CURRICULUM NEEDS TO DEVELOP ATTRIBUTES OF ENGINEERING GRADUATES FOR SUCCESS IN 21ST CENTURY INDUSTRY -RELEVANCE OF CHANGES IN USA TO SRI LANKA

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ABSTRACT

This is an exciting and challenging time for Mechanical Engineers worldwide. With the locus of challenging jobs shifting from Government controlled corporations to entrepreneurial firms with global reach, continuing scientific advances and technological innovation, rapid shifts and expansion in critical technologies, and the infusion of computer and information technology into professional engineering has come a need for a new kind of graduate. This new kind of engineering graduate should not only have a sound fundamental knowledge of traditional and evolving areas of Engineering, but be able to adopt to the rapid changes in technology, and have a new skill set referred to as "softer skills" associated with communication, teamwork, and leadership, to be successful in Industry in the 21st Century.

In this paper, we share our experiences working in different parts of the world and for leading global companies in the forefront of technology and business, and emphasize on the additional "softer skills" which are essential for success of our graduates in the 21st century industry.

The Accreditation Board for Engineering Technology (ABET) is recognized in the United States as the sole agency responsible for accreditation of educational programs leading to degrees in engineering. In recognizing the new demands by the world's industry from a 21st century engineering graduate, ABET has adopted a new standard for engineering program accreditation from 2001, referred to as "Engineering Criteria 2000". Engineering Criteria 2000t maintains the traditional core of engineering, math, and science requirements, but also places importance of a new skill set that includes teamwork as well as global, economic, social, and environmental awareness.

Mechanical Engineering programs across the United States are adapting by revised curriculum's to meet these new demands by the world's industry on mechanical engineering graduates, by embedding such skill development in the curriculum. We will survey published literature outlining these curriculum changes, and will examine the relevance of

such changes to Sri Lanka, and present our opinion for curriculum and program needs to continue producing world class mechanical engineering graduates from University of Moratuwa in years to come.

INTRODUCTION

This is an exciting and challenging time for Mechanical Engineers worldwide. With the locus of challenging jobs shifting from Government controlled corporations to entrepreneurial firms with global reach, continuing scientific advances and technological innovation, rapid shifts and expansion in critical technologies, and the infusion of computer and information technology into professional engineering has come a need for a new kind of graduate. This new kind of engineering graduate should not only have a sound knowledge of fundamentals of traditional and evolving areas of engineering, but be able to adopt to the rapid changes in technology, and also have a new skills set referred to as "softer skills" associated with communication, teamwork, and leadership, to be successful in Industry in the 21st Century.

We graduated from University of Moratuwa 18 years ago, where the foundation for our careers in industry were laid with a sound education in the fundamental theories of mechanical engineering. Today, our careers are a tribute to those dedicated professionals who took pain to teach us the fundamentals of mechanical engineering and a few lessons in life. Their dedication and effort under trying conditions, and within a system where such custodians and mentors of our future technology and business leaders are not adequately rewarded is truly admirable.

In this paper, we share our experiences working in different parts of the world and for leading global companies in the forefront of technology and business, and emphasize on this new dimension of "softer skills" which are essential for success of our graduates in the 21st century industry.

1. ABET & USA ENGINEERING EDUCATION

The Accreditation Board for Engineering Technology (ABET) is recognized in the United States as the sole agency responsible for accreditation of educational programs leading to degrees in engineering. In recognizing the new demands by the world's industry from a 21st century engineering graduate, ABET has adopted a new standard for engineering program accreditation from 2001, referred to as "Engineering Criteria 2000". Engineering Criteria 2000, is composed of eight criteria:

1. Students
2. Program Educational Objectives
3. Program Outcomes & Assessment
4. Professional Component
5. Faculty
6. Facilities
7. Institutional Support & Financial Resources
8. Program Criteria

These criteria remain the same for basic engineering courses as well as for higher level courses.

In a nutshell Engineering Criteria 2000, itself emphasizes quality and professional preparation. ABET strives to maintain the traditional core of engineering, math, and science requirements, but also places importance of a new skill set that includes teamwork as well as global, economic, social, and environmental awareness3.

These changes were initially resisted by some faculty in USA before they really got themselves involved. The fact that the first statement of the Engineers' Council for Professional Development (ECPD, now ABET) relating to accreditation of engineering educational pro-grams was proposed by the Committee on Engineering Schools and approved by the Council in 1933, and with subsequent amendments was the basis for accreditation for programs until 2000, highlights the potential resistance and the need for a new criteria. Engineering Criteria 2000, marked the birth of something new but at the same time marked the demise of something old.

Mechanical Engineering programs across the United States are now enthusiastically adopting Engineering Criteria 2000 by revising their curricula to meet these new demands by the world's industry on mechanical engineering graduates, by incorporating skills development in the curriculum. These skills are developed not only through a change in curricula but also through the changes to the delivery of curricula and changes in the learning activity itself.

We will examine the relevance of such changes to Sri Lanka, and present our opinion for curriculum needs to continue producing world class mechanical engineering graduates from University of Moratuwa for generations to come.

2. NEW WORLD ENGINEER

Our own personal experience in the required attributes of a Mechanical Engineering graduate to succeed in today's industry around the world is best articulated in reference1 "The message from our industrial partners concerning the desired attributes of engineering graduates is very clear: a good grasp of engineering science fundamentals, a good understanding of design and manufacturing, good communication skills, curiosity and a desire to learn for life, and a profound understanding of the importance of team work".

The need of the new world engineer is also expressed in a report2 summarizing the outcome from a 1999 workshop at MIT sponsored by the ECSEL (Engineering Coalition of schools for Excellence in Education and Leadership), which brought together faculty, department chairs and deans from a wide variety of US engineering schools. The report states "What does the world now expect and demand of an engineer? It remains true

that our graduates should be well prepared in the fundamental theories, methods and tools of mechanical, chemical and civil engineering. But that, while necessary, is no longer sufficient: Students must be able to deal with ill-defined problems, to exercise judgment in the formulation of a task or in diagnosing faulty performance, able to tolerate ambiguity and work in the midst of uncertainty. For today's world they must know how to marshal evidence in constructing a rational proposal, describing the cost and benefits of one option compared to another and able to communicate that rationale to others. They must be able to put a variety of resources to use, especially the new computer and information processing tools, able to judge which tools are appropriate each task they face. They should be able to work across disciplines, in teams with others who espouse different views, able to understand the non-technical forces that profoundly influence engineering decisions. They should be prepared for active, life-long learning. They too must have an ethical sense; recognize the legitimate role of code and regulation and know the difference between cutting corners and rushed, but fully competent, effort."

Meeting these new demands requires nothing less than a paradigm shift in engineering education. United States academic leaders are already taking action towards that goal.

3. ENGINEERING CRITERIA 2000

On November 2, 1996, the Board of Directors of ABET approved Engineering Criteria 2000, criteria for accrediting programs in engineering in the United States from 2001 onwards. According to the criteria, engineering graduates must demonstrate the following attibutes3:

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design and conduct experiments as well as to analyze and interpret data
3. An ability to design a system, component, or process to meet desired needs
4. An ability to function on multidisciplinary teams
5. An ability to identify, formulate, and solve engineering problems
6. An understanding of professional and ethical responsibility
7. An ability to communicate effectively
8. The broad education necessary to understand the impact of engineering solutions in a global/societal context
9. A recognition of the need for and an ability to engage in lifelong learning
10. A knowledge of contemporary issues
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

While the above are broad objectives required for accreditation, it is the responsibility of the institution seeking accreditation of an engineering program to demonstrate clearly that the program meets the above criteria.

How does the industry rank the above? Industry survey ranking the ABET Engineering 2000 criteria is presented in reference4: "Initial findings of the survey indicate that the most important ABET criteria are the "softer skills" which are: the ability to identify, design and conduct experiments as well as analyze results; formulate and solve engineering problems; to engage in life-long learning; function on a multi-disciplinary team and communicate effectively. This survey indicates that engineering schools will need to improve on the "softer skills" while maintaining their strength in teaching the "harder" technical skills."

The word 'ability' appears in eight of the above 11 attributes compiled by the ABET. Emphasis on "softer skills" and "ability" or competence underline the fundamental shift in engineering education. Being able means being confident and being productive as well. Ability also referred to as competence and forms the corner stone of modern "Competence Based Training (CBT)"

4. INTEGRATING "SOFTER SKILLS" - HOW PURDUE DID IT

Mechanical Engineering programs across the United States is responding to the demands of the 21st century industry, and ABET 2000 criteria with curriculum revisions to integrate "softer skill" development into the curriculum.

Purdue, a highly rated mechanical engineering program in the US, recognized the need for curriculum change to meet the demands of the 21st century industry in the early 90's. In our research for this paper, we were quite impressed with the curriculum revisions implemented at Purdue's school of Mechanical Engineering5, to integrate the development of these "softer skills" in to the core Mechanical Engineering curriculum. The authors will be using the revision of the Purdue's Mechanical Engineering Curriculum, as an example of how to integrate "softer skills" into the core mechanical engineering curriculum.

The first step in the curriculum revision was a self-assessment of the Mechanical Engineering program by Purdue University. Incopera, et al.5, summarizes the conclusion of the assessment of the Purdue's Mechanical Engineering (ME) Curriculum, as follows: "... students were clearly adept at treating problems which had a single pathway to a single result, often by imitating solutions to examples in text. However problems encountered in engineering practice are rarely so structured and typically involve system-level issues requiring a synthesis of diverse inputs .... the following attributes emerged as tenets of a revised curriculum.

- Design should be introduced early in the curriculum and integrated throughout the curriculum.
- A strong foundation in the engineering sciences should be retained, but with greater emphasis on applications to real systems, including the use of basic principles to explore the effect of decisions on system design or performance.

- Greater exposure should be provided to problems and issues which are open-ended and cross disciplinary boundaries, technical and otherwise.
- Increased exposure to engineering practice should be provided through industry-in-the-classroom activities.
- Increased emphasis should be placed on communications (oral and written), again with requirements integrated throughout the curriculum."

Purdue's core mechanical engineering curriculum consist of course sequences in three principal subject areas are :

- The thermal/fluid sciences;
- Mechanics, materials, and mechanical systems; and
- Measurement and control.

Realistic design projects and open ended problems solving are integrated across the curriculum. Elective courses are included to emphasize elements of the design process which relate to product realization. Learning experiences pertaining to engineering practice are being enhanced through increased involvement with industry-sponsored design projects5.

Communication skills are introduced early in the curriculum and reinforced throughout the curriculum. To provide a focal point for the activity, a full-time position of Communication Coordinator has been created and filled with a professional having a Ph.D in communications and some background in science/technology. Student evaluation is continuous and are based on the broader learning experience rather than exams focused on problems which have a single pathway to a single answer. Finally, it has been recognized that assessment of student learning outcomes are essential to evaluate the effectiveness of the curriculum. Procedures have been developed to systematically obtain feedback from students and alumni.

Since the subject of design is central to the revised curriculum, Purdue's ME department recognized that a consensus has to be reached on the definition of design. Incopera, et al.5 defines "design" as follows: "Our approach has been to adopt a broad interpretation of design, viewing it as a process which integrates many diverse technical and non-technical activities to proceed from product conceptualization and definition, through production, and ultimately to disposal. Hence, in addition to considering means by which technical performance requirements may be realized, issues such as customer requirements, manufacturability, cost, safety/liability, intellectual property, and environmental impact are to be included".

Since it has been almost eight years from the curriculum restructuring commenced at Purdue's Mechanical Engineering Department5, the authors researched the current status of the implementation of the recommendations from the assessment. An excellent presentation of the

undergraduate curriculum and course objectives are presented in the university web site6.

Figure 1 show the overall Mechanical Engineering Curriculum, which gives a good overview of how these "softer skills" have been integrated.
Figure 2 presents the overview of Introduction to Mechanical Engineering Design which was developed as a result of the revised curriculum. The course includes treatment of the fundamentals of design and design methodologies, including establishment of customer requirements (recognizing the customer requirements early on in the product development cycle, referred to as customer CTQ's...Critical To Quality... and product development to satisfy these customer CTQ's is the cornerstone of the highly successful Six Sigma quality initiative at General Electrics). The course material also includes methods for concept generation and evaluation; manufacturing, assembly, economic, and ethical issues; and requirements for developing a detailed product/system design.

Figure 3 presents an overview of Mechanical Engineering Professional Seminar, which is another course resulting from the revised curriculum. Providing a solid foundation of professional communication skills is a key objective of this project. Such communication skills are essential for success in the 21st century industry.
Figure 4 presents an example of the core mechanical engineering course Thermodynamics II which is offered in the 3rd year of study.

The authors would like to make the following observations:

- Format of each module of the curriculum highlighting inter-connections of subject content and the course objective;
- How realistic design projects are integrated even in the core curriculum.
- Student assessment is continuous. Assessment methods such as open book exams, percentage of the overall grade assigned to design problems, homework etc. promotes learning and skills development.
- Student Portfolios are encouraged even for highly theoretical subjects such as math.

Finally, Figure 5 presents an overview of Mechanical Engineering Design which is offered in the last semester of the mechanical engineering studies. As a result of experiences accumulated throughout the curriculum, students enter the last semester of their studies with a broad perspective on design, an extensive engineering knowledge base, an assortment of computer tools, and with improved teamwork and communication skills.. The purpose of the Capstone Course is to provide project experiences which draw on these attributes and enhance the student ability to function as an integrator.

The authors consider the Purdue Mechanical Engineering program to be an excellent model on how to integrate the "softer skills" into the core mechanical engineering curriculum in order to educate undergraduates who are going to be successful technical visionaries, and business leaders in the 21st century industry. It is also an excellent example on how to make studying mechanical engineering an enjoyable experience, which a practicing mechanical engineer will enjoy lifelong practicing this vast and diverse profession.

5. CONTEXT OF ENGINEERING IN THE USA AND SRI LANKA

When we endeavor to draw from changes in the USA to guide us in reforming Mechanical Engineering Curriculum in Sri Lanka we must be also cautious of the vast differences observed in the two countries.

In the USA mechanical engineering and engineering in general have seen a continuous period of rapid growth and prosperity over the decades after the World War II. This was initiated by commercial application of war technologies, expanding the horizons of engineering, which in turn triggered a chain reaction of innovation and further commercialization of such inventions. Supported by the dominant role played by the USA in world politics, industry in the USA received a thrust from internal infrastructure development, international aid programs and defense expenditure.

Engagement of the USA in a cold war with Russia and the resulting nuclear, arms and space programs, boosted the image, morale, productivity and national relevance of the engineering profession.

Together with this transformation, ASME, SAE and other engineering bodies in the USA were seen playing an increasingly prominent role in setting engineering standards that were soon accepted and followed by engineers across the world.

In parallel engineering education had its influence from the industry (in the USA 'industry' means the 'private sector'), which had close links with the universities on research programs and funding. High quality of the USA engineering education, availability of scholarships and the promise of an improved standard of living attracted the best undergraduate and post graduate students from across the world, specially from the developing countries.

Emergence of industry leaders, venture capital and an efficient legal system made the USA a heaven for intellectual property development and the preferred place for patents and other rights to be registered. Availability of cutting edge innovations in the form of new patents further propelled the USA engineering.

Increasing acceptance of capitalism across international barriers and removal of tariffs coupled with aggressiveness of the USA industry saw that important global resources and industries coming under the control of USA multi-national companies.

Thus, today after more than half a century of unparalleled growth the USA engineering profession is ready to lead the rest of the world in many areas and the USA is a heaven for engineering education and training.

In stark contrast engineering profession in Sri Lanka, especially mechanical engineering, has seen a set back during the same period. Irrigation and other infrastructure undertaken soon after independence in 1950s, rays of hope brought about by major government enterprises such as Steel Corporation, State Engineering Corporation, River Valleys Development Board, Machinery and Equipment Department etc. in 1960s, Accelerated Mahaweli Program in late 70s and early 80s provided intermittent thrust to the local engineering profession.

Inward looking policies that gave a protection to the local industry were suddenly removed in late 1970s making engineering enterprises a major casualty. Large production workshops that were in the forefront of providing workshop training to mechanical engineers until 1980's are no more: Browns, Commercial, Samuel & Sons, Walker & Gregg etc. Accelerated Mahaweli Program has not produced a single engineering enterprise, contracting or consulting, which has since then entered the international market. Ethnic unrest that surfaced in late 1970s and two armed uprisings in 1971 and 1989 has seen the resources which would have otherwise been invested on infrastructure being diverted for defense and international investor community not taking a keen notice of what Sri Lanka could offer.

Brain drain coupled with the above dealt a devastating blow to the social status of engineering and engineering training.

Most of the surviving government controlled enterprises such as Ceylon Electricity Board, Ceylon Petroleum Corporation, National Water Supply and Drainage Board are on the verge of collapse. While poor public policy is the reason for the imminent failure of these enterprises, such failure would unfairly be regarded as failure of engineers.

In Sri Lanka, engineers in general, are known for their poor softer skills. Failure of engineers to secure an adequate presence in the higher levels of management in private industry as well as public administration has had its impact on engineering and engineering enterprises in Sri Lanka. Often due to poor softer skills, voice of engineers on critical matters that determine the fate of their enterprises and the destiny of their country is poorly communicated with disastrous effects. Their influence on public policy is minimal. As such for the raw graduates picking these skills from their seniors in the industry is not a bright prospect.

As a speaker at a recent seminar pointed out "engineers are recruited for their technical skills, promoted for their leadership skills and fired for their poor peoples skills".

Today it may be argued that engineering as a profession in Sri Lanka has reached an all time low level in its prestige, national relevance, affecting the morale of the engineers as a community.
Mechanical engineering discipline in Sri Lanka has borne the brunt of the adversities discussed above. Today we see that the majority of undergraduates who end up doing mechanical engineering do so because they had not secured a place in a more popular discipline such as Computer Science & Engineering etc. Until the end of 1970's mechanical engineering in Sri Lanka provided bright career prospects and was an equally preferred choice of the best students at the University.

However, mechanical engineering continues to be one of the most popular disciplines of engineering in the United States due to the steady and diverse career opportunities presented to graduates.

6. PROFILE & PROSPECTS OF ENGINEERING UDERGRADUATES

In education the primary client and the beneficiary is the student. Thus, it is important that we understand the aspirations and limitations of our clients.

Today, after a few decades since education in native language was first introduced, the majority of students entering the universities are from a non-English speaking working class background. This is underlined by the fact that almost 90% of students receive Mahapola Scholarship which has a family income limit of Rs 7,500/- as reported by the University Grants Commission7.

Given that only 2% of students entering grade 1 finally enter the university after 13 years, and that the best of them enter the engineering and medical faculties, it may be argued that the academically best 0.5% students do engineering and medicine. Severe competition they have to face may not allow them to develop their personality and softer skills during primary and secondary education.

This is recognised by the Ministry of Education in Sri Lanka (MOESL) which observes that our general education to be seriously flawed with8 "a strong academic bias, lack of practical skills, lack of life skills, mismatch with employment, and focus on competition instead of cooperation".

MOESL further observes that "the education system did not produce pupils with the knowledge and understanding and the skills and aptitudes appropriate for successful living. Total personality development,

characterised by creativity, initiative, discipline, team spirit, respect and tolerance for other people and other cultures, was not achieved."

Thus, when they enter the university at the age of 18-19, majority of these undergraduates seriously lack in command in English, life skills and softer skills.
Even after four and a half years of engineering education in English, lack of knowledge in English is quoted by a significant percentage of graduates as a barrier to win the first job and thereafter in progressing in their careers.

Despite all these problems faced by the profession, engineering education continues to be in great demand in Sri Lanka. Unfortunately it does not stem from an increased demand for engineers from the industry but due to a career in engineering is still a much preferred alternative to those who enter the universities.

In 1999, 631 engineers graduated from the Universities of Moratuwa and Peradeniya. In addition there would have been some others joining the profession from the Institute of Engineers in Sri Lanka (IESL) stream and other streams. The intake of the engineering faculties at Universities of Moratuwa and Peradeniya in 2000 was 1,337. Total enrolment in engineering faculties at Universities of Moratuwa and Peradeniya in 2000 was 5,687 of which 4,129 (73%) being at the University of Moratuwa7. This shows that the cumulative effect of increase in intake over a period of four years, without the country's economy or the facilities at the Universities showing a similar expansion.

This increase causes problems to the academic and other staff and to the undergraduates themselves. Physical infrastructure such as lecture rooms, laboratories and workshops, libraries, hostels, recreation facilities etc per undergraduate may be at an all time low.

From the perspective of already worsening problem of unemployment and underemployment of engineers, such an intake policy could be accepted only if we produce world class engineers, who are willing to migrate and secure jobs elsewhere.

In the past we have had the experience of engineers taking up teaching appointments at public schools. Unless we foresee these macro and micro problems and take immediate action degradation of the whole profession may be imminent.

In contrast, some other professional bodies, both local and overseas operate a policy of matching the industry demand by adjusting the supply. Although such a policy may be impractical due to political reasons, it may be the only feasible solution to prevent the degradation of the profession further and having some of the most talented students in the country frustrated and demoralized after graduation.

There is a widely accepted delusion that tertiary education in Sri Lanka is a monopoly of the government owned 13 universities. There are education institutions operating in Colombo that offer foreign degrees and hold convocations in Colombo itself. Private sector university education in Sri Lanka is a flourishing business and a basic right which should be available to the citizens of this country, as the government is unable to give everyone eligible an equal opportunity.

With relaxed exchange controls, the more affluent leave the shores of Sri Lanka to have their tertiary education completed at a foreign university. Inevitably, most of them do part time jobs in different fields of activity, to supplement their living allowances. In addition to the degree, they gain exposure to a developed country, working experience, and survival and living skills.

In addition Chartered Institute of Management Accountants of the United Kingdom, Institute of Marketing etc. provide opportunities for students to obtain degree level qualifications, which are very well accepted by both the private and public sectors.

With no disruption to the academic programs through strikes etc. that normally plague our universities, these students graduate from compressed courses at the age of 19-22 with a good command in English and equipped with softer skills. When they enter the job market, they are preferred and rewarded better by the employers. They would have accumulated a few years of work experience before their classmates graduate from local universities and they would be ready to peak in their careers as early as at the age of 30-35 holding top positions in the private sector.

On average a B.Sc. Engineering graduate has to wait for 4.4 months after graduation, preferred for managerial positions compared with those who hold other degree, and earn on average Rs 13,379/- per month.

Equipped with softer skills and soon after advanced level, a good percentage of students from popular public, private and international schools in Colombo may command similar or better packages on their entry into the job market.

Implications of this situation are unfortunately not understood by engineering undergraduates at our universities until they meet these smart, relatively young and confident graduates from alternative streams while waiting to be interviewed for the same job.

Perhaps, then, it may be a bit too late. Starting a career at the age of 26-27 does not give anyone much room to peak at between 30-35 as expected by the private sector. It is a known fact that some batches took as long as 7-8 years to graduate due to disruptions to the academic

program. Such situations not only adversely affect the individuals concerned but would badly reflect on the entire professional community.

7. ROLE OF THE UNIVERSITY

Today we have the majority of engineering undergraduates entering the university with very good academic capabilities, strong ability to face competition and lacking in command in English and softer skills.

On the other hand University delivers hard technical skills at an acceptable standard and have no strategy to correct the imbalance created by the primary and secondary education.

Given the proposed reforms in primary and secondary education may not significantly change the profile of undergraduates entering the universities within the next decade, it may be argued that the universities need to proactively compensate for the imbalance in the general education. Thus, the University has to take an increased responsibility of focusing on the softer skills at least until the primary and secondary education reforms are complete.

In this regard, there are two equally important questions the University is confronted with:

- ✓ Are we teaching the 'right thing'?
- ✓ Are we teaching the 'thing right'?

In answering these two questions, we may heavily draw from the USA experience. This is because despite obvious contrast in the two systems, the challenges and problems of the engineering education are the same.

Emphasis on English and softer skills need their inclusion in answers to both the above questions.

It is encouraging that the University has responded to both these questions through a Corporate Plan9 and a revised Curriculum.

University Corporate Plan lists seven goals and associated strategies and objectives. Within the five year period from 2001-2005, the university envisages to play a broader role in undergraduate and post graduate education, research, and policy making and to enhance the standard of physical and intellectual resources.

With these activities the exposure of the academic staff to the industry, their skills and links with private and public sector would be vastly improved.

Implementation of the comprehensive and integrated program presented in the Corporate Plan is extremely important and would require radical changes. Any piecemeal or patchwork approach may prove to be counter productive or even disastrous.

Far reaching changes to the legislation to tertiary education may provide new opportunities and challenges to the University.
While the required policy framework may be provided within the University Grants Commission and Ministry of Higher Education, the initiative and drive has to still come from the within the University itself, undergraduates and the staff alike.

However, ultimate success would largely depend on mobilisation of resources required for the delivery of changes including additional academic and other staff and their training.

In view of the context of engineering in Sri Lanka and the profile and problems of undergraduates, the University has an unprecedented responsibility to respond quickly to the needs of the hour, within a carefully formulated strategic plan. It is heartening to see that the University has understood this role and is making a concerted effort to deliver it.

8. CONTENTS OF MECHANICAL ENGINEERING CURRICULUM AT UNIVERSITY MORATUWA

New Mechanical Engineering Curriculum in its draft form is a refreshing improvement from what we had for years now. In this discussion we would retain our focus on incorporation of softer skills.

However, we would like to make a few general comments as well. While making these comments we appreciate the work of the Curriculum Reform Team and the resource limitations that they may have had to take into consideration in the delivery of the revised curriculum.

Two streams created through optional subjects in Level 4 are a welcome change. Given the limited opportunities available in the local industry, this may compare well with three streams made available at Purdue.

Workload in Semesters SS1, SJ1 and Term T1 appear to be low, and are in line with the previous curriculum. This would change undergraduate expectations of workload at University and may take them by surprise at Level 2. While there may be important and valid reasons for the reduced workload in Level 1, it may leave students vulnerable to developing poor time management etc. At Purdue, optional subjects are offered in Freshman Year itself. However, such an approach may need significant resources.

Engineering in Context and The Engineering Profession, two non technical courses in Term T1, may be advanced to the beginning of Semester SS1 and may be combined as a Professional Seminar in the style and form as at Purdue (Figure 3). It is important that the undergraduates develop a sound understanding of their chosen profession from the day one.

Some other skills that need to be developed in Semester SS1 itself would be learning skills, research skills, presentation skills etc. and could be included in the Professional Seminar. The importance of softer skills development in engineering education and success of a career should be emphasized by making the communication and professional seminar courses GPA credit courses.

After undergraduates complete English and English (Certificate Course) in Semesters SS1 & SJ1 respectively, they may soon follow a Technical Writing Course in Term T1. This may come under Objective 1.2: Strategy 5 - Restructuring of the English Language Training Centre and review ELTC programs to meet the communication skills development needs of the students.

Non technical courses in Level 2 would certainly broad base the knowledge of undergraduates and is a welcome change from that perspective. However, except in the case of for example, Speech & Drama and Finishing Courses, the emphasis is still on gaining knowledge rather than an ability or skill. This imbalance may be corrected through the introduction of skills oriented assignment such as:

- ✓ *Understanding an Entrepreneur;*
- ✓ *Participation in a Community Development Project;*
- ✓ *Socio-economic impact of an Infrastructure Development Project;*
- ✓ Review of Work of a NGO;
- ✓ Vacation employment at a private or public enterprise.

Undergraduates may approach the relevant host organizations or groups and may make their own arrangements as part of the training.

Together with Industrial Training in Term T3 and Semester SS4, undergraduates may study the business philosophy, supply chain, reward system, management style etc. of the host employer as a parallel non-technical course.

This may be in line with the Changes to Industrial Training programs as already identified in Strategy 9 of Objective 1.2 in the Corporate Plan9.

9. DELIVERY OF MECHANICAL ENGINEERING CURRICULUM AT UNIVERSITY MORATUWA

Even after revision, if the emphasis continues to be on acquisition of knowledge as against development of ability, working on well defined problems as against solving ill-defined problems, closed book exams as against open book exams, then we may have lost the plot.

These aspects related to curriculum delivery would determine whether we have successfully incorporated the development of softer skills or otherwise. As discussed earlier following would determine development of softer skills:

- ✓ Making the curriculum and its delivery interesting and enjoyable to students;
- ✓ Introduction of more open book exams;

- ✓ Industry in the class room through solving ill defined problems;
- ✓ Moving away from single assessment, and de-emphasizing the mentality of an education geared towards the preparation of such an assessment ;
- ✓ Introducing design at an early stage, and emphasizing on communication and teamwork throughout the curriculum;
- ✓ Introduction of Student Profiles for course and curriculum;
- ✓ Interaction with the industry.

The ultimate test would be whether the revised curriculum, through its content and delivery, would achieve the development of a graduate with the 11 attributes specified in Engineering Criteria 2000 in Section IV with a commitment to active life long learning.

Changes proposed in the Corporate Plan of the University would certainly lend to the development of softer skills. Most of these changes are encapsulated in Objective 1.2 of the Corporate Plan: "Develop diversity of skills in the students to face the challenges and needs of the global society and industry".

Some of these changes may not cost the University heavily yet they would make a tremendous impact on the quality of graduate engineers produced by the University.

Curriculum and material of foreign universities may be useful if formal linkages could be established with such universities. Greater cooperation between the University of Moratuwa, University of Peradeniya and Rhunu University may also result in greater synergy.

MOESL admits8 "out of a teaching force of 190,000 around 1/3rd are untrained." This problem may be worse at universities. Most of the lecturers join the academic staff soon after graduation and without any industry exposure and training skills. Thus, they have to self-learn teaching and training. Lecturers need to showcase softer skills and they themselves may need further training in these areas. It is encouraging to see that the Corporate Plan9 covers these aspects:

- ✓ Objective 1.2: Strategy 7 – prevent in breeding of academic staff as far as possible;
- ✓ Objective 5.2: Implement necessary staff development programs on a regular basis.

Lecturer/industry, lecturer/student and student/industry interactions would be critical to the transfer of softer skills. Unless the University engages itself in industry based problem solving through research and consultancy, this may not be feasible.

As Objective 4.4: Strategy 2 – Commence a private radio and TV station for Moratuwa and adjoining areas, Corporate Plan9 identifies the need to maintain a prominent public presence and strong relationships with the broader community. Such a project could be used to good effect in

developing the softer skills of students through an open learning environment.

In addition, programs from foreign open universities may be received and broadcast with permission, for the university community and others to sharpen their softer skills.

Extra-curricular activities such as participation in university sports teams have always been an effective method of the development of certain softer skills such as time management, physical and mental endurance, team work and leadership development. The benefits are quite evident from a survey of alumni with such backgrounds who have moved onto significant leadership positions in industry and academia.

Students should be actively encouraged to pursue these avenues of softer skills development, by giving consideration to offering non-GPA elective credit for such participation.

Changes that are discussed in the Corporate Plan would require substantial resources for their implementation and maintenance. Given the current budgetary situation of the government such resources would be beyond annual budgetary allocations of the government. Therefore, within a policy framework of free university education such resources would have to come from a source such as the Asian Development Bank and other overseas linkages. Establishing such linkages would therefore be a priority for the University.

The University has a proud record of achievement in this connection. "The Department of Applied Science at (then) Katubedda Campus was established by forging a link arrangement with the Houldsworth School of Applied Science at Leeds University in the United Kingdom with the help of British Government Aid. Under this agreement senior academic staff members of the University of Leeds visited Sri Lanka to assist with the teaching program, and aid for books, equipment and training of local staff in the United Kingdom was provided. The aid scheme was referred to as Katubedda - Leeds Link."10

It could be argued that greater portion of wealth of the University is in overseas in the form of its distinguished graduates who hold positions of prestige and authority in industry and academia. This network may be used for active assistance in this onerous task of curriculum reform and other changes planned by the University.

These changes together with the other reforms when fully implemented would ensure that the University of Moratuwa would continue its tradition to produce world class mechanical engineers.
We congratulate the team responsible for these changes for the progress they have made so far and wish them resolve and success in overcoming

many administrative, attitudinal, funding and political obstacles that are yet to be encountered.

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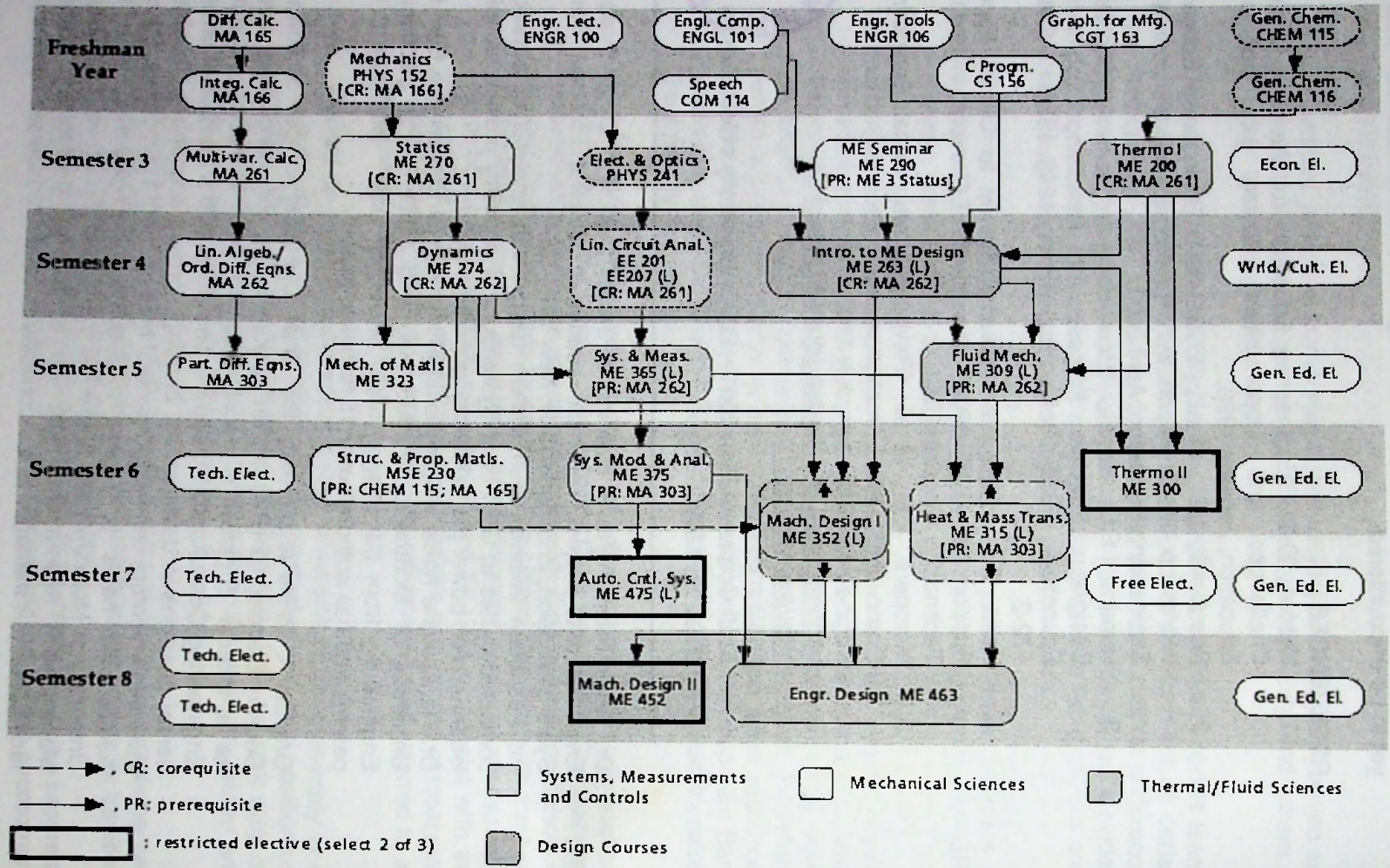
Mechanical Engineering - Program Map

Program 284 - For students who entered ME after Spring 2000

CLICK on a course for more information

Program 283
For students who entered ME prior to Summer 2000
CLICK here



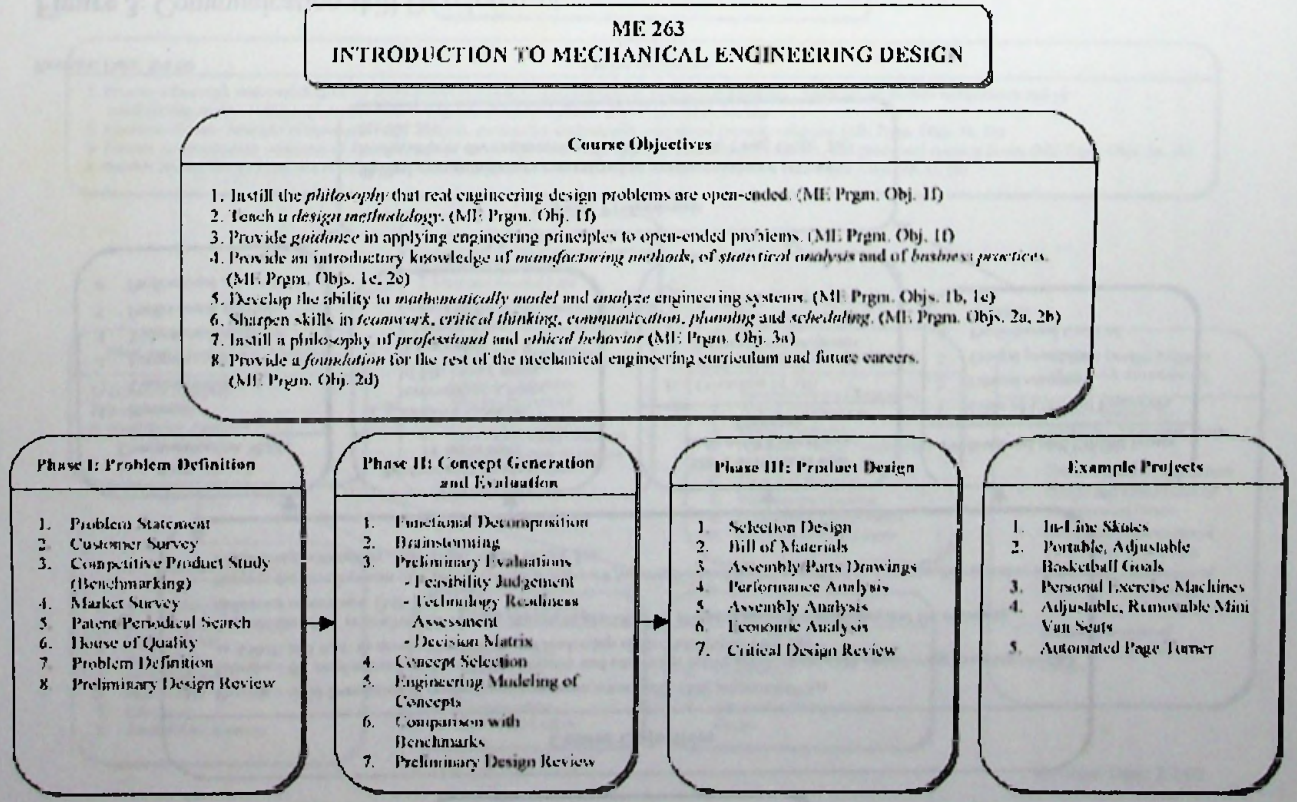


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Figure 2: Early Introduction of Design

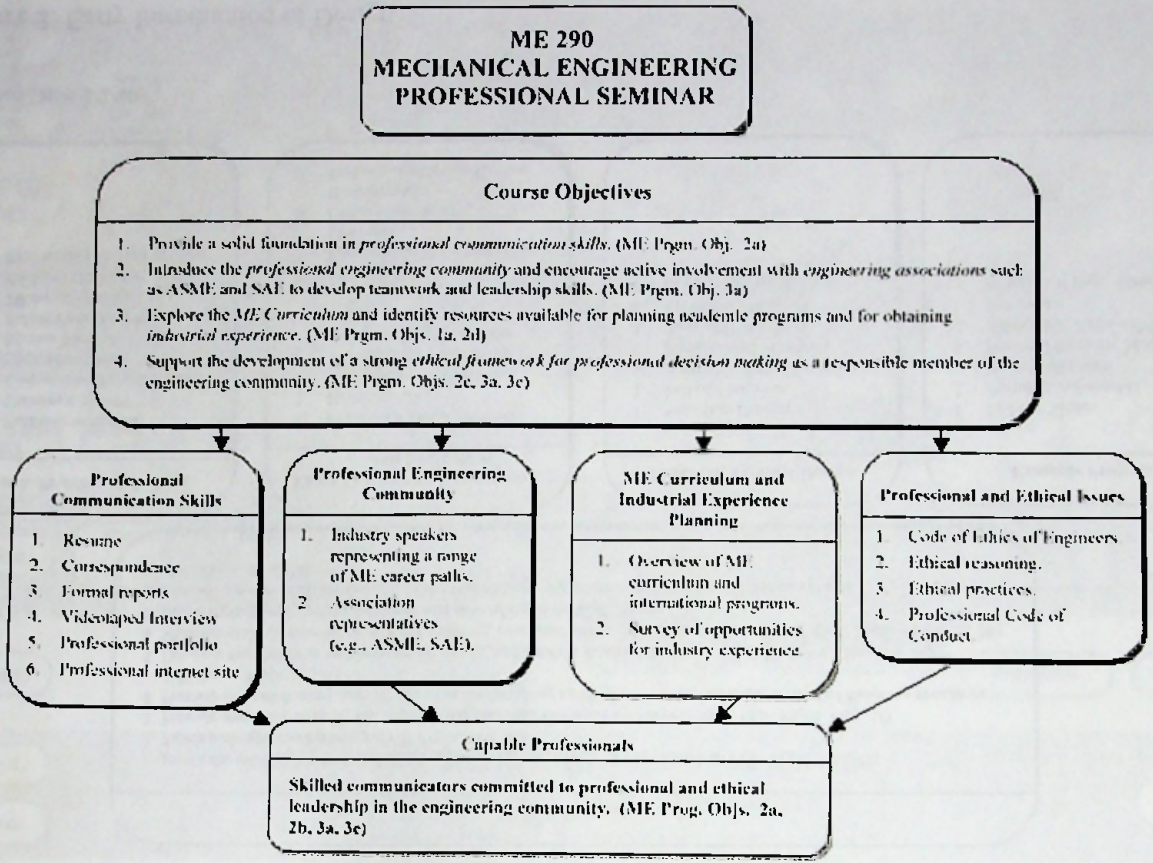

Figure 3: Communication skill Development

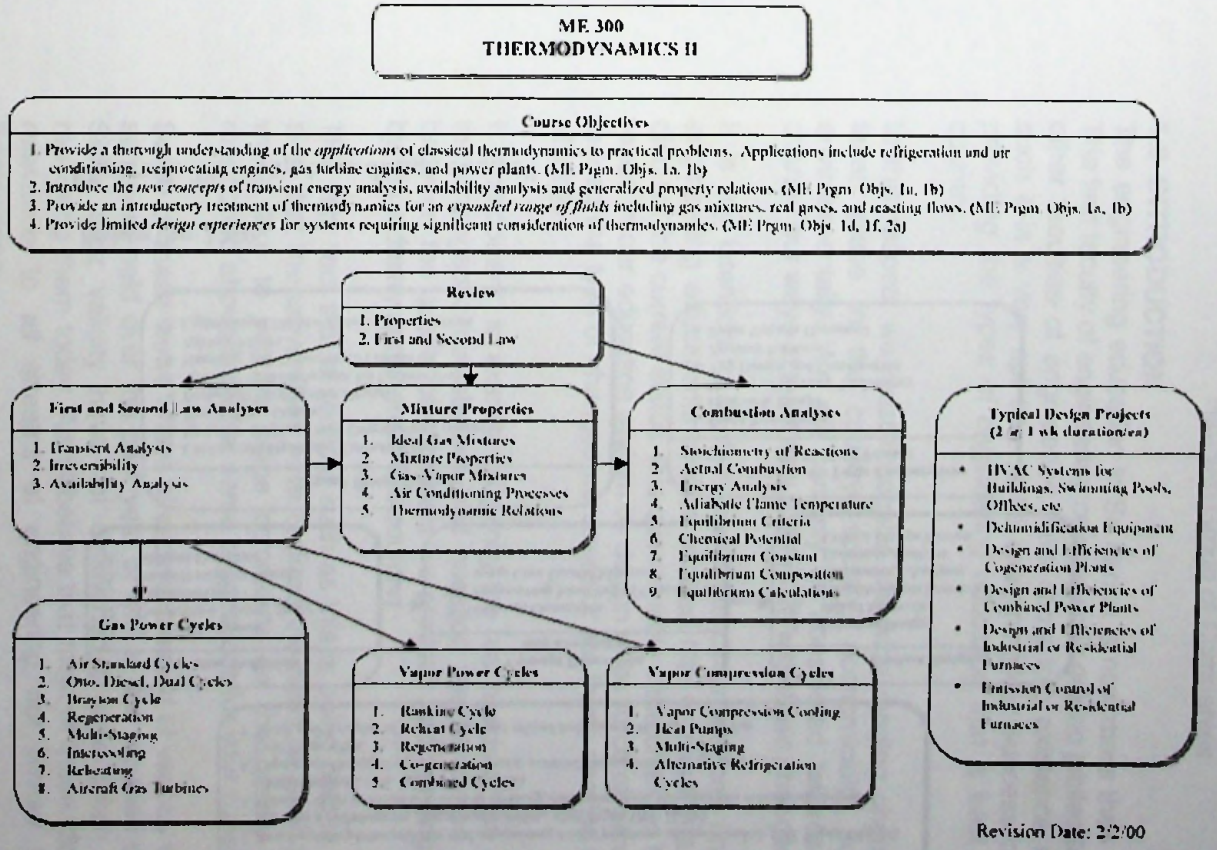

Figure 4: Integration of Design into traditional core subjects

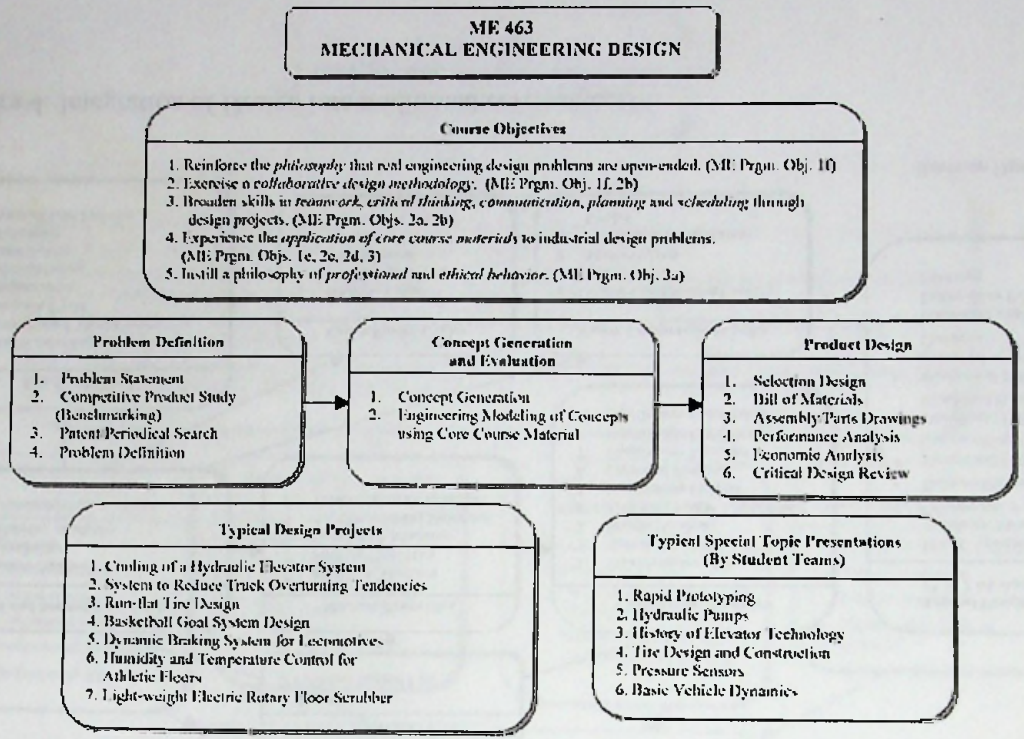

Figure 5: The "capstone design course"