Is Our Engineering Education System Suitable to Fulfill the Needs of the Wireless Industry?

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Abstract
To survive in the globally competitive marketplace, the traditional "microwave engineer" of the past decades has gradually transformed to a "wireless RF engineer." Industry expectations for this new breed are quite different from its predecessor, therefore our universities must develop new programs to prepare young engineers for their careers.

Introduction
Until the last decade, microwave engineers were primarily involved with manufacturing and production of defense communication product, characterized by state-of-the-art high-performance, long product life, high-cost, relatively low volume, and a "Made in USA" label. Product development could take years and cost was not a major factor, since "the government was paying for it." Accordingly, many engineers in the field became specialists, frequently working in isolated environments on a narrow segment of their project.

The end of the cold war and the rapid growth of personal wireless communication industry drastically changed the requirements for successful engineering professionals. Since pagers and cellular phones typically sell for less than $100, manufacturing cost, tied very closely to yield, must be extremely low. Product lifetimes are very short and to be competitive, the "development-to-market" cycle has shrunk from years to months. Instead of maximum performance, development managers often demand the quickest solution, preferably without a lot of time-consuming detailed design. Long-term R&D has been virtually eliminated, and specialists have been replaced by generalists who must know about analog and digital circuits and systems, materials, and manufacturing processes. Global competition is fierce; many of the previously called underdeveloped countries now offer low-cost development and manufacturing capabilities and high-quality products. Finally, today's engineers must also work in teams, made up by members drawn from manufacturing, Q.A., marketing, sales, and finance. To operate effectively in this environment, verbal and written communication and "people" skills are often as important as technical skills,.

To prepare our young engineers for this new environment, teaching methods and undergraduate course curriculum must also change. In yesterday's education system primarily based on theorems and proofs, students do not learn how to deal with today's practical problems posed in industry.

In 1989, a trade magazine (MSN) survey collected input both from educators and practicing engineers, regarding the status of American engineering education. First, a brief questionnaire focusing on undergraduate course curricula was sent to a selected group of educators who teach microwave courses. They were asked to choose the most beneficial courses and tell how they felt about the importance of industrial summer job programs for their students. Next, the magazine's readers were asked to complete a more detailed

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questionnaire on the same topics. A similar survey was conducted by a training organization (BAI) in 1996.

Of the educators selected for the survey, about two-thirds sent back replies. In addition, 500 practicing engineers responded to the questionnaire, a figure that represented slightly over one percent of the total circulation of the magazine.

One of the most interesting parts of the survey was rating the importance of various undergraduate college courses(see Table 1). On a scale of 0 to 10, the reader survey participants rated labs (8.42), microwave circuits (8.28), oral and written communications (7.94), and microwave filter theory (7.58) the highest. The college professors indicated field theory beyond first semester (9.76), math beyond calculus and differential equations (8.57), followed by microwave circuits (8.47), and labs (8.24). Another point of interest was the value placed on oral and written communications; readers gave these skills one of their highest ratings (7.94), while professors rated them considerably lower (5.95). Additional course suggestions by the professors included circuit theory (we overlooked it in the survey,) microprocessor applications, and numerical methods for field analysis. The most frequently suggested courses by the readers (more than 10 mentions) were material technology, optics, ethics, literature and grammar, foreign languages, ergonomics/ human factors, time management, technical writing, advanced physics, and production techniques. In the 1996 survey, the practitioners' ranking order was virtually unchanged, but new courses were added (DSP, Digital Comm. & System Design).

	Readers (1989)	Readers (1996)	Professors
1. Laboratories	8.42	8.51	8.24 (4)
2. Microwave circuits	8.28	8.21	8.47 (3)
3. Oral and written communications	7.94	7.99	6.05 (11)
4. Circuit Theory	7.85	7.44	6.90 (6)
Digital Communications and System Design*		7.21	
Digital Signal Processing*		7.02	
5. Microwave filters	7.48	6.73	6.75 (8)
6. Microwave CAE	7.39	6.90	6.47 (9)
7. Field theory, beyond first semester	7.33	5.10	9.76 (1)
8. Math, beyond calculus and diff equations	7.18	5.15	8.57 (2)
9. Semiconductor theory, beyond Circuits I and II	6.80	5.26	7.71 (5)
10. Systems engineering	6.77	5.41	4.86 (13)
11. Telecommunication system theory	6.58	6.52	5.81 (12)
12. IC/MIC/MMIC	6.39	5.97	6.90 (6)

Table 1. Academia and practitioners significantly disagree about the make-up of necessary microwave engineering course curriculum. Ranking by the professors are shown in parentheses.

When asked to rate five sources of available continuing technical education, in 1989, "learning from colleagues" rated the highest (7.85), closely followed by short courses held by continuing education institutes (6.98). The third most popular source was trade magazines, with a score of 6.27. Reading the IEEE MTT Transactions received a 5.24 mark, while attending IEEE meetings scored 4.70 Additional sources, listed by the respondents, were industry-sponsored short courses or night schools, self-study, and video-taped tutorials. By 1996, fewer mentors were available and most of the learning was sought from other sources (Fig. 1 compares the 1989 and 1996 results).

When asked about the importance of learning non-technical skills such as getting along with co-workers, person-to-person communications, managing people, successful team-building philosophy, 70 percent of the engineers felt that they would benefit from having better “people-skills.” Interestingly, 88 percent of this group stated that either they would not be willing to, or their bosses would not let them, attend courses aimed at non-technical areas.

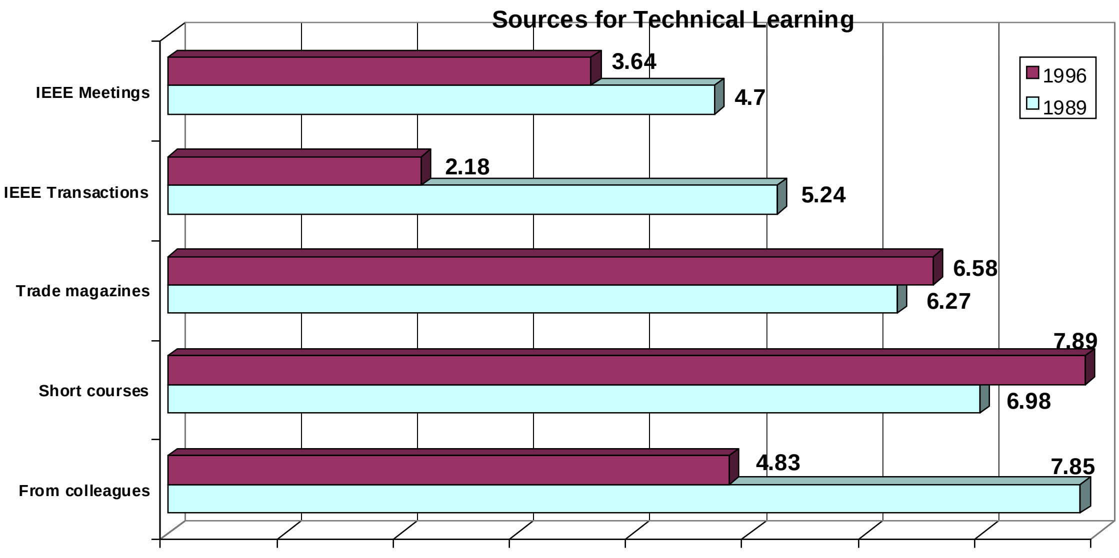

Figure 1. In 1989, mentors provided most of the on-the-job training. By 1996, the emphasis shifted to attending continuing education courses or reading trade magazines.

Many of the participants, particularly in the 1996 survey, complained about the style and quality of teaching methods they faced in college. With the advancements in desktop publishing, students expect high quality audio-visual aids and clear presentations in the classrooms. Professors mumbling into the blackboard, while rapidly scribbling unreadable notations, are no longer appreciated. Students also want labs with real-life circuits and components and teachers who can relate to the same.

In all fairness, we need to recognize that professors are not necessarily at fault. Many were not trained in the art of teaching. Universities are traditionally research institutions, and some professors treat teaching as a "necessary evil" that provides for their cost of living. Faculty staff are generally hired for their potential to do research, which does not guarantee ability or interest in teaching (none of the universities that we contacted require taking even a single teaching course). Once hired, the "publish or perish" principle determines status and promotion, and the fate of students becomes secondary in importance.

Of course there are exceptions. Some EE faculty members do have practical experience and are also capable of passing their knowledge on to the students. Unfortunately, most of them are required to focus their energies only on graduate-level teaching, leaving the crucial introductory courses in the hands of lesser skilled instructors or graduate assistants.

A recently released guideline of the IEEE Educational Activities Board, that advocates directions for engineering education from the employer-need viewpoint, calls for practice- and design-oriented courses and programs, in addition to teaching engineering skills. In addition, the guideline recognizes the need for teamwork and communication skills. Cooperative internship between industry, government and universities are encouraged. Graduate- level engineering programs should also offer teaching practicums for those interested in teaching careers.

Conclusions

Our educational system needs revision to ensure that we capture and maintain the interest of young minds early in their educational process. It is very difficult, if not impossible, to build permanent structures on shaky foundations.

1. Schools need to place the importance of teaching on par with research activities. Those who choose teaching as a profession should be required to pass some level of teaching proficiency, even if it means taking a course or two on the fundamentals of teaching. If applicable, universities should consider relaxing the Ph.D. prerequisite to teaching. Such compromise would probably invite capable and experienced engineers from industry.

2. Companies should recognize the value of continuing education and treat it as a long-term investment that should not fall victim to business cycle variations. Forecasters predict a serious shortage of engineers in the future; therefore, it is very important to maximize the effectiveness of the available work force.

3. The "performance-oriented" design approach should be augmented by "yield-oriented" methods to prepare engineers for today's global, competitive industrial environment. Students should be introduced to the importance and limitations of real-life manufacturing situations.

4. Academia and industry need to establish better two-way communication links, including a healthy exchange program that would benefit both sides. We need more "practitioners" to teach students real-life engineering based on proven practical techniques. We should also work out the details and guidelines of a summer job program for engineering students, and a more meaningful degree program. Perhaps the IEEE could also be involved in these last two tasks.

5. As new technologies emerge, undergraduates need to be exposed to an increasingly broad range of topics, just to develop a basic awareness of what they will face in industry. Many people feel that a four-year engineering program is not sufficient to provide a solid understanding of the technical requirements. Therefore, it is hard to justify courses aimed at developing people-skills. Unfortunately, many new engineers get off to a bad start due to a lack of interpersonal communication skills. Once they are "labeled," it is hard to change the opinion of co-workers and managers. Picking up some basic people-skills while in college would pay off later in their careers.

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