspect of this project that has not yet been implemented is the use of commercial design notebook capture software to produce electronic design notebooks that qualify as legal documentation.

Educational Technology Use Survey

Another EI2G group member collaboration produced a paper addressing the use of educational technology in ECE[14]. The motivation for the paper was the authors' observation that few professors seemed to adopt new educational technologies introduced at various faculty meetings over the past few years. They thus developed a survey to determine which technologies the ECE faculty used and why they did not use others. The survey, administered at a faculty meeting, looked at participant demographics as well as usage. Not surprisingly, PowerPoint was the most-used classroom technology, and, interestingly enough, its non-users tended to be the newest faculty members. In response to an open-ended question concerning possible reasons for not using various classroom technologies, comments fell into five major categories: 1) questions about the educational benefits of technology, 2) prohibitive learning and preparation time, 3) insufficient technical support, 4) the limitations of currently available technology, and 5) the limitations of classroom facilities. These results were presented as a work-in-progress paper at the 2007 Frontiers in Education Conference.

Interactive Online Learning Tool

"Rhea"[15] is the name for an enhanced Wiki environment one ECE professor/occasional EI2G participant has implemented to encourage her students to collaborate on course materials and making connections across courses. This multidimensional learning tool is entirely student-driven, with written comments, data, links, and graphs added by student contributors. After the professor and one of her students demonstrated Rhea to EI2G, group members were so excited with the educational possibilities offered by this Wiki that they asked the professor to demonstrate it again for the benefit of the entire faculty at the 2008 faculty retreat. This semester, in continuing the evolution of Rhea, the professor is helping another EI2G member start her own Rhea for the latter's academic writing course for international graduate students in ECE. The intent is to provide a space for these students to communicate between class sessions, to discuss their concerns about any aspects of their research and writing process, and tap into each other's areas of expertise. During the current semester, a total of seven other ECE courses

and four math courses are using Rhea in their courses, and the faculty member eventually hopes to expand the tool to courses throughout the university. Recently, the project garnered funding from Motorola to equip a lab for its sole use. More complete information about Rhea can be found at its website.

Future Work

Much of the work of EI2G described previously is ongoing, but there also are projects and issues on the horizon. In recent months, group members have identified a need to increase the internal and external recognition of student work within ECE. To this end, we propose to promote and facilitate the development by students of online portfolios of their work. This is not a novel idea in academia, but it is something that has not been practiced on a consistent basis within ECE. At the same time, we want to complement the student efforts with an effort by ECE to feature student work in a variety of ways, including the use of the departmental web site. The best student portfolios, projects, awards, and other noteworthy achievements will be nominated on a recurring basis and selected for recognition.

A frequent source of opportunities for EI2G is in the area of faculty education related to changes in the academic environment, both locally and internationally. For example, Purdue University has instituted a new online system for grade submission which enables plus/minus grading. While the concept of plus/minus grading is not difficult, the impact on grade distribution and student performance is not immediately obvious. One EI2G member has already collected data and has offered to present the data and recommendations to faculty during a faculty meeting. Another change that has been building for several years is a rising awareness of the need to educate students in professional and non-technical skills, such as those identified in the book *Engineer of 2020*[1] and in ABET accreditation criteria[3]. Many faculty do not have experience with making such skills an explicit part of their teaching to be assessed along with technical skills. Thus, this is an opportunity for EI2G to advise faculty and guide them to resources that will be helpful in integrating these skills into their course curriculum.

Conclusion

Having committed people involved is the reason for EI2G's success. That EI2G exists and thrives is due to the unwavering support of ECE's head and his appointment of a very motivated person to spearhead efficient steward of the group. The school head has unfailingly allocated a precious commodity—time--during faculty meetings and annual retreats to give EI2G opportunities to present educational innovations from which the entire faculty could benefit. In addition, in June 2008, "Education" formally became the latest ECE technical area in response to the School's interest in education, demonstrated by strategic planning discussions and the hiring of joint faculty positions with the School of Engineering Education.

Clearly, the diversity of the group members and their common interest in lifelong learning for themselves and enhancing the educational experience of their students has given the group its momentum. A number of award-winning teachers at various stages of their careers are regular group members, and the number of professional papers in the area of engineering education written by group members has increased over the past several years. Given the confluence of the recent national swell of interest in undergraduate engineering education and their own personal

interest, these individuals likely would have contributed to the field through their classroom practices and professional papers without EI2G. However, perhaps EI2G has helped to sustain or rekindle this interest in some of the more established faculty members and foster it in newer ones.

References

1. "Engineer of 2020", National Academy of Engineering, National Academies Press, Washington, D. C., 2004.
2. "Educating the Engineer of 2020", National Academy of Engineering, National Academies Press, Washington, D. C., 2005.
3. ABET website: http://www.abet.org/. Last accessed on January 22, 2009.
4. Vanderbilt-Northwestern-Texas-Harvard/MIT (VANTH) website: http://www.vanth.org/. Last accessed on January 22, 2009.
5. Purdue University School of Engineering Education website: https://engineering.purdue.edu/ENE/. Last accessed on January 22, 2009.
6. Virginia Polytechnic Institute and State University Department of Engineering Education website: http://www.enge.vt.edu/index.html. Last accessed on January 22, 2009.
7. Clemson University Department of Engineering and Science Education website: http://www.clemson.edu/ese/news/071507.php. Last accessed on January 22, 2009.
8. Utah State University Department of Engineering and Technology Education website: http://www.neng.usu.edu/ete/about.htm. Last accessed on January 22, 2009.
9. EI2G website: https://engineering.purdue.edu/ECE/EI2G. Last accessed on January 22, 2009.
10. C. M. Brown and D. G. Meyer, "Experimental Hybrid Courses That Combine On-Line Content Delivery with Face-to-Face Collaborative Problem Solving, Proceedings of the 2007 American Society for Engineering Education Conference, June 2007.
11. C. M. Brown, Y.-H. Lu, D. G. Meyer, and M. C. Johnson, "Hybrid Content Delivery: On-Line Lectures and Interactive Lab Assignments", Proceedings of the 2008 American Society for Engineering Education Conference, June 2008.
12. C. M. Brown, M. F. Cox, N. Kohli, and D. G. Meyer, "Integrating Feedback Technology into the Electrical and Computer Engineering Classroom". Proceedings of the 2006 American Society for Engineering Education Conference, June 2006.
13. D. G. Meyer, M. C. Johnson, and C. M. Brown, "Tablets for Timely Design Documentation", Proceedings of the 2008 American Society for Engineering Education Conference, June 2008.
14. C. Brown, M. Johnson, and J. Lax, "Educational Classroom Technology: What Works Best in the Engineering Context", Frontiers in Education Conference, v. 2007, p. S4J-18 - S4J-19.
15. Rhea website: http://kiwi.ecn.purdue.edu/index.php/Main_Page. Last accessed on January 23, 2009.

Bibliographical Information

Dr. Cordelia Brown (brown83@ecn.purdue.edu) is an Assistant Professor in the School of Electrical and Computer Engineering (ECE) and the School of Engineering Education (ENE) at Purdue University. Her research interests are digital design, learning styles, cooperative learning, active learning, instructional innovation, and recruitment and retention issues. Currently, she teaches a sophomore level Digital Design course and directs an e-Mentoring program. She is a member of IEEE, ASEE, NSBE, and SWE.

Dr. Mark C. Johnson (mcjohnso@ecn.purdue.edu) is the Lab Manager for Digital and Systems Laboratories in the School of Electrical and Computer Engineering (ECE) at Purdue University. In 1998, Dr. Johnson completed the Ph.D. degree from the Purdue University School of ECE. Engineering ECE). He currently supervises several computer engineering laboratory courses and co-advises Digital Systems Senior Design projects. Dr. Johnson is the chair of the EI2G and served as general chair of the 2007 International Conference on Microelectronic Systems Education.

Joanne Lax (jlax@ecn.purdue.edu) is the communications specialist for the School of Electrical and Computer Engineering (ECE) at Purdue University. Ms. Lax holds master's degrees in English as a Second Language and Journalism from Purdue University and Northwestern University, respectively. She teaches courses in academic written and oral communication for international graduate students in ECE.

The authors are member of the ECE Instructional Innovation Group (EI2G) at Purdue University. EI2G was formed in 2004 by interested faculty and staff of the School of Electrical and Computer Engineering and the Department of Engineering Education of Purdue University to implement, encourage, promote visibility, and verify the effectiveness of instructional innovations in Electrical and Computer Engineering education. For more information, see https://engineering.purdue.edu/ECE/EI2G.