
Curricular Enhancement to Support Project-Based Learning in Computer and Electrical Engineering

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2008 ASEE Annual Conference & Exposition
June 22 - 25, Pittsburgh, PA

1

Contents

- Introduction, Motivation and Teaching Methodology
 - Electronics Design and Manufacturing
 - Introduction to Systems Design
 - Computer Engineering Capstone
 - Conclusions and Acknowledgements
-

2

Introduction

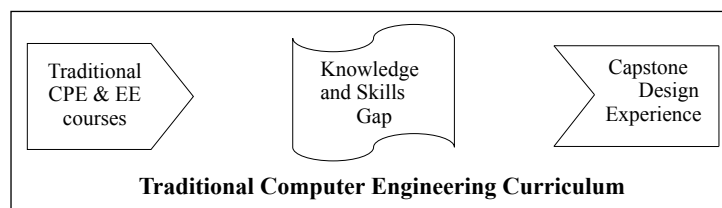
- In today's global economy, Electrical and Computer Engineering graduates must have the skills necessary to be productive members of an engineering team.
 - Many engineering programs include several courses taught in isolation followed by a capstone or senior project experience culminating experience.
 - Project-based learning and open-ended design projects facilitate self-directed learning and enhance students' project management, communication and professional skills.
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Introduction (Cont.)

- Students often struggle during their senior design project
 - Cal Poly traditional computer engineering courses
 - Engineering orientation
 - Fundamentals of computer programming I, II and III, systems programming, discrete structures, computer networks, and operating systems
 - Digital design, computer design and assembly language programming, computer architecture, microcontroller design
 - Electric circuit analysis I, II and III, continuous-time signals and systems
 - Semiconductor device electronics, digital electronics and integrated circuits
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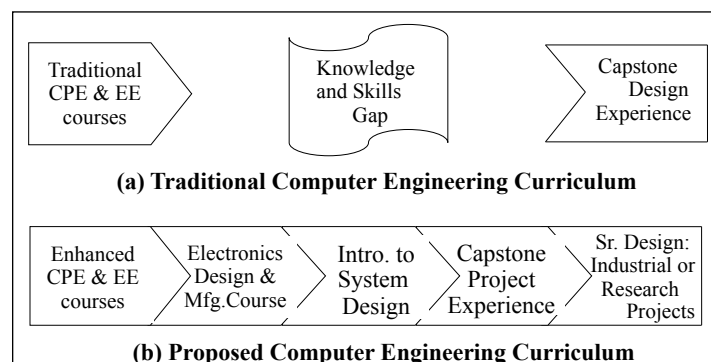
Introduction (Cont.)

- Knowledge and skills needed
 - Teamwork, communication, project management, and self directed learning
 - Systems Level Design: system requirements, partitioning, design, integration, & verification
 - Computer Aided Design Tools for embedded systems and printed circuit board design



Introduction (Cont.)

- Enhanced traditional courses with design experiences
- Developed and enhanced critical upper division courses



Teaching methodology

- Project-based Learning
 - Students are presented with a challenging project, then students decide how to solve the problem in a preset timeline and what activities to pursue.
 - "Learner-Centered," not "Teacher-Centered"
 - Active learning, not passive learning
 - Enhance compliance with the ABET2000,
 - ▶ 3c an ability to design a system...
 - ▶ 3d ability to formulate and solve problems
 - ▶ 3e an ability to function on multi-disciplinary teams
 - ▶ 3g an ability to communicate effectively
 - ▶ 3i ... an ability to engage in life-long learning
 - ▶ 3k an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
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-

IME 458 Electronics Design and Manufacturing

- An upper division technical elective course for electrical and computer engineering students that builds upon their microelectronics, digital and analog design knowledge
 - Schedule
 - Lecture: three hours per week for 10 weeks
 - Lab: three hours per for 10 weeks
 - Laboratory Experience
 - A tutorial based project to learn the design flow
 - A self-selected open-ended design project
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IME 458 Learning Outcomes

Students will be able to

- identify appropriate electronics components and connectors for electronics design
 - explain microelectronic and electronic interconnect technologies including die attachment, wire bonding, flip chip, and encapsulation techniques
 - explain the semiconductor manufacturing process including deposition, lithography, ion implantation, and etching
 - describe the fabrication process and identify board materials used in multi-layer printed circuit boards
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IME 458 Learning Outcomes (Cont.)

- layout printed circuit boards for both electrical functionality and manufacturability
- design printed circuit boards using state-of-the-art electronics design automation software
- assemble printed circuit boards using through hole and surface mount assembly processes
- verify circuit functionality
- identify and correct design flaws
- exercise communication skills by writing a final report and presenting in class

IME 458 Overall Lab Schedule

Week	Activities (3 hours/week)
1	Introduction to Cadence <i>HDL Concept</i>
2	Introduction to Cadence <i>Alegro</i>
3-4	<i>Alegro</i> : Design rule constraints and component placement <i>Alegro</i> : Routing and generation of manufacturing data
5-9	Open ended design project
6	Surface Mount: Stencil printing
7	Surface Mount: Pick and place
8	Surface Mount: Solder reflow
10	Final project demonstrations

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-

13

CPE 329 Introduction to Systems Design

- Students design their computing platform using only the necessary hardware and peripheral devices. They analyze system performance based on hardware and software tradeoffs against a backdrop of hardware resources utilization metrics, thus vastly increasing the design space they consider for their projects.
 - Schedule
 - Lecture: three hours per week for 10 weeks
 - Lab: three hours for 10 weeks
 - Finish 5 projects in a 10-week quarter
 - Four required design projects
 - One self-selected open-ended final design project
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CPE 329 Learning Outcomes

Students will be able to

- determine and document system requirements for student proposed design projects
 - select appropriate design type, hardware or stored program, to meet the system requirements while optimizing various cost functions
 - use digital, analog, and serial input and output devices such as UART, SPI, I2C, PS2, LCD, VGA, Keypad, Keyboard, RAM, LED, etc.
 - design, implement, and verify a digital system using a hardware description language
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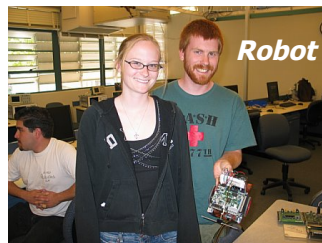
CPE 329 Learning Outcomes (Cont.)

- design, implement, and verify a system using a higher-level programming language
 - analyze hardware vs. software tradeoffs such as performance, power consumption, system economics, and design time
 - document designs using block diagrams, flow charts, verification test matrix and system measurements
 - select external components and interface to embedded system using product datasheets
 - exercise communication skills through preparing a proposal, writing final design reports, and presenting in class
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CPE 329 Overall Lab Schedule

Week	Laboratory Activities (3 hours/week)
1-2	Hardware-based digital clock design
3	Stored-program computer system using LCD display
4-5	Stored program-based digital clock design
6-7	Function generator (sinusoidal, sawtooth, and pulse width modulation)
8-10	Student proposed final design project
10	Final project demonstrations

CPE 329 Final Design Projects



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-

19

CPE 350/450 Capstone Sequence

- During the six month capstone sequence, teams of 4-6 students participate in the design and implementation of a complex system
 - All students must be assigned one or more roles and be held accountable for their portion of the project
 - The project must meet the needs of a real user and be deployable for use by those users
 - Schedule
 - Lecture: three hours per week for 20 weeks
 - Lab: three hours per for 20 weeks
-

CPE 350/450 Learning Outcomes

Students will be able to

- articulate design specifications and criteria by which they are to be measured
 - design and defend solutions to real-world problems
 - verify that their design implementation solves the real-world problem and satisfies all of the specified project requirements and constraints
 - evaluate the effectiveness of one's own team and other teams' designs
 - effectively contribute one's own disciplinary knowledge on a team as well as locate and evaluate new information
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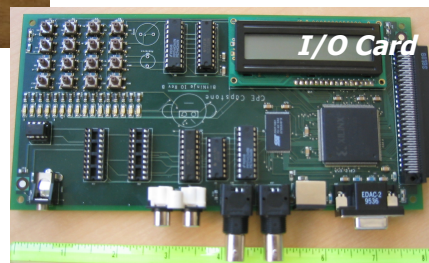
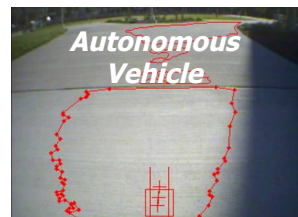
CPE 350/450 Learning Outcomes (Cont.)

- contribute to effective project management (e.g., through the use of Gantt charts)
 - effectively communicate with others in a team, fulfilling one's individual role in the project and in interfacing with customers
 - employ principles of effective communication
 - employ ethical practices in all aspects of the design process
 - reflect on aspects of design and the design process
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CPE 350/450 Project Schedule

Project Phase	Deliverable	Milestone
1. System requirements	Requirements documentation	Requirements review
2. Conceptual design	System features and specifications	
3. Usability study	Usability case studies	Design and feature freeze
4. System architecture and design	System block diagram, critical component selection, interface specifications, protocol definition, and data structures	Design review
5. Component procurement	Bill of Materials	Purchase order submission
6. Subsystem design	Functional subcomponent design	
7. System Integration	Completed prototype system	<i>Senior Design Fair</i>
8. User documentation	Installation and user manual, and design documentation	Customer project delivery

CPE 350/450 Capstone Lab and Projects



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-

25

Conclusions

- Students learn how to define system requirements, partition the design into subcomponents, design, build, test, and verify that the system requirements have been met.
 - The project content in each of these courses has been increased to give the students many opportunities to engage in self-directed learning and to get experience as a member of a development team.
 - The students' feedback and final project demonstrations indicate that the courses are providing a solid foundation of systems and PCB design while meeting the learning outcomes of these courses.
 - Through project-based learning, undergraduate students not only learn technical skills to design and manufacture systems, but they also synthesize their engineering knowledge and develop project management, communication and other professional skills.
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Acknowledgement

- This work is sponsored by the **National Science Foundation** Course, Curriculum, and Laboratory Innovation (NSF-CCLI) program, under award DUE-0633363.
 - Project Student Assistants: Ron Sloat, Brian Wright, Greg Lacaille, and Ed Adams.
 - Teaching Assistants: Jackson Pang, Rafael Kaliski, Don Heyer, Carter Deleo, Tom Hickok, and Arvin Faruque.
 - BitNinja Capstone Project Team: Joseph Nouri, JJ Krakowski, Will Samuels, Daniel Schacht, and David Herrera
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Thank You!

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Questions?
