Work in Progress - PEER College Summer Camp

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Abstract -The Partnership for Engineering Education in the Rockies (PEER) is comprised of local educational and industrial institutions committed to improving the engineering education paths available to students at all levels. Programs start with introductory engineering courses in the 8th grade and scaffold through the high school level. The PEER college summer camp expands on these course offerings to further enhance students’ learning experience in a college setting. The camp also brings together secondary students and educators for an opportunity to extend the reach of the PEER program to new students and schools. This paper provides an overview of PEER, and describes the specific goals and format for the PEER summer camp.

INTRODUCTION

With intellectual properties (IPs) in computer and semiconductor engineering becoming increasingly important in order to improve US competitiveness in the world market, there is a tremendous need for young people in this country to go through K-12 science and engineering education that fits the future needs of computer and semiconductor industry. Students entering college not prepared for the rigor of the engineering discipline tend to fail and withdraw from the programs. By introducing engineering concepts and practices to junior high and high school students, PEER programs offer a reason for studying core sciences which help prepare students for future educational success in difficult college curricula. This early introduction to science has been shown to be key to forming a lasting interest through higher education.

Offering a summer camp within the PEER programs has two major objectives. First, it acts as a recruiting tool to get high school students involved in other PEER courses while enriching the educational experience of those already participating. Second, it offers an opportunity to expand the geographic reach of PEER by helping high school educators develop engineering curriculum for their classroom.

PEER OVERVIEW

The larger goal of PEER is to increase applicant quality for jobs in the computer and semiconductor industry. To accomplish this, early engineering and science curricula must create distinct paths leading students to become better qualified engineers and designers. By bringing together Colorado State University (CSU), Front Range Community College (FRCC), and the Poudre School District (PSD), along with industry partners like Intel, PEER provides a diversity of these paths for various types of students. Paths can lead to a certificate in microelectronic mask design, an AS degree or a BS degree in electrical engineering. Students can enter any of these paths as high school students by cross-enrolling in courses offered through FRCC within the PSD, or they can come from the community by enrolling directly at FRCC or CSU.

All of the PEER programs take advice on course material and topics from local industry partners. This makes students finishing any PEER path more marketable to industry, and better prepared to address current problems facing the computer and semiconductor industry at large. The close relationship with industry is vital to the success of all the PEER programs. This relationship even manifests itself with Intel engineers teaching one course each semester, and the guarantee of a set number of PEER interns at local and national Intel sites.

PEER SUMMER CAMP

The summer camp is a small but critical part of PEER. Among the objectives mentioned above, it provides an opportunity to enrich the education of students participating in other parts of PEER paths.

The format of the summer camp allows for presenting material that would otherwise only be seen in the later years of a BS program. The summer camp is a combination of lower and upper level college courses redesigned to immerse advanced high school students in computer engineering. Campers attend classes, participate in hands-on labs, and contribute to research designed around real-world problems.

The camp is also unique in that it brings high school educators and students together in a single camp. The educators learn side-by-side with students, giving both groups a refreshing perspective on the other’s position. The educators develop an engineering curriculum that uses technology to address state standards in a real class setting. This curriculum can be exported to their classrooms with technical support and remote computing facilities provided by PEER.

A. Tiered camp structure

The camp is structured into three scaffolding tiers with successively limited enrollment. Each camper completing one tier is given the opportunity to continue to the next based on their interest and performance. Each tier is capped by a symposium where students present their final projects to their peers and parents. The tiers are outlined below.
B. Tier 1: Introduction to Circuits and VLSI

The first tier is the 3-week Introduction to Circuits and Very Large System Integration (VLSI) camp. All campers, students and educators, attend this section. In it, campers are introduced to the basic concepts of electrical engineering, digital circuits, basics of a hardware description language, computer architecture, simple MOSFETs, basic boolean gates, silicon design and processing. The extent that these topics are presented is limited to what the campers need to know in order to complete and understand the final project. Campers are also given the opportunity to tour local industry sites in order to show what a career in computer engineering is like.

This tier might be categorized as an accelerated survey course since it provides a quick overview of many normally disparate topics and a view of real-world computer engineering life. However, it is different in that it is directed at a younger audience. Hands-on and computer-based labs provide a much needed break from monotonous lectures and rote-based homework assignments which normally dominate presentation of electrical engineering basics. In a traditional basic course, lecture-lab combinations are only unidirectionally self-reinforcing. That is, lab time is used to reinforce topics covered in the lecture. By adding in the lab-to-lecture direction, camper learning can be greatly accelerated. Each lecture-lab combination is carefully designed to enable this bidirectional coupling. Topics are introduced in lecture and reinforced in lab. In the lab, a relatively obvious intellectual leap is left open for the students to take during lab. The theory behind this leap is then discussed during the following lecture.

A simple example of this lab-lecture coupling can be seen with basic resistor circuits. During lecture, basic concepts of charge, current, electrical resistance and Ohm’s law are presented. During lab, campers are given the opportunity to observe all of these concepts. Inevitably, at least one camper will wire up multiple resistors in series or parallel, thus discovering voltage or current division. Campers can then be encouraged to experiment further in order to derive a theory behind these important concepts. During the next lecture, campers’ theories will be compared to the real theories, and then other concepts can be built on top of these (e.g. Kirchhoff’s circuit laws). This combination of traditional lecture and experiential learning can greatly improve the efficiency with which the campers can absorb concepts.

Educator and student campers work together for the first 2 weeks, learning the same core concepts and technologies. The last week, the campers work with their respective peers about 50% of the time. While educators develop curriculum that they can use in their own classroom, students work on the final project. The final project is the design of a non-functional silicon layout (their name, a fun design, etc.) which will be manufactured in the CSU silicon fabrication facility.

C. Tier 2: Advanced VLSI

The 2-week Advanced VLSI camp is an extension to the introductory camp and is open to student campers only. The main goal of this tier is to present current problems in VLSI and chip design. Maintaining the tight lab-lecture coupling is done by having campers work on producing a functional silicon layout. Producing this layout involves learning almost every aspect of silicon design and manufacturing, including use of industry standard software tools. The final layout will be manufactured in industry fabrication facilities with brokerage through MOSIS. Each student will get a silicon die they helped design as a souvenir and show-piece. This souvenir adds a significant cost to the camps, but is very important to keeping camper interest and involvement.

This tier is markedly more computer lab focused and has much less formal lecturing. Many concepts are presented in real-time in the computer lab as they arise in the campers’ work. Some more hidden concepts, like those occurring during processing, are still presented with a traditional lecture. However, a real-world link is still prominent since the campers saw the integration between the computer lab and the silicon processing lab during the first tier. This link is important in order to keep a hands-on feel to the campers’ work.

D. Tier 3: Advanced Research

The final 3-week Advanced Research camp is just that: research. Student campers are teamed with researchers from academia and industry to approach a real world research project. The exact role each camper performs in this tier depends on the needs of the project. Campers will experience and participate in the process of research. While campers’ contribution to the projects might be small, they will gain a great deal from the experience. The culmination of a successful project is the eventual publication of a research paper in a peer-reviewed conference or journal.

Student campers can attend as many of the tiers as their interests allow. Campers completing the entire sequence get the largest educational and experiential benefit. Of course, it is encouraged that they attend all tiers, but it is understandable that students have other obligations and responsibilities during the summer months. In the end, all student campers will have gained an fundamental understanding of computer engineering, silicon chip manufacturing, and careers in the industry.

Educator campers get a usable curriculum addressing state standards with technology. They also gain access to PEER remote computing facilities and technical support to help implement their curriculum. Finally, they receive graduate continuing education credits for their work.

E. Extra-curricular activities

It is summer, after all. In order to keep the students’ interest and excitement in the program, and give them a taste of the college experience, every weekend is reserved for adventures of another kind. Campers choose between several trips and excursions ranging from touring local industry and day hiking to several-day camping trips. While these adventures do not directly work towards the camps academic goals, they do indirectly work towards the goal of getting students interested in pursuing a college or university career.
IV. SUMMARY

The PEER programs currently being developed in northern Colorado can potentially improve applicant quality for positions in the local semiconductor industry. By introducing engineering curriculum into junior and senior high schools, students will be better prepared for all future educational paths. Designing the courses with industry input, makes these students better prepared for industry, too. To enrich this experience further, and expand the concept behind PEER to new secondary schools, the summer camp will provide an chance for high school educators and students to work together in a college setting. The camp also recruits new students to join into other PEER pathways. By bringing together educational and industrial institutions to coproduce high school curriculum, PEER is able to develop programs that meet the current and future needs of the computer and semiconductor industry while advancing opportunities available to students.