

Enhancing Student Learning Through Systems Level Design and Implementation

Al Liddicoat, Jianbiao Pan, James Harris, and
Lynne Slivovsky California Polytechnic, SLO
Dominic Dal Bello Allan Hancock College

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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.)

■ Objective

- To enhance the Computer Engineering curriculum through team-based system design experiences.

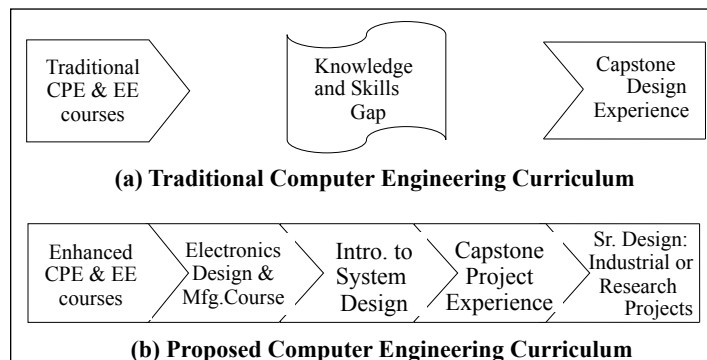
■ Knowledge and skills needed

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

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Introduction (Cont.)

- Enhanced traditional courses with open-ended team-based design experiences
- Developed and enhanced critical upper-division courses



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Project Phase 1 goals

1. Development of a lower-division PCB design module for all engineering majors
 2. Develop and enhance upper-division courses
 - Electronics Design and Manufacturing
 - Introduction to Systems Design
 - Capstone Design
 3. Collaboration with community college partner
 4. High school outreach
 5. Assess student learning
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Lower-Division Lab Module

Objective – to provide engineering students with the knowledge and skills needed to design and manufacture Printed Circuit Boards

Two lab period module with outside homework

1. PCB tutorial and Board Assembly
2. PCB Design, Assemble and Test Op Amp Circuit

While meeting learning objectives of Circuit Analysis Course

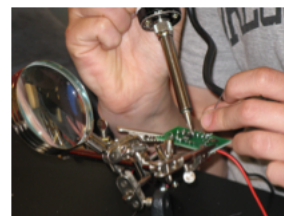
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Lower-Division Lab Module Status

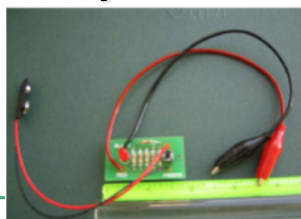
- Instructional module developed at Cal Poly Fall 2007
- Instructional module trial at Allan Hancock Spr 2008
- 90% students agreed and strongly agreed that *"they learned about PCBs and how they are manufactured"*
- 85% students agreed and strongly agreed that they *"learned how to design PCBs"*
- Module took the student more time than expected
- Identified and corrected points of confusion in tutorials and supporting materials
- Full class trial scheduled in 2008 Fall-AHC Winter-CP

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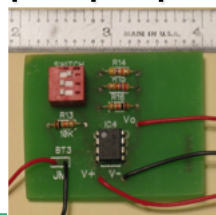
Lower-Division Lab Module Status



Continuity Tester



Op Amp Experiment



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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 has been implemented
- 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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Electronics Design and Mfg 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 begins
6	Surface Mount: Stencil printing
7	Surface Mount: Pick and place
8	Surface Mount: Solder reflow
10	Final project demonstrations

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Electronics Design and Mfg Lab Schedule

Network Adaptor Card (FPGA, Ethernet, PCI, RS 232, Parallel Interface)



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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

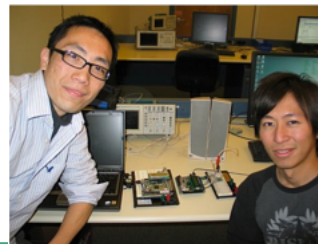
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CPE 329 Overall Lab Schedule

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, saw-tooth, and pulse width modulation)
8-10	Student proposed final design project
10	Final project demonstrations

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CPE 329 Final Design Projects



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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

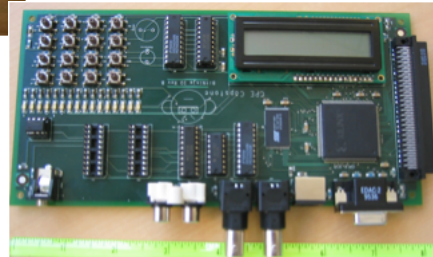
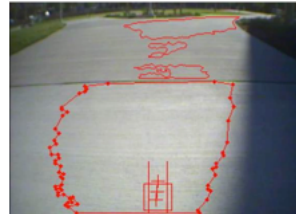
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CPE 350-450 Project Schedule

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	Senior Design Fair
8. User documentation	Installation and user manual, and design documentation	Customer project delivery

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CPE 350-450 Capstone Lab and Projects



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Collaboration between Cal Poly and AHC

- Regular communication and interaction established between Cal Poly and Allan Hancock College (AHC)
- AHC participated in student final PCB design project demonstrations
- Successful transfer of PCB module from Cal Poly to AHC
- AHC provided student and instructor feedback to Cal Poly
- AHC students that worked on project have been admitted to Cal Poly and will continue working on project at Cal Poly

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Outreach to High School Students

- Objective – creating student interest in engineering, engaging students in hands on design experiences, and get high school teachers involved to create new opportunities for education and understanding
- Presented PCB assembly module at the Cal Poly Engineering Summer Camp for 96 local high school students
- Plan to work with high school teachers over Summer 2009

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Cal Poly Engineering Summer Camp



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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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Project Contributors

- Cal Poly State University, San Luis Obispo, CA
 - PI Albert Liddicoat
 - Co-PI Jianbiao (John) Pan
 - Faculty Affiliate James Harris
 - Faculty Affiliate Lynne Slivovsky
 - Assessment Linda Shepherd
- Allan Hancock College
 - Dominic Dalbello

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- 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.

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Dissemination at ASEE Conferences

- "Embedded System Design using the FPGA", L. Slivovsky and A. Liddicoat, Approved Workshop for the ASEE 115th Annual Conference, Electrical and Computer Engineering Division in 2008.
- "AC 2008-2189: Curricular Enhancement to Support Project-Based Learning in Computer and Electrical Engineering", A. Liddicoat, J. Pan, J. Harris, and L. Slivovsky, Accepted for Presentation at the 115th ASEE Annual Conference in Electrical and Computer Engineering Division, Pittsburg Pa, June 2008.
- "AC 2008-1165: Development of a Project-Based Electronics Manufacturing Laboratory Course", J. Pan, A. Liddicoat, J. Harris, and D. DalBello and A. Liddicoat, Accepted for Presentation at the 115th ASEE Annual Conference in Manufacturing Division, Pittsburg Pa, June 2008.
- "AC 2008-1243: Enhancing Student Learning Through State-of-the-Art Systems Level Design and Implementation: The Development of a Lower Division Learning Module", J. Harris, J. Pan, D. DalBello and A. Liddicoat, Accepted for Presentation at the 115th ASEE Annual Conference in Electrical and Computer Engineering Division, Pittsburg Pa, June 2008.
- "Transforming the microprocessor class: Expanding learning objectives with soft core processors", L. Slivovsky and A. Liddicoat, 114th ASEE annual conference, Hawaii, June 2007.

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