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Business education reforming engineering education: a multidisciplinary approach

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ABSTRACT: The National Science Foundation (NSF) has sponsored an *Action Agenda for Systemic Engineering Education Reform* (NSF 98-27). A multidisciplinary approach is required in order to achieve this reform . The role of business is pivotal to the reform, presenting the commercial elements of manufacturing activity. This paper describes the design of an engineering degree programme, its range of courses, illustrative projects with the several disciplines employed and learning objectives, as well as implementation aspects of the reform programme.

INTRODUCTION

Globally-Based Engineering Education

National Science Foundation (NSF) grants are awarded to schools to develop and implement two approaches to a globally-based education for engineers.

One approach is an engineering Programme in Integrated, Sustainable Manufacturing (PrISM). This approach allows students to participate in a team effort to design, manufacture and market a commercially viable product. PrISM is structured on engineering courses and on business *module courses*. PrISM provides students with hands-on experience in manufacturing processes, integrated product-process development and design for manufacturing. Business modules include:

- Strategy, negotiation and global competition.
- Entrepreneurship, management of technology and marketing.
- Cost accounting, financial planning and budgeting.

The modules are business courses specifically designed for the integrated effort.

The Engineering Enterprise

The other approach is to participate in an enterprise organisation: an *engineering enterprise*. Students *join* the Enterprise, not unlike taking a professional job position. Enterprise teams are assigned projects with purpose of the project, goals and objectives, and the required disciplines specified. Within the product team, a business student also *joins*, fulfilling discipline requirements.

The entire Enterprise includes conceptual design, manufacturing analysis, prototyping, testing, problem-solving and taking the product to market. The Enterprise activity is scheduled for three years of courses in engineering: from sophomore to senior. Business students take the courses for a technology management concentration in the Business Administration degree.

About Engineering Education

The decade of the 1990s emerged as a time for change in engineering education. In response, engineering colleges have become national leaders in innovative programmes. Among the new standards for engineering are education across disciplines, team learning and undergraduate research [1]. One of the major efforts is to promote a learning atmosphere where faculty serve as mentors and coaches; that is, they move from simply imparting knowledge to helping students discover knowledge. Sponsors provide a mentoring role and act as a resource.

Engineering programmes include concepts such as sustainability, ethics, safety, business process, innovation, creativity and communications. These programmes demonstrate where inquiry and innovation are the norm, where learning and application go hand-in-hand, and where students and faculty work in a team environment on problems of significance to industry [2].

AN INNOVATIVE EDUCATIONAL CONCEPT

In the fall of 2000, the Michigan Technological University, Houghton, USA, introduced a new engineering curriculum option intended to serve the needs of both students and industry [3]. Called the Enterprise Programme, the new curriculum gives a team of students from varied disciplines the opportunity to work for several years in a business-like setting to identify

hands-on solutions of real-world engineering problems supplied by industry. These Enterprises will operate much like private companies. PrISM is part of the engineering curriculum redesign, implementing student-led *Engineering Enterprises* throughout the engineering programme.

At the beginning of the year, an Enterprise team selects a product or product concept for development. Under the leadership of a student Product Manager, student teams identify product requirements, finalise product specifications, and develop and document product designs. They create appropriate manufacturing process flow-sheets and product prototypes and then evaluate both the prototypes and the manufacturing process.

Through these activities, students gain experience with advanced engineering tools, materials and process selection software, as well as rapid prototyping with manufacturing processes such as machining and casting. Experience is also acquired in business fundamentals such as market and product research and project management.

Educational Expectations

The University offers undergraduates an education that emphasises study across disciplines, team learning as well as research. From the position of reformed education, a means is needed to establish a continuing and managing focus of this innovation. Such a means is the University's strategic plan.

The Enterprise Programme is the University's answer to private industry's need for graduates with technical competence but who also have an understanding of the practical application of skills. These skills include the following attributes:

- Strong skills in communication and relationships.
- Conflict resolution, leadership and teamwork.
- Awareness of global markets and competition.
- An appreciation for other cultures and outlooks.
- A firm grounding in environmental and social issues.
- Ethics and professional responsibilities.
- The ability to solve problems and think critically.
- Demonstrated business sense and management skills.
- Provide the facility to learn continuously.
- Use information effectively [1].

All Enterprise employees (students) have prescribed responsibilities corresponding to their maturity, abilities and technical education. Project goals and objectives are further responsibilities of the Enterprise team.

Students enrol in the Enterprise option for six semesters for a total of 16 credits, seven of which result from working on real-world projects, and nine credits involving structured mini-courses or modules [4].

Educational Goals

Students are expected to learn:

- Hands-on experience in solving real-world engineering problems by applying technical and business skills that have been learnt.
- Exposure to the complications of a real-world engineering project.
- The ability to apply critical, analytical thinking and problem-solving skills.
- The development of managerial judgment and project management skills.
- The opportunity to address multiple objectives, accomplish multiple goals and communicate effectively with diverse constituents [2].

This provides heightened awareness of the importance of teamwork in engineering and the challenges associated with a working, diverse and cross-functional team.

Students are expected to perform with:

- A fresh look at important engineering problems to yield potential solutions through the eyes of an unbiased team.
- The application of unique university facilities and faculty expertise to industry projects.
- Exposure to the latest tools, techniques and theory from one of the leading engineering schools in the USA [2].

In addition, faculty members make first-hand observations of the undergraduates' performance within the context of a leading engineering school. Furthermore, sponsors have the opportunity to gain exposure to a pool of talented engineering students from strong technical and business schools [5].

EXTERNAL VIEWS OF REFORMED PROGRAMMES

How implementation is viewed external to the University is important. In some respects, an external view is determinative for accreditation and for the employment of graduates. A comparative view is against expectation in the current global market.

The global market for the *essential skills and attributes* of engineers (above) was recently addressed by Nguyen [1]. Seven generic engineering skills and attributes significant to the modern demands on an engineer have been defined as:

- Technical knowledge and skills, as well as intellectual skills.
- Attitudes and standards of engineering practice.
- Business practices (economic and financial).
- International orientation (culture and language).
- Technical language proficiency.

The overall emphasis of business integration in engineering education was reported as important-to-necessary [1].

A further view is towards effectiveness, that is, will student teams perform given the enterprise team structure and expanding use of project goals and objectives?

Students are given a degree of independence in the team-course structure: guidance by advisors and goals and objectives related to plan and performance.

CONCLUSION

Overview of Reformed Engineering Education

The criteria for the engineering curriculum, as set by the Accreditation Board for Engineering and Technology (ABET), include integrating educational outcomes [6]. Elements in ABET Criterion 3: Programme Outcomes and Assessments, are identified for the accreditation of reformed engineering programmes.

A resulting benefits of the reformed engineering education is the experience needed for future engineering employment, for global commercial competition, utilisation of advances in information technology, the global deployment of manufacturing and service, and imperatives of environmental and sustainable deployment.

This focus on integrated, multidisciplinary education is supported by the American Assembly of Collegiate Schools of Business (AACSB) [7].

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Conference Proceedings of the *4th UICEE Annual Conference on Engineering Education* under the theme: *Innovation in Engineering Education*

edited by Zenon J. Pudlowski

Published by the UNESCO International Centre for Engineering Education (UICEE), this volume of Proceedings comprises papers delivered at the *4th UICEE Annual Conference on Engineering Education* in Bangkok, Thailand. These Conference Proceedings include papers that present a multitude of innovative approaches to engineering education and specific activities, which are demonstrated in the four opening addresses, 12 keynote addresses, 16 lead papers, and over 60 regular papers. It also illustrates the international nature of UICEE meetings and will provide readers with valuable insights and experience in engineering education contributed by academics from almost 30 countries from around the world in the global community.

The Conference's theme of *Innovation in Engineering Education* was chosen to identify and present best projects, programmes and relevant examples, to discuss the importance of the status and quality global engineering education and to debate their impact on best practice and engineering academic endeavour. The papers tackle topics of vital importance to engineering education and have been put into various groups, with each chapter headed by a lead paper that is felt to be most representative of the topic under discussion:

- Social and philosophical aspects of engineering
- Innovation and best practice in engineering education
- Effective methods in engineering education
- The impact of new technology on the effective training of engineers and technologists
- Management of academic engineering institutions
- Engineering and technology education and training in other countries
- Technical issues in engineering education
- Development of new curricula
- Promotion of continuing engineering education, distance education and open learning & Academia/industry interaction programmes
- Quality assurance in engineering education

Several papers included in the Proceedings present research and development activities in the host country, which has several high-class universities included in the ranking list of best universities in Asia. They demonstrate that the global debate on engineering education and the international expansion of interest in engineering education has also had a strong impact on the engineering scene in Thailand.

All papers have undergone assessment by independent international peer referees, ensuring their high quality and the value of the Proceedings for the future.

To purchase a copy of the Proceedings, a cheque for $A100 (+ $A10 for postage within Australia, and $A20 for overseas postage) should be made payable to Monash University - UICEE, and sent to: Administrative Officer, UICEE, Faculty of Engineering, Monash University, Clayton, Victoria 3800, Australia. Tel: +61 3 990-54977 Fax: +61 3 990-51547