Teaching and Outreach

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1 Overview

During my time at BU, I have taught 3 different courses at both undergraduate and graduate levels on embedded systems, computer architecture, and software design. One of these courses was a new advanced graduate course that I designed. *Common themes* in the courses I have taught are (1) project-oriented nature of the courses with substantial hands-on design components and (2) opportunities to connect fundamental science and engineering knowledge with real-life applications. The hands-on design components of my classes motivated and enabled me to introduce *active learning* techniques in my courses. I have received strong positive feedback from the students so far, with evaluation scores above the departmental average. Furthermore, enrollment to my courses has grown steadily over the years.

In addition to closely mentoring my PhD students in their research and career development, I have continuously hosted *undergraduate students* in my lab. I also participated in several outreach programs such as BU Research Internships in Science and Engineering (RISE) and BU Summer Challenge, through which I had the opportunity to help attract *high school students* to science and engineering. I was a guest lecturer at the BU Artemis Summer School, which targets engaging rising 9th grade girls in computing.

I am committed to *increasing diversity* in engineering, and as a result, I have been involved with several organizations that work in this direction. I have been a faculty advisor to the BU Society of Women Engineers (SWE). I have also been serving as the Council on Electronic Design Automation (CEDA) liaison to IEEE Women in Engineering (WIE) organization since 2012. I have recently been appointed as a CEDA Executive Committee member, and have been working on connecting diversity promoting efforts in the EDA community with the IEEE WIE programs.

2 Curricular Development

2.1. Introduction to Embedded Systems (EC535) – *Spring'10, Spring'11, Spring'12, Spring'13, Fall'13*

EC 535 is a mezzanine-level graduate course and also a technical elective for senior undergraduates. I have substantially revamped the existing course and revised its lectures and lab content.

The lectures survey a broad array of subjects including embedded processors, memory and communication architectures, real-time operating systems, scheduling, energy efficiency in hardware and software, hardware-software co-design techniques, and verification techniques. The concepts are reinforced with homework and project assignments that involve system design, modeling and validation. The assignments involve C/Linux programming, designing kernel modules, system development on ARM/Linux-based evaluation boards, and optionally use of other microprocessor or FPGA-based boards.

EC535 has grown from a 20-student class to a typical enrollment of over 50 people. *Active learning* methods I have employed in this course include *in-class labs*, where students come with prior preparation to the lab and perform a start-up component of the labs during class, while getting help from the TAs and myself. Students who have taken this course have repeatedly commented that the in-class labs and group exercises were among their favorite aspects of the course.

Students comments (collected through the BU evaluation system and via individual unsolicited emails) elaborate on the reasons of rising interest to my course. Some examples are as follows:

- "One of the most industry-relevant courses I have ever enrolled in."
- "Much of the work I'm going to do at Lincoln Labs over the summer will be possible because of stuff I learned in EC535."
- "Labs were extremely valuable in understanding material and gaining skills for job interviews".
- "EC535 helped me further my understanding of operating systems and C programming in general".

Constructive feedback I received from the students led me to improve the connections between lectures, labs, and homework assignments. After my recent revisions to the course to address this aspect, my course and instructor ratings have raised to 4.4 /5 and 4.5 /5, respectively, both of which are substantially above departmental averages.

2.2. **Introduction to Software Engineering (EC327)** – *Fall'10, Fall'11, Fall'12*

EC327 is an undergraduate course, which is required for CE students and elective for EE and other engineering students. I have revised the existing course material, and also designed new lab and project assignments.

The course is an introduction to software design, programming techniques, data structures, and software engineering principles. The topics include fundamental elements of functional programming languages, using C/C++ as the case example, principles of object-oriented programming as embodied in C++ and Java, and an introduction to elementary data structures and algorithmic analysis.

Assignments involve programming under Linux/Unix environment as well as the use of Integrated Development Environments such as MS Visual Studio. I have also created an Android app-design project in collaboration with Prof. Ari Trachtenberg in Fall 2012. This project, for the first time, gave an opportunity for students to design real-life apps, work in a real-life-like software development team environment, and place the end product on the app market. An ECE news article on this project component appeared at: http://www.bu.edu/ece/2013/02/07/applying-what-they-learned/. Some of the later editions of EC327 taught by other professors also leveraged the app-design project component.

The enrollment to EC327 scaled from 35 students to 80 over the 3 consecutive years I taught this class. Despite the diversity of the backgrounds and skills of the students enrolled in the class, I have received mostly very positive comments. Students especially liked the fundamental preparation EC327 provides for job interviews, academic or industry internships, and for their future software courses. Some comments (from BU course evaluations and unsolicited emails) are as follows:

- "Homework assingments were diverse and very informative – I learned a lot from them!"
- "Thank you very much for helping me appreciate further the realm of software engineering. Being an experienced programmer, I never thought about the aspects of hardware interaction [prior to EC327]".
- "The course gave a very good understanding of programming and writing algorithms."

Criticism by EC327 students mainly was related to the high amount of workload. This comment was especially common from EE seniors who were taking the course in conjunction with project-heavy courses. Most EE students have then started taking the course in their junior year. Some students also had difficulty with the computerized, programming-based exam environment that I used. Since then, I have adjusted the workload throughout the course as well as during the exams. In Fall 2012, a commonly-raised issue was related to the app-design project (the students submitted their course evaluations while they were heavily working on their projects). At the end, I was greatly impressed by the quality of the apps designed, and I can confidently say that the vast majority of the students were highly satisfied with their experience as well. Scaling a smaller hands-on class to 80 people was another challenge that I learned from, especially in terms of organizing the TA-student interactions. Based on course evaluations, I was happy to see that almost all students appreciated my teaching method, availability/approachability, organization, and enthusiasm about the course.

In Fall 2012, I have started recording and posting short videos (with a length of 10 minutes or less), which demonstrated how to solve key example problems or explained important concepts. Students have greatly enjoyed this method as they were able to easily review material at their own pace at home. I plan to integrate similar *flipped classroom* methods in future editions of the course.

2.3. **Advanced Computing Systems and Architecture (EC700)** – *Spring'14*

I designed an advanced systems-architecture graduate course, and offered it for the first time in Spring'14. The course reached an enrollment of 15 students, a rather high enrollment level for a 700-level course.

This class aims to enable students follow the latest developments in computer systems and architecture. The lectures cover a broad array of subjects including memory/cache management in multi-core systems, hardware multi-threading, tiled architectures, heterogeneous systems, large-scale system architectures, virtualization and hypervisors, data center management, energy awareness in computing systems, and system reliability/resiliency.

The concepts are reinforced with research paper readings (i.e., over 20 technical papers throughout the semester) and also with hands-on homework and project assignments that involve programming/scripting, system design, and analysis on real-life systems and state-of-the-art simulators. I was pleased to see that the final projects were very high quality in terms of the rigorousness of implementation/experiments as well as

their analytical depth. In fact, out of the final projects, one team project was submitted and accepted as a conference paper at the IEEE High Performance Extreme Computing (HPEC) Conference, 2014.

3 Tutorials and Seminars

To disseminate my research outcomes to a broader audience, I have given over 45 invited talks over 5 years at companies (and at research summit events hosted by industry) such as VMware, Intel, Oracle, IBM, and AMD as well as at various universities such as Brown University, UT Austin, Princeton University, Caltech, and EPFL. I have also given tutorials and tech-talks on 3D-stacked system modeling and management, thermal management, and energy-efficient architectures at a broad range of top-notch conferences such as at DAC, DATE, VLSI Design, and ITHERM. A full list of my recent invited talks and tutorials is in my CV.

4 Diversity and Outreach

I have participated in several outreach programs at BU. BU RISE and Summer Challenge target engaging *high school students* in science and engineering. As part of the RISE internship program, I hosted two rising seniors in my lab, each for 6-week projects. Both students continued to top-ranked engineering schools for their undergraduate studies (i.e., CMU and Caltech), and one of the RISE interns even co-authored a workshop and a conference poster paper with me. I continue to host one such student in Summer 2014.

In the 2-week BU Summer Challenge course in 2013, I delivered one of the EE seminar and lab sessions, focusing on basic circuit design, breadboarding, and smart-lighting applications that demonstrate the basics of communicating via light. I continue to act as s Summer Challenge instructor in 2014. As part of the federally funded Upward Bound Science Math (UBMS) Science Vacation Week at BU, I designed a one-day programming and robotics introduction course in collaboration with Prof. Ajay Joshi in 2013. Most participant students indicated they are more interested in studying engineering after attending our course in their exit survey.

I am committed to participating in and designing programs that improve *diversity* in science and engineering. In 2011-12, I was a guest lecturer in the BU Artemis program, which is a summer program for 9th grade girls, focusing on attracting more female students in computing early on to address the gender gap. As an advisor to BU SWE, I continue to help female engineering students at BU to organize recruiting, networking, and career-building activities. My recent involvement with IEEE WIE as a CEDA liaison has given me the opportunity to learn more in-depth about the programs at IEEE, and I am currently working towards building long-term proposals to improve diversity in EDA.

5 Mentoring

I closely mentor my *PhD students* on their research practices and also on their career development. I enabled my students to attend programs such as the DAC Richard Newton Young Student Fellow Program and ACM SIGDA Design Automation Summer School, both of which provide technical mentorship and networking opportunities to students entering the EDA field. I also supported my female students to attend the NSF-funded CRA-W Diversity Workshop at DAC. My PhD students participated in PhD forums at DAC, DATE, VLSI-SoC, and IPDPS conferences.

My lab's close interactions with industry and external university collaborators provide broader career-building, networking, and mentorship opportunities for my students. My students have so far interned at Intel, IBM, Sandia National Labs, AMD, and EPFL.

I believe early engagement in research has substantial benefits in developing technical and professional abilities of students. To this end, I have hosted undergraduate researchers in my lab throughout my time at BU. All of the undergraduate researchers that were members of my lab (John Furst, Katsutoshi Kawakami, Samuel Howes, Ben Havey) made substantial software and hardware development contributions, and as a result, co-authored research papers with myself and my PhD/MS students. I currently host 3 undergraduates (Ann Lane, Nathaniel Michener, Dean Shi), all funded through BU UROP and other programs.

Diversity of the level and backgrounds of my students has provided me with the opportunity for building a highly capable team with a breadth of skills. In addition, I have engaged my PhD students in mentoring undergraduate and Masters students who are doing projects with me. Similarly, my undergraduate students help with the mentoring of high school interns and the operation of the summer outreach programs. In this way, my aim is to create an active, dynamic, closely-knit team environment, where students improve their research skills as well as their other professional skills such as team work, presentation, and mentoring.