Abstract - The Milwaukee School of Engineering replaced a traditional computer engineering curriculum that located the majority of the core computer engineering topics in the final two years of study with a new freshman-first curriculum in academic year 2006-2007. The new curriculum was designed around the 2004 guideline report of the IEEE/ACM Joint Taskforce on Computer Engineering Curricula but took a more aggressive approach by distributing the computer engineering topics throughout all four years of study. The result is a balanced, freshman-first curriculum that presents software, hardware, math, science, and humanities side-by-side for most of the twelve undergraduate quarters. The goals of the curriculum was to improve retention, reduce prerequisite material time gaps, and respond to the industrial advisory committee request for improved soft skills. All three of these goals have been met: first-to-second year retention has improved, large gaps in hardware coverage have disappeared, and a course on teamwork and leadership has been taught for the first time.

Index Terms – Degree programs, Skills development, EE courses and labs, Curriculum development

INTRODUCTION

The Milwaukee School of Engineering implemented a new computer engineering curriculum in academic year 2006-2007. The new curriculum was designed after a two-year self-study of the pedagogical successes and failures of the old curriculum. Three areas of concern motivated the self-study and each was confirmed to exist by examining collected institutional and assessment data. First, freshman-to-sophomore retention was low with a large migration to other majors. Second, large instructional gaps were present between hardware courses. Finally, while praising the technical skills of graduates, the industrial advisory committee desired stronger teamwork and service skills. These concerns helped focus the curriculum redesign along with the technical content guidelines of the 2004 IEEE/ACM Joint Taskforce on Computer Engineering Curricula (CE2004). The main goal was to improve each of the three areas.

The degree program redesign resulted in a balanced, freshman-first curriculum. The first published report on the new curriculum presented an overview of the three areas of concern and the curriculum solutions [1]. Now, the first student cohort is at the end of the second year and data can be provided to gauge the success of the new curriculum.

FIRST-TO-SECOND YEAR RETENTION

There is a significant bulk of published literature that suggests students both receive and see value in early exposure to engineering. One classic paper summarizes the work by the NSF-funded Engineering Education Coalition universities to integrate engineering into the traditional freshman mathematics and physics coverage [2]. The paper also provides an extensive bibliography of the published literature supporting the integrated approach. The MSOE faculty evaluated the integrated approach and recognized that this would require a university-level commitment that could not be guaranteed.

Many universities that do not choose the integrated approach instead create freshman design course sequences or develop innovative ways to approach retention in the early sophomore years. One recent example in computer engineering was the implementation of digital design learning streams in the sophomore year at Iowa State University [3]. The new MSOE curriculum is, in some-sense, stream-based because of the planned per quarter balance in computer software and computer hardware. This balance required that many traditional single quarter courses be split up into multiple sequential courses.

The CE2004 report acknowledges the need to distribute core topics throughout the curriculum and also directly mentions the perceived disconnect between traditional curricula that place core topics in the final two years of study versus the student desire to be exposed to the core material in the first two years [4]. But, the model curricula provided in CE2004 do not move hardware design all the way into the freshman year.

The MSOE approach, however, chose embedded computer systems as the core computer hardware specialty area to develop over all four years. This choice built on faculty strengths and provided a vehicle for building four-years of hardware training alongside four-years of software training. Student assessment data suggested that most students migrated away from the old computer engineering curriculum because it only exposed them to object-oriented computer programming during the first year. The new curriculum balances computer software, computer hardware, math, science, and the humanities in nearly all twelve quarters. Thus, freshmen are exposed to both computer
programming and computer hardware design fundamentals in the freshman year.

The first year retention results have justified the balanced four-year approach. The fear had been that moving digital logic design techniques, as well as hardware description language instruction, to the freshman year might prove too difficult for students because of academic maturity. However, the retention numbers showed a higher percentage remaining in the major between the first and second years. The achieved first-to-second year retention was 39 out of 50 students (78%) and was higher than the previous five years of data for the old curriculum where retention was more commonly between 60% and 70%.

Anecdotally, the faculty was also pleased with the quality of the students. Students seemed more dedicated and focused compared to students taking similar courses in the old curriculum. Study teams self-formed and met regularly in the laboratories during the year as they worked together through course material. This had not been commonly seen in the old curriculum. Also, the quality of student questions did not suggest a lack of maturity. On the contrary, the faculty was impressed with the depth of questioning! These anecdotal points seem to confirm the previously mentioned published studies that have shown the value of integrating engineering into the first year. In fact, a veteran of the faculty has stated that these are “the best students I’ve had in thirty years!”

CLOSING HARDWARE COVERAGE GAPS

The balanced curriculum was designed so that large prerequisite course gaps no longer occurred. In the old curriculum, many core topics were taught in a single quarter or perhaps two quarters. For example, circuit theory was taught in two ten-week quarter classes during the sophomore year. Yet the study of control systems, the coursework that relied on this prerequisite material, was not taken until the final quarter of the junior year – a gap of three quarters. Similarly, combinational and sequential logic design was taught as a single ten-week class in the second quarter of the sophomore year but computer architecture, the principle class relying on logic design techniques, was not taken until one year later during the junior year. These long gaps created distress not only for the students but also the instructors.

The new curriculum split circuit theory into a thirty week sequence. There is now only a one quarter gap before the start of control systems. Similarly, the flow of computer hardware design was dramatically improved by expanding digital logic techniques into a twenty-week sequence in the freshman year followed by a twenty-week embedded systems sequence in the sophomore year. Finally, the sophomore year culminates in computer architecture – a class that ties together most of the concepts learned through the freshman and sophomore years. This class can provide one anecdotal measure of success with the new course placement and gap closure by analyzing the due date of the first microprocessor simulations in the computer architecture laboratory. Students in the previous curriculum had been required to implement two processors using the VHDL hardware description language. These processors were traditionally due in weeks 8 and 10 of the academic quarter. This year, both instructors of the course were able to advance the demonstrations into weeks 5 and 7. This allowed students to complete a third processor – a full pipelined processor – with a due date in the week 9 laboratory. The new due dates suggest that the student confidence built by the balanced progression in hardware design translated into stronger student classroom performance.

TEAMWORK AND SERVICE SKILLS

At the end of the second year, the faculty is least confident in the goal of improving teamwork and community service skills. This is not because data suggests the curriculum approach did not work. Rather, it is because only one of the classes designed to address these skills is placed in the first two years of the new curriculum. Additionally, since this course is taught by faculty from the general studies department, the computer engineering faculty has no first-hand experience with student performance or outcomes. However, students will be given a survey instrument at the end of the sophomore year that will allow them to evaluate their first two years at the university. Many of the questions will be designed to help determine how the sophomore course in teamwork has improved their study skills and interpersonal relationships. The survey results will be presented at the conference.

CONCLUSION

The balanced, freshman-first computer engineering curriculum at the Milwaukee School of Engineering has shown higher first-to-second year retention rates compared to the old curriculum. It also has a more logical flow in computer hardware study that has resulted in strong student performance and less need for prerequisite review. The conference presentation will outline the entire four-year curriculum and discuss experiences and results to date.

REFERENCES


