

**AC 2010-1275: UNDERGRADUATE COMPUTER ENGINEERING EDUCATION IN WESTERN INDIA**

**Michael Black, American University**

**Hiren Patel, Sankalchand Patel College of Engineering**

# Undergraduate Computer Engineering Education in Western India

## Abstract

Computer science and engineering education in India is a growing industry, with numerous new engineering colleges founded in the last decade. Many graduates of these colleges pursue postgraduate studies and industry jobs in America. Consequently, the quality of Indian engineering education directly affects American technical industry. While the computer engineering curricula in these Indian colleges is largely similar to that in the US, there are significant differences in the teaching approaches and emphasis. Faculty tend to be relatively inexperienced, with many not yet possessing a Masters degree, and rarely have autonomy over their courses. Syllabi and examinations are developed by an external Board of Study comprised of academicians and industrialists. This results in a rigid, examination-focused educational system that under-emphasizes student design projects, creativity, and classroom innovation.

The authors of this paper instructed computer engineering at a teaching-focused engineering college in Gujarat, India. This institution was founded in the last decade and is typical of these new undergraduate engineering institutions. One of the authors is a computer science professor from American University who taught courses at this college under the Fulbright program. The other author is an assistant professor of that institute.

This study contrasts Indian undergraduate computer engineering education in teaching-focused schools with the model prevalent in American schools. The paper describes initiatives taken by the authors to introduce Gujarati students to more hands-on design projects. These initiatives include a short-term training program for computer engineering faculty members across Gujarat. This program introduced faculty to examples of design projects used in American universities and resulted in a laboratory manual targeted for undergraduate engineering students in Gujarat.

## 1. Introduction

Sankalchand Patel College of Engineering (SPCE) is typical of the new engineering colleges that have been springing up throughout the Indian state of Gujarat in the last decade. SPCE is a teaching focused, primarily undergraduate institution that offers the usual engineering programs: Electrical, Mechanical, Civil, Electronics and Communications, and Computer Engineering / Information Technology. SPCE is not an old or established school; it was founded only ten years ago and is unknown outside of its region. It is governed by the members of the local community who founded it. Virtually all of its students and faculty come from within a 200 km radius. In terms of facilities, opportunities, or staff, it is similar to numerous other young engineering colleges appearing throughout rural India.

Engineering colleges are a booming industry in India at present. An engineering diploma is perceived by students as a ticket to a middle class lifestyle (or better), prestige, good marriage prospects, and emigration to industrialized countries<sup>1</sup>. Demand for an engineering education is far greater than the number of available seats at existing schools. Entrepreneurs are consequently building new colleges at a feverish pace. These founders include wealthy local business leaders and Indian corporations, and in some cases have little connection to engineering themselves, creating these schools strictly as an investment. Such investments are profitable: the Management and Technology Institute in Rajkot, founded by Marwadi Industries (a financial company), has over 200 post-graduate IT students enrolled even before the construction of the campus is completed. SPCE, in contrast, is not-for-profit, but it is

unquestionably popular. Since its first class graduated in 2003, SPCE's CE/IT program alone has produced over 900 alumni. At present, over 500 students are enrolled in the CE and IT programs.

These small regional Indian engineering colleges have an impact in the US. Many recent reports have documented the rising number of Indian international students coming to the US to study engineering and technical subjects<sup>4,9</sup>. Indian students now comprise over 15% of the international student population, more than any other country. While some students come from well-known universities such as the Indian Institutes of Technology, many more come from these smaller colleges. Of these 900 students who graduated the SPCE CE/IT program, over 100 pursued further study in the US. The quality of education at these schools, consequently, impacts the readiness of these graduate students.

One author of this paper was a visiting lecturer at SPCE for five months in 2009 and 2010, under the Fulbright faculty exchange program. During this time he instructed classes in operating systems, artificial intelligence, parallel processing, and computer organization; visited and lectured at similar colleges nearby; and conducted faculty development training. During this time he spoke extensively with professors, students, administrators, trustees, and parents of students about their perceptions of the quality of the engineering education at SPCE and similar schools. All of these individuals gave similar reasons why they believe the education offered is inferior to that offered in the Indian Institutes of Technology or in universities in America and Europe: low faculty qualifications, an emphasis on rote memorization, "teaching to the exam", too much theory and not enough hands-on learning.

This paper examines the Computer Engineering and Information Technology (CE/IT) department at SPCE and summarizes the factors that determine its education quality. While the authors recognize that many of these factors are not easily changed, they believe that there is reason for optimism.

## 2. The Educational Environment

Unlike in the United States, the Indian educational system is very rigid. Quality is enforced by requiring colleges to affiliate themselves with a government university with degree-granting power (Gujarat Technological University in SPCE's case). The government university dictates nearly every aspect of education, including curriculum, syllabi, the content of daily lessons, textbooks, and examinations. In exchange, the government university grants the diploma that the students earn. This process leaves very little flexibility to the individual colleges. A computer engineering degree is earned in eight semesters, with an internship in the eighth semester, and no nonengineering courses. Each lecture of each course is scripted, and the instructor is expected to follow the script. Centralized exams, given by the parent university at the end of each course, determine the entirety of the students' marks.

When the author interviewed individuals involved, the preparation of the faculty was cited as the single biggest concern. India has few graduate degree programs for producing new professors, and colleges seldom hire from industry, making for a shortage of qualified faculty. Of the 22 faculty in the CE/IT department, only 7 hold Masters degrees. One, the head of the department, is in the early stages of pursuing a Ph.D. The majority of the faculty have under 2 years of teaching experience and no industry experience; prior to which they were undergraduate students themselves. The faculty hiring guide requires only a first-class Bachelors degree for the Lecturer position<sup>8</sup>. The typical age of a professor ranged from 23 to 27, and the department head, in his early thirties, is the oldest in his department. Not having industry, research, or long-term teaching experience to draw on, many faculty do little more than teach directly from the textbooks. To compensate for weak or absent faculty, most courses are instructed by teams of two to four professors, with the lecture periods divided up between them. At the end of the semester, faculty are evaluated for career advancement primarily on the test scores of their

students.

One key component of the coursework, however, is handled by the college: the laboratory sessions, called "practicals." Weekly practical sessions are held for each course in a computer lab with reasonably modern equipment (Pentium 2s and 3s, running Windows and Red Hat Linux). Unfortunately, like the coursework, the existing practical exercises teach simple rote tasks, not creative design.

The results of this system are troubling. In the best case, students are given a more solid theoretical background than American undergraduates. However, students are not taught to be innovative and are seldom exposed to real-world examples. Textbooks are often out of date (a textbook from 1982 is still used in the Parallel Processing course). Examinations test the memorization of knowledge rather than its application. On working with students on extracurricular design projects, the author found that even the best students required more direction, "hand-holding", and external motivation than students in America.

### 3. Case study: Operating System

*Operating System* is a required course taken by all fifth semester (third year) CE and IT students. The authors instructed parts of this course in the Fall of 2009 and chose to make it a focus of the Short Term Training Program (described below in Section 4). It is consequently examined more closely here.

The course, according to the syllabus, covers the following subjects: "Kernel services, Time sharing, Scheduling, Memory Management, Paging, Virtual Memory, Device Management, File Management, Concurrent Processes, Deadlock, Protection, Distributed Systems". The two textbooks used are "Operating System Concepts" by Silbershatz and Galvin and "Systems Programming and Operating Systems" by Dhandhere. Both the contents of the course and the first textbook are the same as the equivalent course taught in many schools in the US. (Interestingly, though, the Dhandhere textbook was more heavily used in the course because its Indian style of English was more familiar to students and faculty.)

Operating System follows a teaching scheme of two sessions per week (four hours) dedicated to theory and taught in a lecture hall, and a one session per week (two hour) practical, taught in a computer lab. Students are evaluated based primarily on the end-of-semester examination given by the affiliate university. Of the total marks (grade) for the course, two-thirds is determined by the theory portion of this exam, one-sixth by a practical portion of this exam, and one-sixth by homework assignments given throughout the semester. The subject matter actually covered in the course, consequently, focused on material that appears on this exam.

Exam questions and homework assignment problems tend to emphasize rote memorization of concepts and vocabulary. The following questions are typical and come from Assignments 1, 2, and 4:

- *Explain caching and cache-coherency*
- *Draw the complete sequence of process life time*
- *Draw seven-state process transition diagram with notation*
- *Explain Round-Robin & Shortest Job First Scheduling*
- *Define two key properties of an Immutable file*

Practical experiments assigned to students tend to reinforce rote Unix scripting skills. These are typical exercises:

- *Study about the UNIX Commands: date, touch, cat, cp, rm, mkdir, mv, ls, ln, nl*
- *Write a shell script to read 5 digit number and calculate the sum of digits*
- *Write a shell script to find a word in a file*
- *Write a shell script to find out files with ZERO size from current directory*

In the Fall, 2009 semester, theory lectures were instructed alternately (round-robin) by three professors. Lectures were generally non-interactive and taught to classes of 150 students. Professors primarily defined terminology quoted from the textbook. Practical sessions were taught by one professor per session in smaller groups of 20-30 students.

The American author of this paper instructed several theory lectures. He found the students varying in attentiveness. As it became clear that the subjects covered would not be on the exam, about 80% of the students stopped attending these lectures. The remaining students, however, feverishly took notes, and could eventually be coaxed into asking questions.

When asked by the author, ten of these students volunteered to try a creative design project that the author regular gives to his American students. The project asked students to build a simple operating system<sup>3</sup>. Of these students, approximately half sincerely started the project, and quickly completed the first steps, which mostly consisted of following directions. However, upon reaching the first part of the project requiring creative work, all the remaining students became stuck and eventually gave up. In contrast, all of the author's American students completed at least four of the five parts of the project. Of course it must be mentioned that the Indian students did not have a grade-based motivation to complete the project. However, the author has had several American students, not actually enrolled in his operating systems class, attempt the projects independently and successfully complete them.

#### 4. Moving forward

It is encouraging that many administrators and professors recognize that their system emphasizes memorization over creative design. However, short of becoming a university itself, there are few large steps a individual college can do to reform the educational practices. On the other hand, SPCE is taking several smaller steps to expose students to creative design, and improve faculty quality.

"Short Term Training Programs", sponsored by the Indian Society for Technical Education, are week-long development programs intended for engineering college faculty. In December, the authors hosted an STTP on developing practical exercises that emphasize design, with attendees coming from engineering colleges throughout northern Gujarat. The authors introduced faculty to programming projects given to operating systems, networks, and computer architecture students in the United States. Among these projects was the operating systems project mentioned above. Nearly all the faculty were able to complete the projects, and were able to adapt them as practical exercises for their own students. Most faculty had been unaware that there are readily-available alternatives to their present practicals.

Extracurricular student research and design competitions have also been recently introduced. The author observed the first such competition held at SPCE in October. Nearly a dozen students presented research posters and demonstrated programs they had written in their own time. While many of the posters were simply presentations of existing research, some of the programs, utilizing mobile phones

and low level programming, were well designed. Currently, however, only 10% to 20% of students chose to enter the competition.

As these small steps demonstrate, colleges are increasingly open to new ideas for faculty development and student design work. Yet there is limited local support and expertise to draw from. There are several ways, however, that American faculty and schools can contribute:

- Investigate collaborations and partnerships. Colleges are very eager to have foreign faculty visit them and lecture.
- Contribute design projects that can be used as practical exercises. Many Indian faculty are unaware that there are alternatives to their current practicals.
- Review their current examinations and coursework, and provide feedback as to the skills needed for students to become competitive globally.

### Acknowledgements

This work was made possible from a Fulbright grant from the US-India Educational Foundation (USIEF) and the Council for the International Exchange of Scholars (CIES).

### References

- <sup>1</sup>Agrawal, Chahar. "Examining role stress among technical students in India" *Social Psychology of Education*, vol. 10, pp. 77-91, 2007.
- <sup>2</sup>Arora, Bagde. "Human Capital and the Indian Software Industry." Technical Report, Carnegie Mellon University - School of Public Policy and Management, 2006.
- <sup>3</sup>Black. "Build an Operating System from Scratch: A Project for an Introductory Operating Systems Course." SIGCSE Technical Symposium, 2009.
- <sup>4</sup>Burns, "'A Future Unbound': US-India Relations" Speech by the Secretary for Political Affairs to the Heritage Foundation, May 23, 2007
- <sup>5</sup>Garg, Varma. "Software Engineering Education in India: Issues and Challenges." Conference of Software Engineering Education, 2008.
- <sup>6</sup>IEEE Computer Society. "Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering". 2004.
- <sup>7</sup>Pillai, Nair, Bindu. "A Strategic Road-Map to Developments in Engineering Education in India." International Conference on Engineering Education & Research, 2007.
- <sup>8</sup>Sankalchand Patel College of Engineering. "Faculty Norms," 2009.
- <sup>9</sup>White, "Indian Students Flock To The U.S." *Forbes Magazine*, August 2007.