APPROACHES FOR TEACHING MECHANICAL ENGINEERING IN SRI LANKA - USE OF MODELLING AND SIMULATION

Mr.S.Ganesapiragas, Dr.L.D.J.F.Nanayakkara and Dr.S.R.Tittagala,
Department of Mechanical Engineering
University of Moratuwa, Sri Lanka.

ABSTRACT

The factors, which affect the success of Mechanical Engineering profession is identified as a unique one with the country's economic structure and its survival in relation to continually changing world trade. How the profession should pose viable strategies in order to survive and to help the people to attain a reasonable standard of living are our main concern. Engineering is a very vast field comprising many specialized disciplines out of them Mechanical Engineering suffers many difficulties in an unreasonable manner and extent. Healthy profession could be attained only by a sound educational system. We may fail to find satisfactory solutions to the industry's many vexing problems, which involve political issues and economical encumbrances created by it. Nevertheless we can identify the root causes, which may have a bearing on the educational setup, and mainly in the ways subjects are taught and any shortcoming in the variety of subjects offered to the students. Mechanical Engineering laboratories need modern and sophisticated equipment and updating or upgrading them continually is a major financial burden to the Universities and higher educational institutions.

This paper tries to highlight that Applied computing or Customer application software development and computer based treatment of most subjects is a plausible remedy at an affordable cost, if not the total solution.

INTRODUCTION

Engineering profession in this country gets technologies mostly from the advanced countries and adapts them to suit to our needs. The degree of adaptation varies from well adapted to poorly taken-in category. In this paper, no attempt is being made to establish this point by drawing examples from actual or real projects but reader may be able to infer them from his own field experiences. There is a world of difference between carelessly adapted technology and the technology evolved out of necessity and needs subject to the resource constraints by considering the technical skills and know-how resulting from the economic use of prevailing educational setup and facilities.

No country can claim to have immunity from severe competition created by the impact of globalization, globalized world economy and of rapid and effective communication systems provided by satellites, e-mail, etc. Talking of a choice between open-economy and closed-planned one is now mere political or academic pretence as the whole world is already in one global market with no way to retract. In this inextricable and interwoven environment, inputs to the industries should be evaluated meticulously and all the possible steps have to be taken to ensure that the quality and quantity of inputs and outputs planned are appropriate and are economical in accordance with the country's standard of living.

Universities and other higher educational institutions are the major supplier of manpower at the highest level and the highest quality in this country as a whole and specifically to the industry.

INPUT TO THE INDUSTRIES

"Continuous investment is the lifeblood of industries, without it industry stagnates and dies out." This is ever relevant irrespective of whether the country is developed or developing, as one can always elaborate or stretch the meaning of 'continuous investment to suit the country's needs and level of technology it has attained.

The term industry has wide connotations, any activities or infrastructures pertaining to the following endeavours, which are only a few examples:

1. Building complexes for city dwellings.
2. Dams and bridges, road and railway infrastructures.
3. Steel marking plants and other heavy industries.
4. Automobile fleet maintenance and repairs.
5. Computer aided machine (CNC) used to manufacture tailor made parts such as moulds and dies, knee joint especially for a patient measurements, etc.
6. Internet based distance education system.

All the above mentioned activities or projects are needless to say multi-disciplinary in nature.

Important elements of investment are,

1. Personnel, in computer jargon people-ware, investor identifies it as manpower.
2. Machines varying from heavy steel plants to ultra modern information based computers.
3. Land, if the project is more environment friendly there will be less problems otherwise additional constraints and resources are to be considered
4. Venture Capital, either locally raised or foreign investment.

These factors demand attention when making decisions not only in industrial investments but also in planning education.

In this paper focus will be on the issues related to manpower or more appropriately personnel requirement at the level of universities and the other higher educational institutions. In addition to this role technical know-how, technology developed and acquired are also disseminated and propagated by academic communities. All these issues are to be considered and tackled together as a whole, as one is complementary to the other for sustainable and manageable development.

In addition to manpower input, the utilization of land and the creation of venture capital whether by foreign borrowings or by allowing international and multinational companies to invest or any other issues in the sphere of inputs are inter related. Further, the issues pertaining to personnel and technical know-how, to a great extent, are related to the above decision. Certain decisions are normally made at the very top level, may be at cabinet level, and whether engineering profession as a whole can exert a pressure or a say in it, are doubtful. And also it is questionable whether the profession has grown to that maturity and united to create an image, which automatically draws the attention of the top policy makers.

REQUIREMENTS FOR ENGINEERING EDUCATION

Even in the highly developed countries, an engineer is considered and wanted to be a generalist than a specialist because in his career, he takes many decisions, which are multi-disciplinary, and demands general overall perspective of the issue in hand. This is more so in the case of Mechanical Engineer than any other. There is a kind of description, which is somewhat ambivalent goes as an engineer is a specialist in his own field and act as a generalist (manager like person) when it comes to top level decisions. Developing countries should go for a generalist-biased image of an engineer, as their industries are small and medium size by and large. Small and medium industries are ill equipped to employ several specialist engineers and an engineer will have to do a wider variety of jobs without unduly calling in other engineers or external consultants for small scale problems.

"Technology Gap" is considered by William F. Coventry (1) as the failure to utilize the research to economic venture. "....... more generally, a quick ability to exploit other countries' innovations successfully." "The real need is for a harnessing of all such knowledge to coordinated productive ends."

These requirements should be reflected in our educational system but as we have noted earlier that the scenario is changing towards a globalized economy and our engineering graduates will have to face a very wide market. So his prospects are reasonably high, if he proves himself worth to meet the demand.

STRIKING THE BALANCE IN EDUCATION STRATEGY

Engineering educational system has to meet demands that are so varied. The engineer working even in local industry has to face the world market threat in his work because his products and services have to compete with imported goods. He, himself may aspire for foreign employment and further education in advanced countries. Different sectors of the same industry are operating at levels of technology ranging from labour intensive to sophisticated and capital intensive advanced technology. In predicting the future trends and the appropriate level of sophistication needed is not an insignificant issue, but rather demands a think-tank level deliberation. Providing for appropriate technology for small and medium size industries which are going to employ larger portion of engineering graduate output on one hand and endeavouring to meet the needs of the highly specialised global market on the other, has created an unprecedented pressure on educationists and other governmental authorities concerned.

Country's need for more universities are increasing as it goes on in the development path, but failure to provide adequately equipped laboratories result in dilution or diminished quality of engineering students in the existing faculties. These are two competing decision factors. Government in power will have to make the decision either this way or that way depending on the strength of political pressure in making that choice.

WHO DETERMINES EDUCATIONAL STRATEGY

Laurence Urdang's (2) usage of the word 'educationist' is giving some perceptions relevant in this context.

"Educator is another word for 'teacher', though it carries with it the connotation of a person whose teaching has resulted in the presence of people who have not only being taught but educated, that is, people who demonstrate a level of culture and knowledge that is above the average. It is largely a term of respect, usually attained after many years. Educationist is a more recent coinage, though not as recent as some have been led to beleive ....".

In Britain, where the preferred form is educationalist , these terms describe someone in authority on the theory and techniques of education, though not necessarily, an educator (or a teacher)."

So that the educationist in the university and administration with the help of academic's penetrating and in-depth study of a particular field or subject, can draw up a plan which is balanced in every respect including cost of implementation.

NEED FOR STRATEGY IN MECHANICAL ENGINEERING EDUCATION

Any field of study, no matter whether it is in arts or science or engineering or technology, has its unique features. Without these that field will not survive for a long period. When a field blooms into a profession, it has all the attendant (subordinate) problems as a result of interaction and intercourse with the social and cultural environment that prevail in the land. Man is a gregarious animal, he cannot survive in an isolated surroundings. This instinct helps to develop value system in our society such as status, prestige, preference for certain things etc. as well as some notions which are detrimental to the society but they cannot be separated easily.

Causative factors for the weak position of the mechanical engineer in the society, must be studied well in order to find remedial actions. Improved employment status will be an impetus to attract cream of the students into this field of studies.

So far we have examined the factors affecting the mechanical engineering profession, but we should pay more attention to see how the educational system could be reoriented to improve the situation. Drastic changes in the current educational system with enormous investments would be beyond our scope. Dreaming of such gigantic ventures would only lead to frustration. On the other hand, strategies incorporating drastic changes without sufficient ground level preparation are doomed to fail.

Further, to cater the needs of business organizations in new millennium, Yuda Tuva wrote a new book titled as 'Against the flow' which was reviewed in CIMA Management Accountant magazine (November 1999) (3). The following points are relevant even to educational institutions, if they are to go for changes as the means for success and survival.

"It considers the biggest question of all: having chosen the future you want, what should you do next? The short answer is to bring it to the present faster than your competitors. The long answer is to 'use your organization's available levers of changes, as quickly as is organizationally feasible, since taking too long over change can be more damaging than making no change at all.' This addresses the need for responsiveness and flexibility of organisation.

Few changes in the treatment of a particular subject and emphasis on certain manner or fashion of the lectures or practical classes conducted will have profound results. The strategy of offering varied choices of subjects, which give flexibility to the student while offering the education package of mechanical engineering as a modern and dynamic one, is palatable to many students. Students consider favourably if the subjects available are conducive to switch over to their preferred fields in future.

NEED FOR APPLIED COMPUTING IN THE PROFESSION

Many of the computer terms are less rigid as the field itself a very young with tremendous potential to expand its horizon. Like mathematics, computing also a tool in the hands of different professionals for the better or worse. Each professional in his own field is a specialist and analyzes his problem with all his expertise he has gathered from his studies and professional experiences. Some of the problems are similar in procedures but could be repeated with different data sets. These become productivity tools for the professionals. They are ideal for computer based solutions and once the program is developed, it could be reused with or without miner modifications. And this relieves the professional from repetitive work and gives time to be creative and attend to more demanding problems than routine ones. Here we identify the potential for applied computing; without it valuable time would be lost. When a professional engages in the task of programming, he solves his problem and at the same time reviews his procedure for logical integrity. Only logically coherent procedure could be programmed flawlessly. As an added benefit, his exercise gives him valuable training in his own field and a kind of a tool for staff development. Need for the knowledge of applied computing by the professional himself, becomes obvious when he tries to communicate his problem and decision methods to someone who could cast the necessary codes and design the system. This type of or somewhat similar situations arise when Artificial Intelligence AI programmers and knowledge engineers try to extract information from a field expert (a medical professional) for creating a meaningful database. Of course, this takes place at a very high level in computing industry. the task of the professional where he, himself involves in this type of computing work, that is of manageable size is called Applied computing.

It is interesting to identify when exactly the term software could be used to refer to a computer program; as the size and scope of the use of the program increased, it is elevated to software status. Wide scope and application attract the IT professional to develop a systematic software while paying attention to software engineering principles in all the development stages keeping also future version revisions in mind. In customer application software development, professional creates programs, which cater to the needs of a little wider audience than the developer himself. Small add-on packages come under this category.

Mastering some kind of software packages by engineering professional is now a day to day affair. There are scopes to adapt the packages to suit your needs. Professionally developed packages have many common features with other packages and with the operating environment; and the robustness which non-IT professional cannot achieve easily. Customer application software developer simply profit there features available in the environment and concentrate mainly on his application, this pave the way to develop a acceptable program in relatively short time with minimal effort.

LIMITATIONS OF INCREASING OPTIONAL SUBJECTS FOR IT AND COMPUTERS

Introduction of more optional subjects to support computing creates either more workload to the staff or require additional staff with suitable training or even require assistance from other departments of studies, which is difficult to get as they too face similar resource constraints. Staff resources are scarce and difficult to pool around but the ensuing benefits are of paramount importance. Thus the wholehearted effort of a Mechanical Engineering Department to secure this has become an unbearable burden.

It has now become practice in academic departments in the University to offer courses in computer languages such as C, Java, etc. could be offered as a subject (for mechanical engineering students too). In certain British Universities these subjects are given some credit points in a modular system.

COMPUTER ASSISTED TEACHING AS AN ALTERNATIVE

Now, it has become a fashion to have a computer running an attractive word-processing package, in all kind of institutions. Let us not to criticize it because it is a healthy sign, that computer literacy and awareness are already taking place. Being in such computer-literate society and failing to use it widely in engineering education in an effective manner is inconceivable. Common man may be satisfied with mere computer literacy. But engineering students are supposed to develop higher skill such as design of a machine component or production planning and other tasks, which demand detailed knowledge and advanced mathematical abilities in their field of specialization.

Scientific calculators have been there for over three decades and are very valuable to students and practising engineers. It will continue to serve well in the future also. Computer and computing are also a valuable productivity tools like calculators but their potential is more like mathematics as a tool in engineering education. Inculcating the habit if developing professional applications (7) by the use of different computing environments in the student will carry forward into their professional career.

Mathematics relieved us from unwanted recourse into experiments to assert an outcome from a certain situation. With the help of computing, many experiments and situations are simulated on a computer rather than spending on high cost and time-consuming experiments with potential risks.

These facts appear very obvious and you may be wondering what is the point or contention of issue the authors are striving hard to arriving at. Authors have designed and implemented many assignments where software engineering projects of even small scale meant for the mechanical engineering students in areas of CADCAM, air-conditioning, machine design and production management have been able to achieve several educational objectives simultaneously and very cost effectively. There are many simulation programs and software to calculate complicated and intricate problems that arise in industrial situations; wherever possible the students should be trained to use the wide spectrum of sophisticated packages efficiently and to obtain accurate results. Accurate results are very important but in engineering education the method employed to arrive at that solution is far more important.

Customer Application Software development turn the students mind to analyse the problem, develop a methodology that is appropriate in a familiar or in an available environment. Mathematical concepts and even simple logical digressions are interesting and challenging to the young mind than to a matured professional heavily loaded with managerial responsibilities. If the student engineer is trained in this skill, we can hope that he will continue this in his professional career also.

SUPPORTIVE EVIDENCE

You may pose a question whether the above rendering of the scenario is out of experiences encountered or mere projection of ideas and wishful thinking. It is not hard to imagine or conjure such problems and their solutions, only by a cursory glance of books and magazines in related topics. But it is our own experience, which drives us to come out with the proposal that the application software development is a viable and pertinent solution. This approach has to be wide spread in designing and implementing engineering curricula.

Drago Matko et al identifies the importance of Simulation and Modeling in the design, as follows,
" Simulation meaning the imitation or reproduction of certain conditions, is probably older than is commonly thought. The reproduction which is usually on a different scale or representation, but has , or at least pretends to have, the same characteristics but without playing the role of real objects, with the intention of representing some of their characteristics but without having to perform experiments, which could be expensive, dangerous, slow or even physically impossible. Thus Modelling and Simulation are inseparably linked and as such frame the scope of this book." So the same approach plays a vital role in designing curricula.

As we face lack of adequate modern equipment, Simulation of certain engineering problems may to some extent substitute real experiments and augment the quality of the teaching. This could only be achieved when thorough knowledge of the subject to be taught is blended with appropriate computing skill. This is an essential tool affordable at reasonable cost even in Sri Lanka where the University has to upgrade its processes with a minimum of capital investment.

Further Drago Matko et al. state the relevance of these techniques (Simulation and Modeling) in the light of cheaply available PC environment."Although modelling and simulation approaches have been known for a long time, until recently they were not used to great extent because the simulation tools were extremely expensive and were therefore used only as the last possible method. The great advances in computer technology, especially the appearance of the personal computer (PC), quite literally brought the tools for solving mathematical problems into our homes and thus encouraged interest in Simulation and modelling."

With the background experience authors have in the use of such educational processes for enhancing the quality of teaching certain subjects of Mechanical Engineering curricula and having observed fruitful outcomes, authors wish to reiterate the necessity and appropriateness of this method as an essential teaching tool in the ever-changing new computer era.
We like to make reference to the same book by quoting their observations. "So modeling and simulation become cost-effective methods and simulation tools are available to almost everybody: developers, researchers, students, professors, etc."

Several colleagues of ours even in advanced countries find that it is expensive and difficult to perform experiments due cost limitations and wherever possible physical experimentation is replaced with suitable simulation and animation methods. Authors have a lot of confidence in these methods as new avenues for quality teaching.

James S Ross makes a quotation from Aristoles work, in his book on Educational Theory as "There can be no doubt that children should be taught those useful things, which are really necessary." This is a useful idea as authors think that in this computer era, that the students will assimilate engineering subjects effectively when given with computing flavour readily.

James S Ross (5) also draws the attention to the fact by stating that, "Our attitudes towards the curriculum, has been influenced by a desire to assist children to acquire or develop the habits, skills, interest and sentiments which they will need both for their own well-being and for that of the people among whom they will live." When appropriate stuff is given to students, they are useful in two ways, one for the students concerned and for the society to which they have lots of obligations and duties. These are basic facts that have high degree of immunity from becoming obsolete, as their scopes are wider and more general in nature.

But the implementations of these ideas should continuously keep on changing with time and context. Our endeavour in this paper is to draw some attention on computing in a way appropriate to engineering education at present and in near future. Computing in a sense deemed as a skill, of course at a high level. Acquiring this kind of computing skill is very valuable and a need of this hour.

USE OF EFFECTIVE MODELS CUTS COSTS

Much of the pioneering work in science simulations for education was first done in physics (see, for example, Bork 198 1) to simulate difficult, dangerous or costly scientific experiments. As discussed earlier, for many years, industrial, commercial and research establishments have been using large-scale simulators to plan and experiment with expensive and sometimes dangerous processes. For example, by using a simplified version of a nuclear reactor model for education, the program Nuclear Reactor Simulator (AVP 1991), enables students to study the behaviour of an Advanced Gas Cooled Reactor (AGR), in the relative safety of the classroom!

Evidence from a substantial study of 29 secondary pupils, using five computers over three years, involving the use of simulators in mechanics lessons (O'Shea *et al.* 1993), showed that'in a relatively short time a significant amount of conceptual change was detected, which showed up on various measures we used. We found that the number of correct responses and explanations based on correct Newtonian theories increased significantly between the pre-test and post-test and delayed post-test.'

Research by Gallop (1995) using a computer-based simulation of rocket trajectories with 12- to 13-year-old pupils to teach them the relationships between force, gravity, mass, acceleration and distance, found that there was a significant improvement in the pupils' understanding of the relationships between these concepts after having used the computer simulation. This example is taken from the book "Good Practice in Science Teaching What research has to say?
Edited by Martin Monk and Jonathan Osborne" (6), this book deals with the latest research in science teaching methods for secondary students in

The United Kingdom. Their findings are that the pupils' understanding is enhanced with these methods. This is what we hope to achieve with engineering students also when implementing this kind of simulation and modeling methods.

RAM MACHINE SIMULATION GIVES INSIGHT INTO CUTTER PATH SIMULATION AS AN ANALOGY

Here we wish to mention one programming example that could be construed as an strange one but it is taken to explain the fact that deeper understanding of one program may help to develop an insight into another problem which does not show resemblance and relatedness to each other at the first glance. This is a case of generalisation and use of analogies in training the mind for scientific modelling. The model for two entirely different situations can be the same in abstraction as in the following example:

Random Access Machine (RAM) is a hypothetical primitive-computing machine, which understand integers and runs assembly codes with limited instruction set.

Programs for CNC machine, to create or to machine a component, consist of a few numbers of codes categorised as G-codes and M-codes. Particular G-code or M-code may have few arguments, they may relate to co-ordinate positions and instruct machine to move the tool from one location to another location in a particular way; linear movement or circular interpolation etc,. Number of codes are limited and their functions are well defined, this is similar to the set of instructions pertaining to RAM machine.

CONCLUSION

Change is identified as means for achieving high quality teaching of Mechanical Engineering.

Introduction of more optional subjects is necessary to cover electronics biased or computer biased subjects for which students have greater liking. This facilitates them to continue further studies in their preferred choice. There are certain resource limitations of this strategy. These could be overcome by an integrated approach in the design of curricula.

This paper tries to identify that appropriate computing methods and manageable software development activities have a great role to play in Mechanical Engineering Education. And they may permeate into various subjects and ultimately evolve as a subject area that will give much benefit to students following mechanical engineering programmes of study.

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S.Ganesapiragas. TEng, MIMechTE.
He is a Senior Engineering Teaching Assistant in Thermodynamics at the University of Moratuwa. He has engaged in research in CAD/CAM, CAE and Programming especially in AutoLISP.

Dr. L.D.J.F. Nanayakkara is a Senior Lecturer in the Department of Mechanical Engineering, University of Moratuwa. He graduated from the same University in 1974 with B.Sc. Engineering (Hons) in the field of Mechanical Engineering. In 1983 he obtained his Doctorate from the University of Strathclyde, Glasgow. He has been engaged in teaching and research in the fields of Industrial Engineering, Operations Management and Manufacturing Technology.

Dr. S.R. Tittagala is the present Head of the Department of Mechanical Engineering, University of Moratuwa, Sri Lanka