

Full Length Research Paper

The new era of engineering: A proposal of establishing school of engineering education

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In this paper, the proposal of setting up a new "School of Engineering Education" has been presented. The paper discusses the prospective location, the possible degrees offered by this institution, the future prospects of the development of this concept as well as the reasons why Engineering Education needs to be handled in this new format of education. The article tries to support the new field by establishing the new school of Engineering Education. The mission of the establishment of this new school is also framed in the given proposal to show the usefulness of the establishing of this new school. The major design and structure of courses and degrees offered by the institution are also discussed in terms of their provided branches, mission and objectives and the career opportunities for the students. Also, the selection and improvement of faculty and teaching techniques has been discussed. Finally, the proposal paper will assist the students to know their future and get their attention in the field of Engineering Education.

Key words: Engineering education, establishment, teaching techniques.

INTRODUCTION

A very debatable issue that faces future engineers in today's business and technology savvy world is "Is it sufficient to have just a solid knowledge of the fundamentals and how to apply them to be successful as a good engineer?" After a lot of debate, research and though, the simple answer to this question from both engineers and engineering educators seems to be a resounding "no." Engineers definitely require a very strong technical and knowledge foundation, but in the work field of today they are frequently called upon to handle situations or scenarios that require the kind of ability or knowledge which was never part of the engineering education curriculum or was just skipped by the educators who designed the traditional mechanical engineering curriculum. This makes it vital that in the future, engineers who wish to retain their competitive edge over others will need to have not only the traditional solid technical base but also a skill set that comprises of many non-traditional skills (Ogando, 2008). In the last ten years, this issue has made it necessary to perform major reforms and institute a new type of engi-

neering education. In response to this need for a new system of engineering education, this paper proposes the establishment of a new "school of engineering education". Engineering educators as well as institutions can support this effort through improvement in their engineering education curriculum, carrying out research and other active measures directed towards professional faculty development (Dee Fink et al., 2005).

Engineering education now has to make changes in order to meet the demands which current times make on the engineering profession. Thus educators as well as engineering faculty have to develop and also learn new ways of teaching and learning for these will need to be further refined and constantly upgraded for new and experienced educators alike (Dee Fink et al., 2005).

A lot of traditional educators and those who believe in the "science-centric engineering" formulated through heavy influence of traditional academicians feel that as it is the basic fundamentals suffer due to the introduction of science. This lobby feels that the further introduction of more non-traditional courses in the curriculum will adversely affect the time available for technical basics. Another reason for the development of new "schools of engineering education" is the fact that most of the major

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schools that already offer engineering education courses are more concerned with research and the post graduate programs.

Due to this factor, the undergraduate programs hardly receive the proper attention required and many parents as well as taxpayers and legislators have raised concerns on the de-emphasis of undergraduate education at major universities (Smith, 1990). Corporate organizations and employers have stated that lack of professional awareness, inadequate levels of communication and teamwork skills in engineering graduates have been a major issue of recent (Technical Report TMR 152, UK, 1984; Evers et al., 1998; Sparkes, 1989).

The location of the new schools of engineering can be determined according to the needs and the existing engineering education options in any given area, but basically the need of such schools in smaller towns where students cannot afford to go to larger and distant institutions is overwhelming and more appropriate. This is supported by the success of smaller institutions such as Harvey Mudd, Olin College and Rose-Hulman Institute (Murray, 2008). Also, the location of any new school of engineering will also be determined by demand such as the number of potential students that area has government allocation of land and other compliance issues related to the start up of a new educational institution.

LITERATURE REVIEW

During the last two decades, there have been several publications that emphasize the need for new engineering education systems and improvement of the undergraduate engineering curriculum (Dee Fink et al., 2005). The titles of these publications are self-explanatory in nature and depict the need to fill the gap between engineering education and the current engineering schools (titles of important publications include: *Engineering Education for a Changing World*; *Engineering Education: Designing an Adaptive System*; *Restructuring Engineering Education: A Focus on Change*; *Shaping the Future*; *Transforming Undergraduate Education in Science, Math, Engineering and Technology*; and *Reinventing Undergraduate Education*) (Dee Fink et al., 2005).

The available literature today points to the urgent need for major reforms in the curricula in order to equip students to the demands that will be made on them in their career. In a series of six informative research papers on 'The future of engineering education', Woods et al. (2000c) have discussed various aspects related to this field and offered insights and solutions to problems ranging from the need to have new schools of engineering education, teaching methods that work, developing critical skills, learning how to teach, assessing teaching effectiveness to how to make reforms work effectively.

Mills and Treagust (2003) published a paper that explores the application of problem-based and project-based learning to engineering education and reviews the

differences between them. This paper also presents specific examples of where these methods have been utilized to date and discusses the effectiveness and relevance of each method for engineering education. Many authors have advocated curricula that combine integrated and experiential teaching with wide exposure to practical engineering experience (Dee Fink et al., 2005).

Engineering education today is expected to include an interdisciplinary approach, incorporate various soft skills ranging from problem-solving, communication, team work and leadership to financial, legal and social aspects as well as an awareness of the social, economic and, environmental impact of engineering decisions (Haghighi et al., 2008).

Engineers in present times are required to use systematic approaches, environmentally friendly designs (Dee Fink et al., 2005) and incorporate ethical as well as legal issues into work (Wulf and Fisher, 2002). As such a total redesign of the engineering education curricula, courses, and degree as well as pedagogy (Wankat, 1999) in the methods due to which new roles of educators and students in the engineering educational field will come about are needed. Educators both present and old ones have to be re-taught their teaching abilities and 'mental moulds' of teaching and learning engineering (Fowler, 2001).

At the same time, these changes might bring about the establishment of new types of degrees and schools of engineering education so as to provide future institutional support. A recent National Research Council report advocated engineering institutions to create both general and discipline-based teaching and learning centers that will be the foundation of support faculty in the establishment and creation of innovative courses and degrees for engineering education exclusively. Simultaneously, the individual engineering educator has to attend programs and take the initiative in self-improvement. These efforts should be supported by their educational institutions where they teach (Wankat, 1999; Womack et al., 1994).

STATEMENT OF MISSION

The mission of the newly established School of Engineering Education will be to design and enhance workable engineering education and learning at all academic levels as well as provide specialized degrees and programs and seminars that will help future engineering students to be ready for successful engineering careers. The primary need for starting these schools is improvement in the engineering education field and the provision of a comprehensive engineering education that will provide skill sets other than the traditional technical foundation.

The next main need to establish this school is that preparing the students to be an expert in both Engineering fields and Education fields. However, PhD in specific field of engineering means that you are an expert in that particular field as a researcher. In another words, having

a PhD in Engineering does not mean that you know how to teach. The emerging discipline of Engineering and Education, simultaneously, is developing and delivering meaningful and memorable learning experiences for future engineers and educators.

Furthermore, this school will help educators both new and old in the field to develop their teaching strategies and skills by learning new and effective methods of teaching and learning in today's environment. This institute intends to provide 'multi-disciplinary or interdisciplinary courses' of engineering to the students so that the new-age engineers have a comprehensive skill set that includes knowledge of management, research methodologies, teaching others, entrepreneurship and the current IT technology.

This institute will hire faculty that can design and teach engineering in way that is imaginative, comprehensive and self dependent. It also wants to offer practical project-based learning to the future engineers as well as educators who can gain some hands-on experience in the industry in order to supplement their academic knowledge base the same time (Chemical Engineering, 2008). The long-term vision of this institute includes higher retention in engineering undergraduate programs through fostering of student interest, overall improvement and reforms in engineering education to meet the demands of changing times and preparation of future faculty of engineering education professionals.

RESULTS

In planning the course content, curriculums and hiring the right faculty for teaching the new curriculum a number of factors and the opinions of several experts as well as professional educational bodies will be taken into consideration (Shuman et al, 2002). In all phases of the engineering right from engineering education to the field, success is not only about technical knowledge. Instead, an engineer in present times has to have a diverse set of skills.

There exists a gap between field practice and what the client needs; efficiency combined with the "socially competent" engineer is today's client demand. The onus now rests with engineering education schools to enforce this diversification while developing culturally competent faculty and engineers. Degrees and programs that are designed to diversify engineering have to be coordinated with research and evaluation-based results which can be applied to engineering education and field work.

Design and structure of courses and degrees

There are several major factors that need to be taken into consideration when designing the courses and curriculum for the new schools of engineering education. These factors include the following:

Information Overload: In the last two decades, the amount of documents available for engineers in print media, the worldwide internet and virtual information has increased tremendously and is going to continue increasing (Woods et al., 2000 e).

Technological advancement: The need to have multi-disciplinary knowledge in order to keep up with the rapidly changing technological advances in the engineering field can be met by cooperation among the previously separate disciplines in tackling engineering problems that have no recognizable disciplinary boundaries (Woods et al., 2000a).

Globalization of markets: Future markets as well as industries must be able to compete on the international level in order to be successful. This will make cultural and economic knowledge just as important as a solid technical foundation (Woods et al., 2000a).

Eco-friendly engineering practices: Profit alone no longer dictates the engineering industry today as this industry has to now achieve profits while making the best of efforts to reduce their carbon print and use of fossil fuels. Thus the concepts of "green engineering" are a must in all courses taught (Woods et al., 2000a).

Changing corporate structures: Corporate structures are becoming increasingly participatory and engineers are expected to take part in the decision-making process. Many of the traditional management positions now filter down to them so a working knowledge of general management is now necessary (Woods et al., 2000a).

Faster change patterns: Curricula must remain in touch with industrial practice by continuously reviewing and providing courses in the "new technology" identifying future change and training students in skills that they will need to adapt to rapid change (Woods et al., 2000a).

There are several effective majors or courses, which the new school is going to provide. The courses will be designed by the school according to the suitability of the students. The courses are going to cover almost all the fields of Engineering. The course materials are going to develop by the Engineering Professionals, who have a working and teaching experience of the several years. The course designs include both the theoretical aspects and practical and technical education. The course material is going to give with the advanced text materials for the easy comprehending of the students.

Either the new School of Engineering Education is going to be small in comparison to the other major global universities; but it is also providing various degree courses for the students. In addition, it will be a good foundation for the new field of Engineering Education The major degrees provided by the new school are Bachelors of Science in Engineering Education, Masters of Science in Engineering Education, Doctorate of Philosophy in

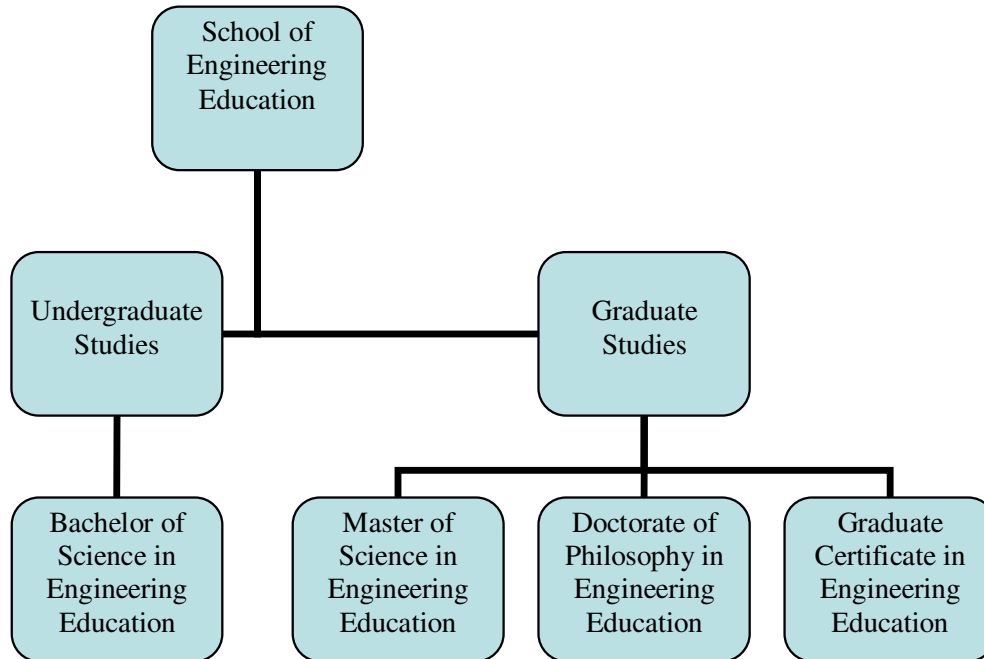


Figure 1. The possible degrees that are going to be offered by the school of engineering education.

Engineering Education and Graduate Certificate in Engineering Education courses for the students, to be chosen, according to their area of interest. In each degree, there are several specializations for the students, which they can select to have dexterity in the particular technical field and can have good career opportunities. The clear description of the each degree is given as under and as shown in Figure 1.

Bachelors of science in engineering education

The initial degree, which the new school is going to offer to the students, is the Bachelor of Science in Engineering Education. There are three specializations of this degree namely, 'Electrical and Computer Engineering', 'Civil Engineering' and 'Mechanical Engineering'. In this degree, the various fundamentals of Engineering are taught to the students such as problem solving, statistics, material science, orchestration, thermodynamics and various other technology based studies (Customize your engineering degree, 2007). The mission of this degree course is not only to provide a BS degree to the students within a specific field of Engineering, but also to furnish a consistent program through which the students can learn to apply fundamentals of mathematics and science in the practical field for the better development of their career. Also, it will give them a better foundation in the education field. After getting this degree from the new School of Engineering Education, the students will have a bright future. The placement services of the school are very effective. The students that are going to graduate from

the School of Engineering Education will be K-12 teacher, Corporate or industrial trainer. Moreover, He can be as traditional engineer with advantage of being engineering leader or as project manager. Also, they will have better jobs as technology experts in IT industries and technology based other industries. They can have good packages with their technical skill in big multinational companies and they can be industrial trainer for the new graduate technicians and the new graduate engineer, as they are having complete technical knowledge and complete educational knowledge.

Masters of science in engineering education

This is another major degree higher than BS offered by the new School of Engineering Education. This degree can be acquired by the students after clearing the BS Degree in any of their selected specializations. The admission in this degree is given on the percentage basis to the students. There are limited seats for this degree, as this is a very higher degree course. This can be done in any field such as Mechanical, Electrical, Civil, etc. The mission of this program is the development of the abilities and experiences of the Engineers; the perfection and command in one of their chosen area, so that, they may have successful progress in future. The main objective of this degree is to make the Engineers, masters in one particular field; hence, they can become better instructors of that particular field (DeLaura et al., 2007). The objective of offering this degree by the University is to provide masters to the society and business entities for better ad-

ministration. After getting this degree, the Engineers can have fast growing future opportunities. With this degree, they can become 'Instructors' in the educational institutions such as community colleges. They can also get the job of 'Supervisors' in technology based industries such as Supervisor industrial trainer or Director for industrial training program. They can also get good jobs in science projects of the governments. They can also have a job as the technical experts with this degree.

Doctorate of philosophy in engineering education

The PhD Degree stands for Doctorate of Philosophy. This degree in Engineering Education is the highest level of degree in this field. These are given to student who has the Masters of Science in Engineering Education and whatever related fields. For attaining the degree of 'Doctorate', the Engineers are required to have very good background in the Master's degrees. This degree from the new school gives the new opportunities to the Engineers to reach at the most advanced fields. With this degree, the Engineers can have specialization in a particular field.

The mission of this program is to develop the 'Specialized Engineers', who possess the skills of doing research on any of the technical fields and contribute to make the nation more technically advanced. The objective of the school with this degree is to make the expert 'Professors and Researchers' in technical fields, so that, they can make the new generation specialist in the same skills. Additionally, they will have education skills of how to teach and develop the research of engineering fields. The other objective is to make the people technology experts. With the attainment of this degree, the Professionals can get the jobs of Professors of the Universities, investigators and forward-looking mortals.

Graduate certificate in engineering education

As we mentioned before, one of the main missions for establishing the School of Engineering Education is to fill the lack or the gap between the engineering field and the education field. As a result of that, the Graduate Certificate in Engineering Education will help and prepare the engineers who hold MS degree or PhD degrees in Engineering and miss the opportunity to pursue the Engineering Education degrees and interested in the academic field to be an instructor or a faculty in community colleges and universities. The mission of this Graduate Certificate is to prepare them by improving their educational skills of how to teach engineering specialized subjects to engineer. At the end, they will be as the same level of Engineering Education PhD holders. They can be universities faculty, Director Research Institutional and Director of Industrial Professional Program.

It is now clear that engineering degrees (Bachelors, Masters and PhD of Engineering Education) of the school

will contain courses that comply with the ABET Engineering criteria:

- In-depth courses in mathematics, science, design and project synthesis, management skills.
- Interdisciplinary and integrative capability will be developed through the introduction of courses on culturally awareness, general management skills, new language courses, a course in engineering economics and basic company law.
- The Bachelors degree program will have courses that are geared towards practice oriented advanced degrees which combine teamwork with social consciousness.
- A fostering of an attitude of a interest and commitment towards lifelong education (Shuman et al., 2002; A Vision for the Future of U.S. Engineers, 2000) will be done through the introduction of community-based projects and workshops for professionals already practicing in the field.

Selection and improvement of faculty and teaching techniques

The is the need to exercise a lot of care when hiring faculty for the new schools of engineering education since a lot of the engineering educators already in the field have a very traditional mind-set and tend to be involved in research rather than teaching. Even though research is an important part of graduate and higher degrees, the undergraduate teaching interests are often overlooked leading to low interest and retention in them.

Basically the faculty will have to shift from "teacher-centered instructions" to "learner-centered instructions" and teaching techniques (Woods et al., 2000 b, c). The faculty will have to handle coverage of fundamentals, use teaching techniques that talk more about "real-world" situations in engineering design and operations, teach basics of quality management, emphasize material on frontier areas of engineering and use improved instructional skills in both oral and written communication and teamwork skills.

New faculty from the social sciences, management and economics field will be hired to provide training in critical and creative thinking skills and problem-solving methods. The selection of such faculty will help and there will be provisions for traditional faculty members to improve their skills through the institution provided workshops, short-term courses and self-improvement programs. All the faculty members will also undergo a yearly student-based evaluation that will help in further improvement of their teaching skills Wankat, 1999).

Some of the new criteria that will be considered when selecting the faculty of this school and which they will also keep in mind when teaching include:

- The educators will no longer be just "talking" heads; rather their role would be more as facilitators of learning.

Student to student collaboration will be given more importance as the faculty makes the transition from teacher-centered instruction to learner-centered instruction (Shuman et al., 2002; Rogers, 1995).

- Teaching methods will be based on improved understanding of pre-held and instruction-generated issues (Shuman et al., 2002).

- Labs will cease to be "bookish," instead there will be more practical-based projects in which students will be asked to do something or told to design the experiment as well as carry it out (Shuman et al., 2002).

- Assessment will be more "authentic" and project-based (Shuman et al., 2002; Woods et al., 2000f).

- Rapidly advancing technology will bring about more distance-learning programs which will be convenient and appropriate to those who cannot afford regular engineering schools (Bourne et al., 2005)

- Educators will provide stronger connections between subjects so that learning becomes interesting as well as contextual each other when integrated together (Chen et al., 1999).

- Students increasingly are from very separate demographic and ethnic backgrounds; a meaningful context for one might not be a meaningful context for another. Thus faculty will face this challenge and need to adopt teaching techniques that cover the needs of all students (Shuman et al., 2002; Woods et al., 2000 f).

DISCUSSION

The schools of engineering education are "the need of the hour" in today's engineering education reforms. They also have great potential of development in the future, which will instill desirable reforms and produce new-age engineers with interdisciplinary knowledge. As already discussed in detail above, the usefulness and need for such schools are vast. In the field of engineering, research and professional bodies have pointed out that the major drivers are experiencing a shift from defense to commercial competition.

These shifts have shaped the future prospects of engineering job sectors, an overflow of information due to massive advances in IT, corporate downsizing, outsourcing of engineering services to other countries and the overall globalization of both the manufacturing chains as well as the engineering periphery services sector (Shuman et al, 2002; Splitt, 2003). Increasingly, employers now require that engineers must have not only a strong technical foundation (the hard skills set) but must also possess an additional set of "soft professional skills" that will comprise the following:

- A strong ability to perform as part of multi-disciplinary engineering teams (Smerdon, 2003; Shuman et al., 2002); this requires a skill set of good communication, the ability to function in all capacities as a team member, and a deep knowledge of the non-technical aspects that affect

engineering decisions.

- A through understanding of professional, social and ethical responsibilities (Oberst and Jones, 2003f; Shuman et al., 2002) of your decisions as they affect others.

- A broader education base that will prepare a future engineer to comprehend fully the impact of engineering solutions in a global, economic, environmental, and societal context (Shuman et al., 2002; National Science Board, 2002).

- The development of willingness and ability to participate in lifelong learning processes (Jackson, 2003: Woods et al., 2000 f).

- A wide knowledge of contemporary issues (Shuman et al., 2002; Woods et al., 2000 d).

In order that future engineers have the above set of skills and are successful, a new engineering education paradigm based on active, project-based learning, integration of subjects, the teaching of mathematical and scientific courses in relation to field application, more interaction of educators as well as students with industry has to be introduced in new age schools of engineering education. There is also the need of wider use of information technology and the development of a faculty that is fully devoted to developing emerging professionals as mentors and coaches instead of "need to know" dispensers of information (Shuman et al., 2002; Pardos, 1997).

Due to outsourcing and globalization to other G-8 countries, a new issue which engineering educators have to deal with today is how to make sure that our graduates will continue to bring value to a market when their salary expectations are thrice those of their international competition. Also, shifts due to the delicate world economy, higher mobility of professional workforce, increased use of communications and IT demand development of the "soft professional skills", thus justifying the need and future potential of new schools of engineering education (Shuman et al., 2002; Pardos, 1997).

In conclusion, it is safe to say that in order to meet the increasing demand on the engineering profession, it is necessary to bring about reforms in the educational system of the engineering schools. This has been to some extent already illustrated by universities like Purdue University that have taken the initiative in establishing a school of engineering education. Educators for future engineers can also be developed with the start of such schools. Therefore it is a viable proposal to establish new schools of engineering that will not replace existing engineering institutions but will in time, make a niche of their own in the engineering education system. Moreover, the new School of Engineering Education with these degrees will be very helpful for the future generations. However, The School of Engineering Education will not substitute the missions of College of Engineering and the College of Education but it will fill the gap between the two fields. In the same way, it will play role of establishing

new generations of innovative and creative Engineers starting from the pre-kindergarten through graduate school and beyond. By establishing the School of Engineering Education under the College of Engineering will build the foundation for the new era of Engineering Education field for the next decades.

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