



# Georgia Institute of Technology®

Office of the Provost and Executive Vice President for Academic Affairs

January 20, 2016

Dear Members of the Board of Regents Awards Committee,

It is my distinct pleasure to support the nomination of Professor Bonnie Ferri for the Regents' Scholarship of Teaching and Learning Award. Dr. Ferri, Professor and Associate Chair for Undergraduate Affairs in the School of Electrical and Computer Engineering (ECE), is a strong candidate for this award, and it is my pleasure to introduce her to you.

A member of the faculty at Georgia Tech since 1988, Dr. Ferri is a leader in educational innovation and research in engineering education. Her commitment to improving student learning by better engaging students in the classroom through technology-enhanced pedagogical techniques has earned her numerous local and national teaching awards. Her educational innovations are grounded in her interest in a) understanding the impact of educational interventions on student interest, confidence, and retention of the knowledge, and b) using engineering design principles to develop appropriate learning analytics to inform course development, modification, and improvement.

Her course and pedagogical innovations have influenced faculty throughout the College of Engineering and Georgia Tech as a whole. Through the establishment of a Teaching Fellows program in ECE, faculty development workshop presentations and mentoring activities, Dr. Ferri is a driver of pedagogical and curricular innovations at Georgia Tech. Starting in 2016, she will also serve as Co-Chair of the Provost's "Creating the Next in Education" Taskforce. In this role, she will have the opportunity to further influence the ways in which Georgia Tech students are educated, now and in the future.

Her commitment to improving student learning through curricular and pedagogical innovations is grounded in both learning sciences literature and her own scholarship of teaching and learning research. She has published the results of her studies, and has used her expertise in this area to influence learning and pedagogical approaches throughout her department, and increasingly within other programs at Georgia Tech. For these reasons, I believe Professor Bonnie Ferri to be a worthy recipient of the Regents' Scholarship of Teaching & Learning Award.

Sincerely,

A handwritten signature in black ink, appearing to read "Rafael Bras".

Rafael Bras  
Provost and Executive Vice President for Academic Affairs

Rafael L. Bras  
Provost and Executive Vice President for Academic Affairs  
225 North Avenue, NW  
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## Scholarship in Teaching and Learning Narrative

**Teaching Philosophy:** Over the last fifteen years, Dr. Bonnie Ferri has been doing research in technology-enabled engineering education with the goal of improving learning by engaging students in the classroom. She has written a junior-level textbook with online interactive exercises, developed two Massive Open Online Courses (MOOCs) that she uses to flip (or blend) courses, created a set of portable hands-on experiments that are integrated into lecture-based courses throughout the Electrical and Computer Engineering (ECE) curriculum at Georgia Tech, and developed an engineering approach to continuous course improvement through feedback of course analytics.

The beginning of that fifteen-year time period marks the start of a gradual change in her teaching style from a traditional lecturer to one that introduced two to three hands-on experiments into her courses each term, to one that is completely blended/flipped with seven to nine hands-on labs in the courses and two MOOCs providing the online lecture and homework content. Positive responses from the students encouraged the steady progression into a more active and engaged learning environment for students, facilitated by technology-enabled education. Her innovations in education are based on research and advances in learning theory along with an engineering approach to technology and course improvement. Her overarching motivation in introducing technology into the classroom is not “What can you do with it?” rather “What should you do with it?”, the former being technology and instructor driven while the latter is student learner driven. The narrative below contains the motivation and overview of her scholarship in teaching and learning, a review of the learning theory on which she bases her work, a description of the approaches for two specific research projects, and her quantitative results showing the success of her work in improving student knowledge, confidence, and retention of knowledge.

**Motivation and Overview:** Laboratory experiments form one of the foundational experiences for all engineering students, giving them an opportunity to learn through observation, to examine the accuracy of theoretical models, and to develop skills of value in engineering industries (Feisel and Rosa, 2005; Koretsky, et al., 2011). However, one of the drawbacks of physical experiments is the increasing complexity and expense of laboratory equipment used in order to give students a taste of the current state-of-the-art in industry. These experiments are typically housed in centralized labs for which undergraduate students have limited access. Due to advances in technology, especially low-cost portable data acquisition devices, laptop computers, and affordable sensors, there is an unprecedented opportunity to bring hands-on experiments out of the centralized labs. In particular, Dr. Ferri used these technologies to devise a myriad of hands-on experiments that are well-suited for inclusion into lecture-based classes to be done at the desks in the class room or to be taken home as a project, so that students can do them *anytime anywhere*. These types of experiments allow for a new pedagogical model that promotes for more complete integration of theory and laboratory experience within the format of a standard lecture-based course.

Dr. Ferri has been the project director of two NSF grants to develop and validate low-cost, highly-flexible, mobile, hands-on experimental platforms and procedures that allow instructors to link theory and practice in lecture-based classes through demonstration and hands-on lab experiences. She is the director of the TESSAL Center that has developed a cohesive program to integrate these experiments across several courses within the School of Electrical and Computer Engineering at Georgia Tech. Due mainly to her efforts, six ECE courses have changed their syllabi to require students to do hands-on experiments and projects using student-owned devices. This means that all sections and all instructors of those courses now incorporate hands-on learning into the courses.

The scale of these efforts has grown tremendously over the years, starting from the year 2005 with approximately 200 students and increasing to the current total of approximately 3000 students per year (as measured by total enrollment in these courses). This scale reflects the overall impact on the Georgia Tech student body.

The desire to bring experiments into the classroom motivated her to expand her efforts towards more technology-enabled learning by developing two MOOCs that she uses to flip (or blend) two high-enrollment circuits courses. One course, the circuits and electronics course for non-majors, was especially problematic because it needed to accommodate 400-500 students per semester, spread over 9 to 11 sections. Due to the sheer number of instructors needed, instruction was accomplished through use of graduate students, with a high degree of variability in teaching experience and/or aptitude. This led to a highly inconsistent delivery of the course, which was a foundational course to a significant number of engineering students. The circuits class taught to electrical and computer engineering majors also suffered from inconsistency due to the large number of sections and instructors involved. She incorporated the pedagogical principles from (Ambrose, 2010) in developing the revised course materials, including videos, in-video pop-up quizzes, online automatically graded homework problems, discussion forums, and lab materials. Now, students watch the video lectures online before class and then spend class time working collaboratively on worksheets, doing experiments, or hearing mini-lectures that give depth on the more difficult concepts or more detailed examples. Over 100,000 people have enrolled in her public offerings of the MOOCs, and 500-700 students per term use the materials in on-campus circuits courses.



Figure 1: Students enjoy hands-on learning in a GT ECE classroom. [Video of this class showing the engaged student environments.](#)

The main **research questions** that she has addressed in her NSF-sponsored research studies are:

- What is the impact of the mobile hands-on experiments on student performance, on student interest and confidence in the subject matter, and on long-term retention of the knowledge?
- To what extent can the blended classroom model be improved by using an engineering design approach that adapts the mix of in-class activities and online resources by feeding back data from course analytics?

***Related Work in Learning Theory:*** In STEM education, proponents of reform generally agree that hands-on work and problem-solving activities promote critical thinking, collaboration, communication, and creativity. Students who are taught with methodology grounded in active learning, cooperative learning, inquiry learning, problem-based learning, and just-in-time teaching are found to be more engaged with the course material, instructor, and/or peers (Smith, et al., 2005). The instructional model of flipping (or blending) a course requires students to prepare prior to class, typically watching online video lectures, in order to free up face-to-face (F2F) classroom time for the higher-level thinking activities.

There has been considerable research on the development and efficacy of blended classes. A recent survey by Zhao and Breslow (2013) contained a summary of 42 studies using blended/flipped courses. Although the subject matter and settings varied, many of the studies showed statistically significant improvement in learning for blended/flipped classes vs classes that were either entirely F2F or online. Another relevant review article was recently presented by Bishop and Verleger

(2013). Citing 83 references plus another 38 online sources, the authors list many perceived advantages of flipped classes, including the ability to combine learning theories that are quite different; namely active, problem-based learning, and instructional lectures based on behaviorist principles. A good overview of developments of flipped or blended learning in engineering courses may be found in (Velegol, et al., 2015).

Dr. Ferri believes that the effectiveness of flipped or blended classes is dependent on the quality of experiences that are substituted for traditional in-class lectures. One such activity is to introduce substantive laboratory experiences into a classroom environment, where the activity is “hands-on”, that is, the students actually build devices and/or run experiments themselves. Her research has shown that authentic, hands-on lab activities are very effective in improving student learning and retention of knowledge. Well-designed hands-on experiments may be more advantageous for learning than other forms of active learning because, by its very nature, it involves sight, sound, and touch.

***Mobile Hands-On Learning Research Approach:*** It might be expected that hands-on experiences will always outperform traditional or passive learning methods. Unfortunately, the benefits of hands-on learning are not always realized due to poorly designed experiments (Hofstein and Lunetta, 2004; Abdulwahed and Nagy, 2009; Koretsky, et al., 2011). Hands-on activities that are done with reflection and metacognition create a deeper understanding (Hofstein and Lunetta, 2004). Pre-labs and other types of preparation are also important as identified in Kolb’s experiential learning cycle (Abdulwahed and Nagy, 2009). Shavelson, et al. (2005) refer to four different types of knowledge: declarative knowledge (“knowing that”), procedural knowledge (“knowing how”), schematic knowledge (“knowing why”), and strategic knowledge (“knowing when, where, and how our knowledge applies”). This framework guides Dr. Ferri’s design of laboratory experiences; what is typically termed “inquiry based laboratory exercises,” are ones that reach the higher levels of the knowledge taxonomy (Koretsky, et al., 2011).

In developing the mobile hands-on labs for in-class administration, Dr. Ferri decided upon some experiment design criteria that are based partly on logistics and partly on using the results of learning theory on laboratory experiences discussed above. The goal is to make the most impact on learning in the course while satisfying practical considerations of time and space in a classroom. The labs are developed to meet the following conditions:

- target concepts that are hard to understand by theory alone
- be well integrated with the theory taught in the class
- have a low learning curve for both instructors and students
- be doable in a 50 minute lecture period (by most students)
- be low cost for students to purchase or for the school to buy enough for a class
- provide scaffolding for students who are novices to the equipment and procedures (Shavelson, 2005)
- require students to relate theory to experiments (Feisel and Rosa, 2005)
- have build, test, troubleshoot, analyze, and exploration activities, and when possible, design activities (Feisel and Rosa, 2005)
- have reflection components (Hofstein and Lunetta, 2004)
- have a prelab for preparation, including analytical analysis (Abdulwahed and Nagy, 2009)

The lecture-based courses in the School of Electrical and Computer Engineering at Georgia Tech that incorporate Dr. Ferri’s developed labs are ECE2020 *Fundamentals of Digital Design*;

ECE2040 *Circuits*; ECE3084 *Signals and Systems*; and ECE3710 *Circuits and Electronics*. Prior to the recent curriculum revision in 2012, ECE3085 *Systems and Controls* also used the laboratories. The experiments have been used by 40-50 faculty members within the School of ECE when they have taught these courses. These efforts are documented in (Ferri, et al, 2011; Droge, et al., 2012; Ferri and Auerbach, 2012; Ferri and Ferri, 2014; Ferri, et al., 2014; Ferri, et al., 2016). In addition, this same model of mobile hands-on learning was used to design two portable experiments for use in a mechanical engineering class, ME2202 *Dynamics*, and Dr. Ferri assisted in designing those experiments using the same criteria described above.

**Technology-Enabled Course Improvement:** The inclusion of videos in ECE 3710 provided a new opportunity to free-up class time for a variety of in-class activities including mini-lectures, worksheets, experiments, problem-solving sessions, and other forms of active/collaborative learning. At the same time, the Coursera learning management system made it possible to gather unprecedented amounts of data on student usage and performance. The advent of course analytics allows for a much-finer adaptation of the course format and resources than has been previously possible with, for example, end-of-term course surveys. In ECE 3710, Dr. Ferri developed a systematic, engineering approach to adapt her course in order to improve consistency and quality. The approach uses the formalism of feedback control. A simple example of a feedback control system is room temperature controlled via a thermostat. In this simple example, the user specifies a “set point” or desired temperature state. When the temperature is lower than the set point, the heater is engaged until the room temperature equals the desired temperature. When the room temperature is higher than the set point, the heater is turned off (or an air conditioner can be engaged if faster response is desired). The general framework requiring a feedback mechanism for engineering curricula/program improvement is part of the engineering accreditation process (ABET), and the importance of feedback for improved learning in an individual student is well known (Ambrose, 2010). Here, the novelty is using a more sophisticated feedback control structure and a larger set of measurements in order to make finer-grain adaptations in the course. The general flow structure of the feedback mechanism is shown in Figure 2, along with the measurements used and the course adjustments made.

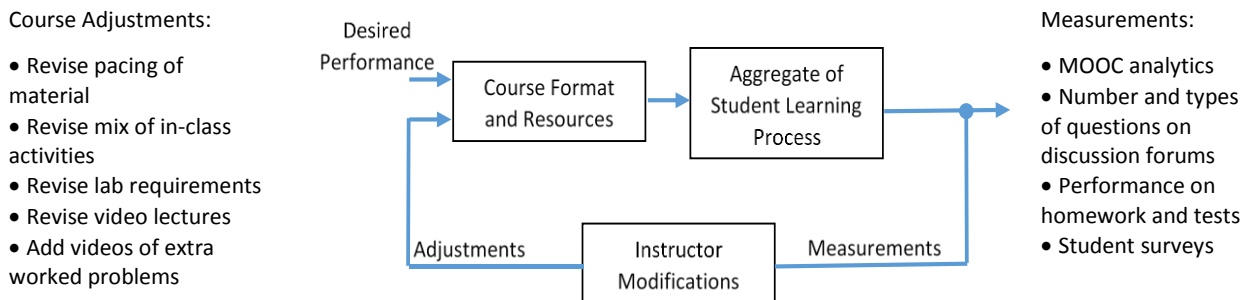


Figure 2: Engineering-based iterative course improvement process, feeding back analytics to adjust course format and resources.

The goals of the course adaptation process developed for ECE3710 were to meet satisfactory performance metrics while gaining consistency across sections and course topics, reducing DFW rates to acceptable ranges, and tracking the desired student workload of 6 hours/week (appropriate to a two-credit hour course). Tracking of student workload is important in this process since it relates to the efficiency of learning. If aggregate student performance (across all sections in a semester) remains constant while the average student workload decreases, then the learning

process has become more efficient. One of the course adjustments was to determine the course topics that were “easy” for students and those that were “difficult” through measurements taken by an analysis of the discussion forums, performance on specific homework problems, and viewer statistics of the related lecture videos. Topics that were “easy” were reduced in coverage the following term (fewer class periods, reduction of in-class activities devoted to those topics) while the topics that were “difficult” were expanded in coverage.

**DATA AND EVIDENCE OF IMPACT OF THE RESEARCH ON LEARNING**

Both quantitative and qualitative data were gathered to understand and evaluate the utility of the broad-based inclusion of portable laboratories into lecture-based courses in terms of increased student interest and increased student performance. The results very strongly demonstrated the success of the approach in improving student interest and student achievement.

In one course, ECE3085 *Introduction to Systems and Controls*, a lecture-based junior-level course, students in one section of the course had two in-class experiments and one take-home design project. Students in the control group, another section taught by the same instructor, had no experiments and worked more problems instead. The assessment included pre- and post-surveys, a longitudinal study with a survey taken one semester after the course ended, and a concept inventory test taken at the beginning and at the end of the course. The controls concept inventory (CCI) test was designed using concept questions from validated tests (Wage, et al., 2005) augmented with basic control system concept questions selected by a consensus of four instructors (three of which were not using the experiments in the course). The CCI data was analyzed by looking at the average change in the test scores from the test taken at the beginning of the term to the scores from the same test taken at the end of the term, specifically looking at the five questions that related directly to concepts covered in the labs. For those five questions, the change in test scores for the experimental class was +41.7% (N=30 students) while the change in test scores on those same questions for the control group class was +22.3% (N=28 students) indicating that the experiments had a definite positive impact on student learning of those concepts.

A survey taken one semester after the course ended revealed an increase in student interest in the topic and an increase in the students’ perception of their own mastery of the material for the experimental group when compared to the control group. On this survey, we investigated long term retention of knowledge by giving students a list of fundamental topics in the course and asking them to rate their level of understanding, with the aggregate results displayed in Table 1. The difference in numbers for the first two topic categories, which might be considered control group topics, were not significant between the two classes. However, for the category of topics related to the experiments, there were significantly higher number of students in the experimental class who felt that they had a “solid understanding” of the material compared to those in the control group class (Droge et al., 2012).

Table 1: Survey Taken One Semester After the Course Ended. Percentage of Students That Rated “Solid Understanding” for Topics Covered in the Course.

	Control Group Class N=28	Experimental Class N=30
Topics Covered in Other Required Classes	71%	69%
Topics Not Covered in the Experiments	40	43
Topics Covered in the Experiments	26	48

In another set of courses, ECE2040 *Circuits* and ECE3710 *Circuits and Electronics*, the experiments were inserted into about 20% of the class periods. The hypothesis of this study was that student performance is enhanced by the use of hands-on labs in the face-to-face portion of a blended class. Also of interest is how the magnitude of gains in performance differs with respect to students of different overall achievement levels and how the confidence levels of students in subject topics is impacted by the labs. The structure of the study, reported in (Ferri, et al., 2016) uses a quasi-experimental design predicated upon both quantitative and qualitative methodologies. A total of 741 students participated in the study, 389 in the fall semester of 2013 and 352 in the fall semester of 2014. In each case, students were distributed across nine sections of the *Circuits and Electronics* course each taught by a different instructor. Overall, participants in each term of the course completed two midterms, a final exam, 6 laboratory activity worksheets, and homework problems. The fall 2013 study used regression analysis to show that the lab grades were a predictor of how students did on a Circuits Concept Inventory test that was created by Evans (2013).

In order to assess different aspects of performance in the fall 2014 study, the final exam was designed to include ten multiple choice/short answer questions: four questions on concepts related to the experiments, Qe, four questions on concepts not related to the experiments, Qc, and two questions that were on higher level thinking, Qh. The Qc questions can be viewed as a control group. All questions were graded on a scale of 0-2. How students did on the Qe questions relative to the Qc questions can be examined from the ratio Qe/Qc, where a score greater than 1 means that they did better on Qe. The questions were reviewed by three professors who normally teach circuits courses at Georgia Tech, two of whom are not associated with this particular course. Efforts were made so that the questions had the same level of difficulty, and inherent bias in the questions was mitigated by examining trends in Qe/Qc ratios for different levels of performers in the class rather than focusing solely on the raw scores.

The table below shows the analysis of how students performed on these Qe and Qc questions. In order to see if there was a pattern of student performance on Qe versus Qc questions relative to overall performance on this part of the exam, the students were split into groups according to the score on the multiple choice/short answer: 0-5, 6-10, etc. Table 2 displays the number of students in each group along with the mean Qc and Qe scores in each group. The ratio of the mean Qe to Qc scores for each group indicates how much better students did on the Qe questions versus the Qc questions. For example, students who scored 16-20 on that part of the test did 7.9% better on the Qe questions than the Qc questions.

Table 2: Mean Qc and Qe scores versus overall scores.

N	Overall Score	Mean Qc	Mean Qe	$\frac{\text{MeanQe}}{\text{MeanQc}}$	p-value
48	16-20	6.604	7.125	1.079	0.041
151	11-15	4.781	5.755	1.204	<0.001
120	6-10	3.217	3.583	1.114	0.083
33	0-5	1.364	1.273	0.933	0.739*

\* not statistically significant

The results indicate that the top three groups of students (that is, all students who were above 9 percentile) performed statistically better on basic concept questions that relate to labs versus basic

concept questions that do not relate to labs- the gains were 8% to 21% better for these student populations. The same trends were seen when analyzed by gender.

Also, a comparison of student pre- and post-survey results indicate that students had higher gains in confidence levels for concepts that were covered by the labs versus concepts that were not covered by the labs. Students in the 20 to 52 percentile range of overall course grades showed the highest difference in gains (28% increase in confidence level, pre to post, for concepts related to the experiments versus 13% gain for concepts not related to the experiments) (Ferri, et al., 2016).

Over a seven semester period, there is strong evidence of improvement in student learning and in course effectiveness for ECE 3710. The improvements can be traced to Dr. Ferri’s feedback strategy discussed above. As mentioned previously, the goal was to deliver a consistent, high-quality course across all sections. The tests and homework were common among all sections and were of consistent difficulty across all semesters. The tests were taken in the evening during a common test period. The trends over a six semester window, starting from the term after the initial pilot offering, are shown in the figures below. This provides evidence that the engineering design process for course adaptation met the desired goals: the student performance levels remained in acceptable ranges each term while the DFW rate dropped and the student workload trended towards the desired value of 6 hours/week. The only anomaly in the data was Fall 2014 (Semester 4) in which there was a very large percent of novice instructors.

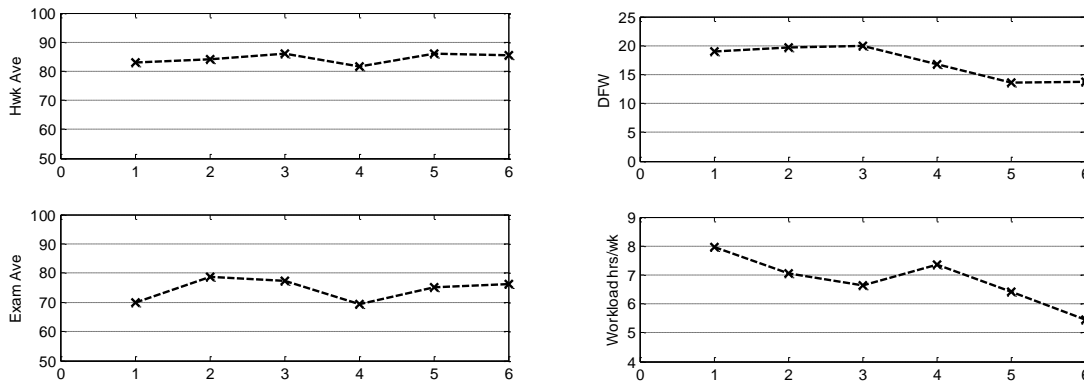


Figure 3: Trends over six semesters of ECE3710. N ranged from 130 during the summer semesters (semesters 3 and 6) to 450 during the Fall/Spring semesters (1,2,4,5). Term 0 was the pilot offering.

As further evidence that the adaptation methodology was successful, Dr. Ferri studied the student confidence levels on individual course topics over the entire semester. Because of the refinement in the duration of study on each topic, she was able to achieve a nearly uniform level of learning throughout the semester (Ferri, et al., 2015). In contrast, courses taught in a traditional manner show confidence levels that drop precipitously over the last few weeks of the course where instructors often find that they increase their pace near the end of the term as they find themselves running out of time.

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**Curriculum Vitae**  
**Bonnie H. Ferri**  
**Professor and Associate Chair for Undergraduate Affairs**  
**School of Electrical and Computer Engineering**  
**Georgia Institute of Technology**

**EDUCATION**

<u>Degree</u>	<u>Year</u>	<u>University</u>	<u>Field</u>
PhD	1988	Georgia Institute of Technology	Electrical Engineering
MS	1984	Princeton University	Mechanical and Aerospace Engineering
BS	1981	University of Notre Dame	Electrical Engineering

**EMPLOYMENT**

<u>Title</u>	<u>Organization</u>	<u>Years</u>
Associate Chair for Undergraduate Affairs	Georgia Institute of Technology	Jan. 2013 - present
Associate Chair for Graduate Affairs	Georgia Institute of Technology	July 2006 – Dec. 2012
Professor	Georgia Institute of Technology	Sept. 2002 - present
Associate Professor	Georgia Institute of Technology	Sept. 1995 – Sept. 2002
Assistant Professor	Georgia Institute of Technology	Sept. 1988 – Sept. 1988
Graduate Research Assistant	Georgia Institute of Technology	Sept. 1985 – Sept. 1988
Engineer	Honeywell, Inc.	August 1983 - June 1985
Graduate Research Assistant	Princeton University	July 1981 - July 1983

**ADMINISTRATIVE DUTIES**

**Associate Chair for Graduate Affairs:**

- In charge of the largest graduate program in ECE in the United States with over 1200 students; 425-450 degrees conferred each year.

**Associate Chair for Undergraduate Affairs:**

- In charge of one of the largest undergraduate programs in ECE in the United States with over 1600 students; 300-330 degrees conferred each year.

**SUMMARY OF TEACHING AND EDUCATIONAL ACTIVITIES**

**Individual Student Advisement**

- 16 PhD students; 12 MS special problems students; 23 undergraduate research and special problems students

**Innovation in Teaching and Learning**

- Mobile Hands-On Learning: Development of a curriculum model where inexpensive, portable student-owned experimental platforms are used throughout the ECE curricula especially in lecture-based courses where the material might otherwise be abstract. Over 1300 students per semester are impacted by this program.
- Revision of the circuits courses to be taught in a flipped/blended method with the use of MOOCs and in-class hands-on experiments. Between 1200-1400 students per year take the courses in this format. Five ECE faculty have taught the course this way.
- Developed (or co-developed) six ECE courses

- Development of two Coursera MOOCs: Linear Circuits and Introduction to Electronics. Over 100,000 people have enrolled in the courses to date.
- ECE MakerSpace: Instrumental in the establishment of an ECE makerspace especially with regard to student involvement; faculty advisor of the new student organization that will run the space; development of a course that teaches skills needed to use the space effectively

### **Professional Society Contributions**

- Chair of Technical Committee on Education, IEEE Control Systems Society (CSS); organization of numerous special sessions on control education at conferences
- Co-organizer of a series of NSF workshops on Mobile Hands-On Learning, 2012-2016
- Co-organized a workshop on flipped and blended classes at the ECE Department Heads Association meeting (ECEDHA), March 2015; invited presentation on innovative education methods at the Southeastern ECEDHA meeting, November 2015.
- Editor Duties: Associate Editor of two journals including the *IEEE Transactions on Education*; Guest Editor (and Associate Editor) for two special issues on controls education

### **Georgia Tech Institute-Wide Activities**

- Chair of two campus-wide task forces commissioned by the Provost's Office: "Creating the Next in Education Task Force" and the "GT1000 Review Task Force"
- Presentations on educational research and innovative classroom instruction given at numerous events across Georgia Tech including those hosted by the School of ECE, School of Mechanical Engineering, Center for Teaching and Learning, Center for the 21<sup>st</sup> Century Universities, and American Society for Engineering Education Georgia Tech Chapter

### **Grants and Contracts on Education**

Dr. Ferri has been the PI on two educational grants from NSF totaling \$675k, and the co-PI on two more educational grants (one from NSF and one from Department of Education) totaling \$1.73M, and a senior participant on an education and outreach grant from DARPA of \$991k.

### **HONORS AND AWARDS**

- National Academy of Engineering Frontiers on Engineering Education Symposia, invited speaker, 2014
- National Instruments Excellence in Education Award, 2014
- Georgia Tech Faculty: Outstanding Use of Innovative Education Technology Award, 2012
- Georgia Tech Women in Engineering Excellence in Teaching Award, 2012
- Harriet B. Rigas Award from the IEEE Education Society, 2007
- Georgia Tech ECE Faculty Outreach Award, 2006
- Women of Distinction Faculty Award, 2005, from the Women's Leadership Conference
- Georgia Tech Women In Engineering Excellence Faculty Mentoring Award, 2005.
- *IEEE Control System Magazine* Outstanding Paper Award, 2004.
- Notre Dame Women's Achievement Award, 1996
- Junior Faculty Teaching Excellence Award, 1991, from CETL and the Amoco Foundation
- Eta Kappa Nu Outstanding Teacher Award, 1991 (selected by the EE senior class)
- NSF Presidential Young Investigator Award, 1990

### **PUBLICATIONS**

Dr. (Heck) Ferri has co-authored the textbook below and written chapters in six other books. She has 161 published articles and presentations including 21 articles on research in engineering education, some of which are given below.

1. E.W. Kamen and B.S. Heck., *Fundamentals of Signals and Systems with MATLAB and the Web*, 3rd Ed., Prentice Hall, 2006.
2. S.E. Poindexter and B.S. Heck, "Using the Web in Your Courses: What Can You Do? What Should You Do?" *IEEE Controls Systems Magazine*, vol.19, no.1, Feb. 1999, p.83-92.
3. B.S. Heck, M. Shor, and J. Wadpole, "Education that Integrates Computer Science and Control Engineering," *Proceedings IEEE Conf. on Decision and Control*, Vol. 3, Dec. 2003, pp. 3005 – 3010.
4. B. S. Heck, N.S. Clements, and A.A. Ferri, "A LEGO Experiment for Embedded Control System Design," *IEEE Control Systems Magazine*, vol. 24, no. 5, October 2004.
5. B.H. Ferri, A. Ahmed, J. Michaels, E. Dean, C. Garvet, S. Shearman, "Signal Processing Experiments With LEGO MINDSTORMS NXT Kit for Use in Signals and Systems Courses," *Proc. of the American Control Conference*, St. Louis, pp. 3787-3792., June 2009.
6. J. Auerbach and B. Ferri, "Work in Progress - The Costs and Benefits of Using Alternative Approaches in Lecture-Based Courses: Experience in Electrical Engineering," *2010 IEEE Frontiers in Education Conference*, Washington,, DC, October 2010, p.2 pp. 2010.
7. B. Ferri, J. Auerbach, J. Michaels, and D, Williams, "TESSAL: A Program for Incorporating Experiments into Lecture-Based Courses within the ECE Curriculum," *ASEE Annual Conference and Exposition*, Vancouver, Canada, June 2011.
8. G. Droge, B. Ferri, and O. Chiu, "Distributed Laboratories: Control System Experiments with LabVIEW and the LEGO NXT Platform," *ASEE Annual Conf. and Exp.*, San Antonio, June 2012.
9. B. Ferri, J. Auerbach, "A Portable Finite State Machine Module Experiment for In-Class Use in Lecture-Based Course," *ASEE Annual Conf. and Exposition*, San Antonio, June 2012.
10. K.A. Connor, B. Ferri, and K. Meehan, "Models of Mobile Hands-On STEM," *ASEE Annual Conference and Exposition*, Atlanta, June 23-26, 2013, paper 7484.
11. Y. Astatke, M.F. Chouikha, K.A. Connor, A.A. Ferri, B.H. Ferri, K. Meehan, D.L. Newman, M.M. Deyoe, D.J. Walter, "Models of adoption and best practices for mobile hands-on learning in electrical engineering," *IEEE Frontiers in Education Conference*, p 511-13, 2013.
12. A. Ferri, and B. Ferri, "Simple Guitar String System for Teaching Fundamental Concepts in a Variety of ECE and ME Courses," *American Control Conference*, Portland, OR, June 2014, paper THB05.2
13. A. Lanterman, M. Giardino, B. Ferri, J. Michaels, W. Hunt, and A. Ferri, "Embedding Low-Cost, Portable Experiments into a Lecture-Based Signals and Systems Course," *American Control Conference*, Portland, OR, June 2014, paper THB05.3.
14. B. Ferri, D. Majerich, N. Parrish, and A. Ferri, "Use of a MOOC Platform to Blend a Linear Circuits Course for Non-Majors," *ASEE Annual Conf. and Exp.*, Indianapolis, IN, June, 2014, paper 10217.
15. B. Ferri, W. Newstetter, D. Majerich, "Instructor and Graduate Teaching Assistant Development and Training for a Blended Linear Circuits and Electronics Course," *IEEE Frontiers in Education*, Oct. 2015, El Paso, TX.
16. B. Ferri, J. Harris, M.A. Weitnauer, D. Majerich, "A Feedback-Based Approach for Evolving a Blended Class Model for Large Enrollment, Multiple Section Circuits Courses," *IEEE Frontiers in Education*, Oct. 2015, El Paso, TX.
17. B. Ferri, A. Ferri, D. Majerich, and A. Madden, "Effects of In-class Hands-On Laboratories in a Large Enrollment, Multiple Section Blended Linear Circuits Course" accepted in *ASEE Journal on Advances in Engineering Education*.

January 12, 2016

Esteemed Awards Committee:

It is my great pleasure to offer enthusiastic support for the nomination of Dr. Bonnie Ferri for the Regents' Scholarship of Teaching and Learning Award. Over the past three years, in my position as the Director of Educational Research and Innovation in the College of Engineering, I have come to know Dr. Ferri as a campus leader in classroom innovation and evaluation. In this leadership role, she has been a pioneer in creating and using novel portable laboratories in ECE classrooms, in creating a MOOC for use in her introductory ECE course for non-majors, and in optimizing the design of flipped and blended classrooms. Her initial classrooms experiments to enhance lectures with more interactive activities were supported through a NSF CCLI grant to use portable, low-cost experiment modules in traditional lecture based classes. As stated in one of her papers on this experiment, she wanted students to “become active learners”. Ancillary to this goal was making it possible to infuse a lecture with elements of a laboratory when a lab was not available, an infusion that could be essential for students who benefit from more kinesthetic forms of learning. The success of this experiment both in terms of student feedback but also in regard to mastery of concepts led her to find ways to make the students more active in their learning.

In 2013, she took a leadership role as the champion for a MOOC innovation hub devoted to developing a better understanding of flipped and blended classrooms at GT (See Daily Digest 5/27/2013). Soon after, working with the Center for the 21<sup>st</sup> century University (C21U), Dr. Ferri designed and created a MOOC for a Linear Circuits course with the intent of achieving greater consistency across the many sections of the course while supporting more collaborative, active learning for many more students. By providing on-line MOOC lectures, the classroom could now be used for more collaborative, interactive activities and would address the lament of faculty that there was no time to cover the material and do classroom activities. Most recently, Dr Ferri has developed the ECE Teaching Fellows Program recently completing its second term, modeled after the very successful unit-based faculty development program in mechanical engineering. At the request of the Provost, Dr. Ferri will co-chair *Creating the Next in Education* taskforce at Georgia Tech that is convening this month to explore future models for higher education and the role of technology.

All of her classrooms and educational leadership activities derive from Dr. Ferri's commitment to designing and delivering quality learning environments that are stimulating, supportive and effective. Unlike most faculty who are satisfied when they



have engaged, successful students, Dr. Ferri takes the next step in actually validating her educational innovation through scholarship. In addition to her technical conferences, Dr Ferri is a regular contributor to the American Association of Engineering Educators Conference and The Frontiers in Education conference, both gathering places for engineering faculty engaged in educational research. I have found her to be eager to develop a deeper understanding of learning theory as well as cognitive science to better inform her classroom interventions. She is very deserving of this prestigious Regent's recognition, so I offer my highest recommendation.

Sincerely,

A handwritten signature in cursive script, reading "Wendy C. Newstetter".

Wendy C. Newstetter PhD  
Director of Educational Research and Innovation

January 11, 2016

Dear Members of the Board of Regents Awards Committee,

I am pleased to give my utmost support to the nomination of Prof. Bonnie Ferri for the **Regents' Scholarship of Teaching and Learning Award**. Dr. Bonnie Ferri is Professor and Associate Chair for Undergraduate Affairs in the School of Electrical and Computer Engineering (ECE) at Georgia Tech. She has revolutionized our engineering curriculum by pioneering mobile hands-on learning in conjunction with novel flipped and blended classroom techniques that are continually adapted and improved based on course analytics. Her innovations reach far beyond Georgia Tech to impact engineering education on an international scale. She has conducted NSF-sponsored workshops at the premier engineering education conferences, devised and shared best practices at numerous cross-disciplinary events, and published her work on student learning, strategies, and results in the top conferences and journals in the field of engineering education.

Dr. Ferri has been leading the effort to transform engineering education in two key ways. She has introduced inexpensive, portable hands-on experiments throughout courses in ECE, including core lecture-based courses that traditionally had no laboratory component. She has also redesigned the core circuits courses to use innovative flipped and blended classroom techniques driven by course analytics, dramatically improving student engagement and performance as well as consistency in coverage and quality across multiple sections of the course. This is all the more remarkable given that these courses have large enrollments, and Dr. Ferri has demonstrated success with these innovations in courses for ECE majors and non-majors alike.

**Innovative portable experimental platforms:** Dr. Ferri is at the forefront of a new pedagogical movement in engineering education in which inexpensive, portable experiments are placed in the hands of students to allow them to perform laboratory exercises at home or in class rather than in traditional, large, and costly centralized laboratories. This exploits the latest in embedded and sensor technology to make hands-on, practical experience ubiquitous throughout the curriculum. Through an NSF grant, she created the TESSAL (Teaching Enhancement through Small-Scale Affordable Labs) Center to develop and integrate these portable experiments across the ECE curriculum. The reaction of the ECE faculty and students to these labs was so positive that the faculty voted to require that all ECE students purchase their own National Instruments (NI) myDAQ board, a student data acquisition board, and an ARM-based embedded processor inventor's kit, for in-class experiments and take-home projects, in several ECE core courses. Approximately 3,000 students per year use these devices in ECE courses, taught by over 25 instructors. Over 700 K-12 students have also been exposed via camps, workshops, and tours of ECE facilities.

Dr. Ferri's publications describe several controlled experiments that strongly demonstrate the utility of including portable experiments into our core lecture-based courses with significant improvement in student achievement and in student interest.

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Based on these successes, Dr. Ferri has been awarded two NSF grants with researchers at RPI, Virginia Tech, Rose-Hulman, Howard University, and Morgan State University. The goal is to build a community of developers and users of portable, affordable hands-on learning platforms centered on ECE topics but expanded to other STEM fields.

**Using feedback from course analytics to improve flipped/blended classrooms:** Dr. Ferri literally turned engineering education inside out by integrating the latest flipped and blended classroom techniques into the new ECE curriculum. She revised the ECE circuits courses to be taught using the blended/flipped format of online video-based lecture material, complemented with in-class labs and advanced topics. Based on cutting edge research in engineering education, she developed educational modules that include both formative and summative assessment. Most notable is that she introduced a revolutionary feedback process to adapt courses (e.g., the pacing of material) based on empirical measurements (e.g., number and types of student questions) from the previous offerings of the course.

Each year, between 1,200 and 1,400 students take courses in ECE in this format. One such circuits course, ECE 3710, a service course to non-ECE majors, enrolls an average of 500 students per term, making it one of the largest engineering courses in the country taught this way. This has greatly improved the consistency across sections, coverage, and quality of these courses with significant improvements in student performance and retention while maintaining the desired student workload.

The impact extends well beyond Georgia Tech. Dr. Ferri has developed two Coursera massively open online courses (MOOCs), *Linear Circuits* and *Introduction to Electronics* in which over 100,000 students have enrolled, with over 1.2 million online lectures viewed since 2013.

Dr. Ferri has published 21 peer-reviewed conference and journal papers describing her pioneering educational research, including in the *American Society on Engineering Education's* (ASEE) annual conference, the *Institute of Electrical and Electronics Engineers (IEEE) Frontiers in Education* conference, the *IEEE Control Systems Magazine*, and the *ASEE Advances in Engineering Education* journal. She is serving as Associate Editor of two journals, including the *IEEE Transactions on Education* and *IEEE Access* and is guest editing two special issues on engineering education. These are the premier international forums on engineering pedagogy and assessment in our field.

**Leadership in disseminating and encouraging educational innovations:** Dr. Ferri has created a seismic shift in faculty teaching methodologies and student learning within the School of ECE. She created an Innovation in Education Faculty Committee to assess the current state of education in ECE and to recommend and promote improvements. She also initiated an ECE Faculty Teaching Fellows Program to encourage innovations in the ECE learning environment, advised and mentored by faculty members experienced in integrating new teaching techniques into the classroom.

Her impact has been felt throughout Georgia Tech and beyond. She has given presentations on educational research and innovative classroom instruction at several cross-disciplinary events at Georgia Tech, including the School of Mechanical Engineering, the Center for the Enhancement of Teaching and Learning, the Center for 21<sup>st</sup> Century Education, and the Georgia Tech chapter of ASEE.



In recognition of her leadership and expertise, Dr. Ferri has been asked to chair two campus-wide task forces commissioned by the Georgia Tech Provost's Office. "Creating the Next in Education Task Force," which she co-chairs with Rich DeMillo, is charged with making recommendations for Georgia Tech to be a leader in innovative and effective education and co-curricular programs; this initiative began in 2015 and is projected to last until 2017. During 2013-2014, she led the "GT1000 Review Task Force", which reviewed the status of this freshmen seminar course (taken by 60% of freshmen) and made recommendations for changes to enhance its effectiveness in providing resources and advice to promote student success in college.

Dr. Ferri is an internationally recognized leader, organizing workshops on Mobile Hands-on Learning for the *American Society on Engineering Education Annual Conference and Exposition* and for the *American Controls Conference*. She also served as Chair and Deputy-Chair of the IEEE Control Systems Society's Technical Committee on Education. She recently co-organized a workshop on flipped and blended classes at the ECE Department Heads Association meeting (ECEDHA) in March 2015 and gave a presentation on innovative education methods at the Southeastern ECEDHA meeting in November 2015. In 2014, she was invited to speak at the *National Academy of Engineering Frontiers in Engineering Education Workshop*.

**Recognition of impact:** Prof. Ferri's dedication to enhancing student learning has been recognized in numerous honors, including an Eta Kappa Nu Outstanding Teacher Award, a Junior Faculty Teaching Excellence Award, an Outstanding Paper Award for the *IEEE Control System Magazine*, the Harriet B. Rigas Award from the IEEE Education Society (given annually to an "outstanding woman engineering educator in recognition of her contributions to the profession"), the Georgia Tech Women in Engineering Excellence in Teaching Award, and Georgia Tech's Class of 1934 Outstanding Innovative Use of Education Technology Award. National Instruments recognized her in 2014 with an Excellence in Education Award, stating, "Professor Ferri ... is always looking for innovative approaches to learning and has been described as a 'thought leader' at her university."

Dr. Ferri's reputation among students and colleagues consistently upholds not only the tremendous impact she has had on the students, but also the caring and compassionate heart she has for them, her clear vision of their potential, and her ardent desire for their success. She is well-loved and well-respected. One undergraduate related the following anecdote:

*"One of my favorite moments of the class was when we were doing an in-class experiment and she was helping me build my circuit on my bread board. I got so excited when I was able to get a signal on my oscilloscope I almost screamed. When I looked up she was almost as happy as me, and in response she said, 'This is why I love teaching.' She truly cares about her students and will do anything to expand their horizons!"*

I believe Professor Bonnie Ferri is an ideal candidate for the *Regents' SOTL Award*, and I am very pleased to give my whole-hearted support of her nomination for this honor.

Sincerely yours,



Steven W. McLaughlin  
Steve W. Chaddick School Chair and Professor