University Contests with Industry Support as Enablers in Multidisciplinary Engineering Education

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Abstract: Engineering education for the 21st century must prepare the future technologists for a rapidly changing environment, driven by the accelerated rate of technical innovation, as well as by the globalization of the activities, enabled by the proliferation of modern information technology. Essential skills for the future are the ability to engage in life-long learning, to communicate and cooperate across disciplines and geographical boundaries. The newly proposed ABET criteria for university accreditation in USA reflect the shift of emphasis in education towards a self paced, group activity, centered on creative problem solving by cooperation and continued learning. The industry can help facilitating the process.
Multidisciplinary cooperative teaching activities are already taking place in many instances. This paper will illustrate some initiatives at various universities, using, as an example, DigitalDNA™ technology from Motorola made available for educational purposes. Students and faculty are using a multidisciplinary approach to, build systems participating in contests. Examples include explorer robots, fire fighting robots or soccer playing robots. The winners are the teams able to effectively combine knowledge and skills in various disciplines, such as electronics, control systems, mechanical engineering, wireless communications, power, manufacturing sciences, etc. DigitalDNA™technology is an essential enabler for future-oriented educational needs, as it represents a rich set of state-of-the-art intellectual property, embodied in integrated circuits, embedded software and system integration methodologies.
The scope of some university contests with industrial participation can and will go beyond strictly engineering tasks, addressing innovative technology or product proposals, supported by a credible business case. Economic considerations, added to the engineering challenge, create a very realistic context, inducing cooperation between engineering and non-engineering disciplines. This is the case of the "Mission XXI" contest, initiated and sponsored by Motorola, in Latin American universities.
Keywords: education, engineering, industry, cooperation

1 Introduction

The pace of the technology development accelerated considerably. Evaluations by specialists, but also direct experience, indicate that engineering knowledge becomes obsolete at an unprecedented extent, in shorter and shorter time intervals. Today it is unconceivable that an engineer will be able to acquire, during the years at the University, the body of knowledge and required to practicing the profession for the rest of his or her active professional life. Under the pressure of modern information technologies, within a few years, many established professions disappeared altogether, many new professions appeared, and even if the profession as such survived, its content, tools, capabilities, products and services are radically changed.
Taking the semiconductor industry as an example, in the slightly more than 50 years since the transistor was discovered, the profession changed several times. Several such changes happened in a period that spans the professional life of an engineer, most of them in the last 10 years. Initially, the training of an engineer in this discipline was mainly in chemistry and in special solid-state physics chapters. With the advent of the integrated circuit, the knowledge was expanded to include network theory and numeric methods for circuit simulation. Now, the level of complexity technologically achievable generates "systems-on-a-chip", requiring multidisciplinary knowledge, different from case to case, relying heavily on software and information technology for application development and design automation. Traditional strongholds of the profession, such as manufacturing and packaging, are increasingly treated as commodities, being delegated to specialized subcontractors. Leading semiconductor companies become system houses, providing hardware, software and system knowledge for embedded systems,

permeating practically all industries and touching all aspects of human life, and building upon the brand value of the company. One such example is the DigitalDNA™ brand from Motorola.

In this environment, a traditional University degree has a rapidly diminishing value, if it is limited to certifying that a graduate acquired, and was able to apply, a certain body of knowledge. Future graduates must have acquired the ability to learn continuously and rapidly, to function, and be productive, in continuously changing environments, to enter in, and take advantage of interactions with various groups, specialized in multiple disciplines, distributed across continents. The methods and style of teaching, the curriculum and the measurement methods must be changed. Some of these changes happen as a result of regulatory measures, such as the accreditation criteria for Universities in the USA, some others take place spontaneously, under social and economic pressures.

2 Proposed Changes to the ABET Criteria

Recognizing the rapidly changes in the workplace of future engineers, ABET issued a series of proposed changes to the accreditation criteria. Under debate right now, the new criteria will be used as an alternative to the traditional criteria until 2003, and will become mandatory starting in the fall of 2004. The spirit of the changes is to replace static rules, such as numbers of semester-credit hours for specific disciplines, with dynamic criteria, institutionalizing a process for continuous evolution and improvement, with the intent that the Academia will keep step with the rapidly changing realities in the working environment. Universities seeking accreditation must have in place a process by which educational objectives are defined and evaluated with the participation of academic and non-academic constituencies, the curriculum and teaching process are aligned with the objectives, and the results are periodically evaluated to improve program efficiency.

To this effect, the proposal enumerates a set of 11 objectives that became known as ABET Criteria 3, a to k. They already affect the way Universities are thinking about their role in the society and the ways they organize and conduct their business.

In the New Economy, the University themselves may undergo dramatic changes, paralleling the changes in the industry. For instance, a 4-year degree will be replaced by life-long learning ("40-year degree"), perceived by employers not as additional cost, but as a competitive advantage. The learner mobility and the distance education using videotapes and regular mail is replaced by distributed, ubiquitous learning, based on internet and multimedia means. The "one size fits all" approach, conveying "just-in-case" knowledge, will be replaced by individually tailored programs, providing "just-in-time" knowledge. Needless to say, the definition of a University is less related to a campus at a particular geographical location, and more a brand, featuring celebrity professors. To drive the process, not only Universities and Colleges, but also departments are installing Industrial Advisory Councils, involved in defining objectives and driving the continuous improvement process.

3 Robots: Academic Projects

Robots of different kinds represent an interdisciplinary subject widely present in Universities around the world. Indeed, robots are, in this context, systems involving mechanics, electronics, sensors, communications, data processing, etc., developed to solve simple task in a controlled environment. As a teaching tool, developing a robot is a task largely aligned with the ABET Criteria 3 a to k. Students involved in this activity will apply knowledge of mathematics, science and engineering (a), they will design and conduct experiments, and will analyze and interpret data (b). They will design and build a system to meet specified results (c), functioning in a multi-disciplinary team (d). In doing this, they will solve engineering problems (e). The students will be in a situation in which effective communication is essential for the success, in particular if the robots are then participating in a contest (g), and will acquire an ability to use techniques, skills, and modern tools for professional practice (k). Such a program can be easily designed to address professional and ethical responsibility (f), integrate engineering solutions in the global and social context (h), to address contemporary issues (j), while making obvious the need for life-long learning (j).

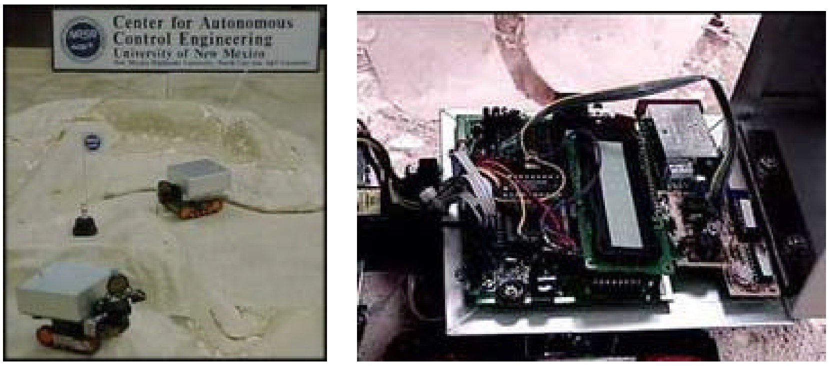

Fig. 1 Robots mapping Mars, developed at UNM, and the control electronics.

Scanning University Internet home pages reveals a remarkable variety of robot-related activities.
Some of them are part of R&D projects driven by scientific and educational interests, such as the NASA Autonomous Control Engineering / PURSUE “Sensor Fusion and Mobile Navigation Project” at the University of New Mexico, USA (http://pursue.unm.edu/pp-75-data/index.html). Two autonomous robots should work together to map their environment (Mars !) in three dimensions, avoiding entrapment, obstacles and destructive environments, while periodically communicating with a remote supervisory computer. The robots are controlled by an on-board microprocessor (Motorola M68HC11, called the Handy-board), and three types of simple sensors: infrared sensors, contact sensors, and sonar. The test environment simulating Mars was constructed at the University as part of the project.

4 Robots: University Contests

Several initiatives in robot development define a specification, then let the robot compete to solve it. The winner is the team that built the robot solving the task in the shortest time. These contests often enjoy the support of industrial sponsors, as the knowledge and skills the contestant will acquire are considered valuable in the modern industry.
One such example is the fire fighting contest held at the Trinity College, Hartford, Connecticut, USA (www.trincoll.edu/events/robot/). This year, it attracted participants from all over the U.S., from Canada, Switzerland, France, Argentina, South Korea, Israel, Palestine, and Australia. . The goal of the contest is to build a robot that can find and extinguish a fire in a house. The computerized (not radio-controlled) robotic device must be able to move through a model of a single floor of a house, 8 ft. by 8 ft, with walls, hallways and rooms. It must be able to detect a fire (a lit candle) and then put it out. Robots that consistently accomplish this task in the shortest time win. The contestants and the event enjoy industrial sponsorship, among others from Motorola’ s DigitalDNA brand.
Similarly, an international contest in Eastern Europe, involving industrial sponsorship, is “The Seventh Annual Students' International Computers Contest HARD & SOFT Suceava 2000”, Romania (http://www.eed.usv.ro/html/hard_soft_contest.html). The theme of this year was to build a vehicle that would follow a path defined by four infrared sources. The hardware was specified in generic terms, like a pair of geared DC motors, a directional infrared sensor, and a DSP card. The contestants were required to build, with some restrictions, a Motor Driver Card and a Sensor Card, assemble the vehicle and write the software that will allow the vehicle to identify each source and drive to them in a specified sequence. Each team runs against the clock.
Alternatively, robots can be required to compete against each other, either individually or in teams. An example driven out of Asian Universities (South Korea), but with a global participation, is the annual world championship organized by FIRA, the Federation of International Robot-soccer Association (http://www.fira.net). As specified in its statutes, FIRA is interested in robotics, sensor fusion, intelligent control, communication, image processing, mechatronics, computer technology, artificial life and related areas, having the goal to take the spirit of science and technology to the younger generation. The means to achieve this goal are intelligent, autonomous robots that will play soccer in different categories of weight and complexity.

The FIRA rules allow for humanoid robots tournaments: a humanoid robot shall have two legs, its size shall be limited to 40cm in height and 15cm in diameter, while the legs shall be within a diameter of 15cm. However, the most popular robot-soccer events oppose field mobile robots without legs. For instance, the “Micro Robots”, of sizes not to exceed 7.5 cm x 7.5 cm x 7.5 cm, compete in teams consisting of three players, one of which can be the goal keeper, assisted by no more than three human team members. The robots of each team are identified by unique patterns on their top surface, are powered by motors and are controlled by a host computer via wireless communications. Two video cameras (one for each team) are overlooking the playing field, the host computer must process the video images, identify the own players, decide upon their actions, and communicate the decision via a wireless communications link.

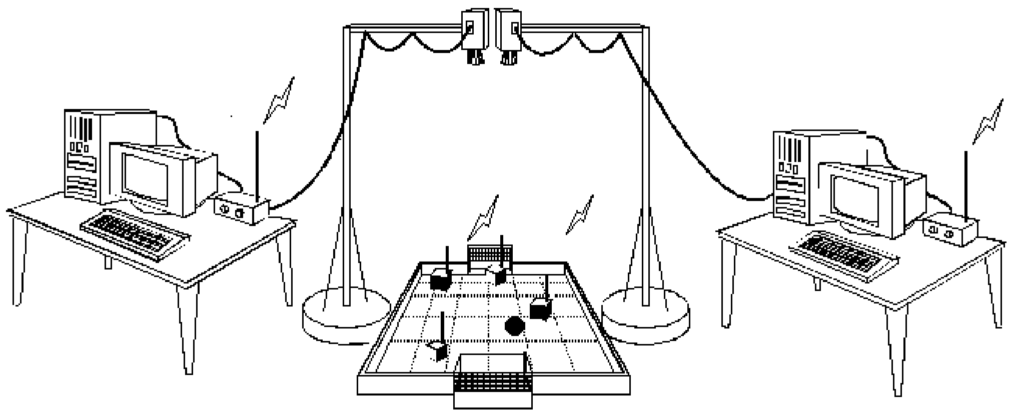

Fig. 2 The overall system view of the robot-soccer competition MiroSot.

It is interesting to note that playing robot-soccer does not impede upon academic achievements. On the contrary, two Canadian students on a team supported by Motorola, have been so busy learning what was necessary to build a competitive robot-soccer team, that they fulfilled the requirements of two years of study in half the time. This seems to give hope that this new paradigm in learning may be in fact more effective that the more traditional teaching methods.

5 Industry Sponsored University Contests

Companies can, and will take initiatives, to generate motivation and provide incentives for the learning process to address industrial needs.
In Latin America Universities, Motorola initiated a University contest to generate creative business ideas in telecommunications, microelectronics and computing, to recognize daring technologies and services proposals having a realistic economic prospective (http://www.mission21.com). The contest intends to become a Virtual Laboratory to generate ideas for the XXI Century.
The contest is opened to multi-disciplinary teams of students, under the leadership of one faculty member, from accredited Latin American Universities, pursuing degrees in engineering, economics, administrations, natural sciences, system engineering and computer sciences, biotechnologies etc. The participants will present their entries that should include an overview and an executive summary, a technical project plan, a commercial plan, conclusions and optional background information.
The first phase of the contest generated more than 600 entries last year. University professors, representatives of governmental development agencies and company executives participated in the jury, who decided upon the project winning prizes. Depending on the alignment of particular projects with business goals of the company, some projects may enjoy a more substantive support or be included in plans for future products or services.

6 Conclusions

Industry and Academia face together the challenges of a world in rapid change, in which the education of newer generation must respond rapidly to new demands. Cooperation is the only effective way to raise to the challenge. University contests with multidisciplinary content, is one possibility to generate change and explore more flexible and effective teaching paradigms.