NEED FOR EDUCATION PROCESS RE-ENGINEERING
A Case based on Mechanical Engineering Education

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ABSTRACT

There has been continuous improvement of curricula and the current processes of education have evolved as a result of the many changes that have been taking place in both external and internal environments of the Department of Mechanical Engineering, University of Moratuwa. Triggered by the major structural and curricula changes that are taking place at the University of Moratuwa now under the Government's new higher education policy for Sri Lanka, the Department considered it as timely now to recast its educational strategy. This action has been fuelled by the drastic changes that have been taking place in a cumulative manner in the demand pattern for mechanical engineers in general as well as mechanical engineering education system in the University. As has been pointed out by many researchers into Business Process Re-engineering (1), the time is ripe now for changing from the strategy of continuous improvement temporarily, for a complete Re-engineering exercise as drastic change is the need of the hour in response to the changes, both external as well as internal, that have taken place resulting in a cumulative effect on educational performance. The author presents a model that has been validated based on his experience of over 25 years in the field of Industrial and Manufacturing Engineering and Management. His conclusions are based on his study of the changing teaching environment, in Sri Lanka and overseas and the industrial environment mainly seen through a significant number of industry based projects and other activities he has conducted. The general conclusion is that drastic changes are now necessary in both mechanical engineering industry and educational curricula as well as in the related organisational structure for education in order to make mechanical engineering education competitive beyond 2000, in both local as well as global market.

1. INTRODUCTION

Not withstanding what is being said about the outdated curricula in the Universities there has been continuous improvement in the faculties of Engineering. This has been the result of the engineering lecturers' intrinsic inclination to objectivity and effective management coupled with the dedication and devotion to work by the few who return to serve the country subsequent to their training almost exclusively in overseas universities. Because of the opportunity work overseas, they get better exposure to advanced work environments and cultures that enhance their outstanding intellectual capacity with training in healthier work practices than their contemporaries in certain other disciplines. This fact has been overlooked

2.1 QUALITY

Research conducted in industry in order to assess the requirements of personnel for successful employment in both manufacturing and services revealed that the behavioural aspects of attitudes, motivation and leadership are the most important characteristics of quality compared with a qualification (2). Qualification was given a low prominence as a criteria for work performance. The consensus of the employers as well as teachers is that the behavioural characteristics need a lot of improvement. Certain students as well as employers believe that these are in-built personal characteristics and cannot be reformed much by either the tertiary education in the University or the employer. This belief leads to screening or preferential treatment at the entry point and this is adopted in certain situations. There are counter arguments against this model. The same person behaves differently in different circumstances. The lethargic behaviour of most personnel at work in Sri Lanka particularly in public enterprises gets modified when they work overseas or for a good private or international firm.

On the other hand, it is known that the Mechanical Engineers produced in Sri Lanka are of excellent academic quality. Because of the fact that the employers have a wide choice in selecting graduates for employment as the numbers are much in excess of the challenging places available for a proper career as a mechanical engineer, the employer can choose the best ones available. Even when employed there is gross under employment of the mechanical engineering expertise that has been imparted to the graduate. At present personal characteristics relating to behaviour, communication ability and IT literacy supersede the engineering expertise partly because the latter is not a priority for those employers who under-employ. Mechanical Engineering graduates are recruited to certain jobs purely for their personnal quality and academic superiority established by the fact that that they successfully faced severe competition for admission to the Engineering Faculty. Some acquire additional qualifications in IT and Management mostly by sacrificing their performance at the University degree. This situation is aggravated by the expansion trends of employment opportunities in the services industry as against those in Mechanical Engineering industry. In certain industries there is a currently emphasis on short-term profitability point of view that under estimates the need for wealth creation by value addition. The long term benefits of employing mechanical engineering as a base industry is not recognized.

However, the department has successfully survived in this environment and made their products competitive in the above environment by an integrated programme for developing the individual from his/her first year in the department, i.e. Part I of the degree. Presentation seminars where students quite ably use multi-media to make presentations on general topics, laboratory work and projects at all levels of the course have been long introduced with clear results in the right direction. The integration of computer and IT and mechatronic applications has been popular among the students and those who have taken up mechanical engineering

assignments and project work in these as well as in management have been well placed in their employment. Much more effort is yet to be put in in order to enhance the quality required for their employability by satisfying whatver the perceptions of quality their employers may have.

Not withstanding all this effort the long term survival, if not competitiveness, of mechanical engineering profession in Sri Lanka depends on the opportunities for value addition by wealth creation in industry through the engineering expertise itself rather than anything else. There is very little evidence to witness an appreciation of this need in the country and the definition of quality of graduate continues to depend on other factors mentioned above.

A fact that needs serious consideration is that while the overseas Universities prefer mechanical engineering graduates from Sri Lanka to other graduates in view of academic capability for advanced research, in contrast the Sri Lankan industry prefers overseas graduates for employment. The broad and in-depth knowledge and the analytical ability of the Sri Lankan graduate is recognised well overseas. On the other hand ,in local employment the personal quality and the broad exposure takes priority over the in-depth analytical knowledge and the overseas-qualified graduate is better recognised by the local industry.

The author interprets that the recent unrest relating to the identity of the Technology Diplomates as against that of the Graduates of Engineering had some roots in lack of opportunity for and under-employment of graduates. The Mechanical Engineering education system must be re-engineered without fail in order to cater to the needs of the different market segments in the industry as well as the long term needs of the industry. There are different quality definitions and different aspirations on the educational level of the degree. A further point of relevance is the satisfaction of professional accreditation requirements which has become the order of the day in many countries where the industry attempts to orient University education in the interests of the industry and for this purpose influence the University's quality specifications.

2.2 COST

Compared with the relatively small investment capital required for setting up facilities for Computer and Electronic education, that required for Mechanical Engineering education is extremely high in terms of laboratory equipment needed. At a time when the number of students opting for mechanical engineering is dwindling one cannot expect an increase in the funding (offered in proportion to numbers) and this limits the possibilities for upgrading and expansion. An important point in favour of National Universities is that the possibilities for private sector operators entering into the education of mechanical engineering are also remote for the same reasons. This highlights the need for a National Policy for strongly supporting the education of mechanical engineers who are essential for the country's industrial base.

However, under usual financial pressures the department has pursued other avenues of funding through projects supported by development agencies, offering short courses etc. Recently, there have been instances of goodwill extended from leading manufacturing firms in the country for limited amounts of funds for skill development. The employers are increasingly realising their obligation to support the institutions that produce their manpower pool.

The cost effectiveness of employing academic manpower is an area that deserves serious study as the major obstacle is faced with regard to its shortage. Staff specialisation in narrow teaching disciplines lead to under-loading of staff with low student numbers while the reverse is true for those who specialise in general areas such as management, mechanics etc. There has to be a balance between specialist and generalist teaching assignments for staff. This can only be achieved by assigning teaching work across a spectrum of subject areas at least for lower levels of the degree programme. This is similar to multi-skilling strategy in industry.

The employment of visiting staff is cost effective as the hourly rate of pay for them is low but the time they can spend for course development is also low. On the other hand in areas such as IT, computers and mechatronics it is almost impossible to attract and retain permanent manpower in a mechanical engineering department. For these subject areas visiting staff have to be attractively paid and a long term solution would be re-training all staff to support such fields. A remarkable achievement of the CADCAM project sponsored by the UNIDO was re-orienting existing staff by upgrading their skills within their own disciplines. A similar approach for introducing IT, Computer and Mechatronics would be more cost effective than attempting the recruitment of specialised staff for such areas. This will also promote integrative teaching and learning across a spectrum of subjects. The number of new optional subjects supporting CADCAM, automation, mechatronics, IT and computers could be dispensed with, cost effectively by integrating the material wherever possible in teaching, projects, assignments, laboratories etc. It may be necessary to replace some of the orthodox and deeply theoretical topics. Simulation and modelling used in the class work can cut down the need for expensive hardware in mechanical engineering education (3) to a certain extent where this is acceptable.

2.3 FLEXIBILITY

The old curriculum was rigid and had only a single choice of menu for all mechanical engineering students except for a few optional subjects in the final year. Even here the choice of the optionals by the student was based on the ease of scoring marks more than anything else. Limited choice has been the practice throughout as the strategy of training a versatile mechanical engineer had been deep rooted from the olden times when the training of a highly versatile engineer was considered as what the industry needed. On the other hand, the employment opportunities were uncertain. This required the mechanical engineer to be trained as versatile as possible for him to take up a career wherever opportunity was available. In the other educational streams there have been trends for specialised

training e.g. Electronics and Power Engineering in Electrical Engineering. Considering the current employment trends for mechanical engineers, the new curricula proposes alternative subject groups for choosing at the final level as Manufacturing, Energy Engineering and several optional specializations. Management modules have been made compulsory. (http://www.mech.mrt.ac.lk).

The duration, entry and exit points to the courses have remained mostly fixed. From time to time there have been changes by way of curtailing and shifting in-plant training, proposing to admit diploma students at level 2 and similar minor changes. At present there seems to be a necessity to train a generalist mechanical engineer in addition to the need for specialised engineers (e.g. auto, marine, aircraft) or for analytical capability for advanced research and higher studies. The attempt to put all these requirements into one mould by compromising the needs of all into one casting of curricula seem to adversely affect the course expectations of most students in terms of their perceived career aspirations. Rigid curricula drives some students to consider certain subjects as a burden on them. There bound to be a burden on the staff too in terms of the range of optional subjects offered every year.

With the trend for the introduction of a number of new postgraduate programmes to provide for specialisation, conversion and engineering management background needed, the undergraduate programmes are now being reviewed considering the requirements for a first degree. The provision of continuing education after graduation could also transfer the 'burden' upwards in the undergraduate programme. All these changes demand an unorthodox view point on the academics who eventually draw up curricula after interpreting and translating the requirements communicated by the industry. To what extent this has been happening in the past is another area that deserves debate and remedial action. The need of the day is to make provision for continually customising all academic programmes, undergraduate, postgraduate and short courses frequently just in time to respond even to the short term trends in industry. This leads to the question of agility and responsiveness of the education system.

2.4 AGILITY AND RESPONSIVENESS

The rate of response from Sri Lankan University system to the many changes that have been continuously taking place under different government policies and global trends since independence, has been disastrously low. Mechanical Engineering curricula has been no exception to it except for minor adjustments made from time to time. Nevertheless, the product has been claimed as resilient enough to respond to the demand of the day but their failure in some way is clear from the failure of local industry today to compete successfully in the global arena. Training for Innovation and Entrepreneurship lagged behind the need. Local mechanical engineering firms that have once had a reputation are closed today. Small and medium industry is staggering. Of course, the blame partly goes to the policy makers.

Has continuous improvement effort that is seen in Mechanical Engineering education, quite exceptionally when compared with certain other Faculties of the Universities, been adequate to provide fast response? It is accepted by Business Process Re-engineering (BPR) researchers (1) that continuous improvement (Kaizen) is not a substitute to BPR. The training lead-times (course durations) remained fixed when more and more effective means of education came into existence at an unprecedented rate. Management education remained limited to conventional theory ignoring integrative learning and the development of soft skills. It is only the new curricula that are being implemented now address the issues of technology management, innovation, entrepreneurship and skill development. Compared with certain such trends that are absent even in the Faculties of Science and Medicine, leave alone the Humanities and social sciences, these are great strides towards being responsive at least at the last moment. The question is the mechanisms to be built into the educational system to make it agile and responsive. In this respect the University system has many similarities with the weaknesses of other public sector enterprises that failed respond. There are trends in the private sector to respond to the need and in certain countries by the setting up of Corporate Universities (4). However, Mechanical Engineering education is costly and less attractive for investment by the private sector and the National Universities will be called upon to provide for it at least in the immediate future.

2.5 EMPOWERMENT

The department is known for the practice of democratic and participative management style with positive results. The human system consists of students, academics and non-academics. It is a professional environment and most persons are motivated to achieve. In managing professionals there are strong reasons for promoting teamwork, personal freedom, flatter structures and autonomy. This approach requires an administrative system that is less bureaucratic than what is normally found in the public sector of Sri Lanka. The management of highly educated professionals and students who come from the cream of the intellect of the country needs, certainly, an unorthodox approach.

There has been strong participative style and closeness with the students at the department level. This is not without the cost of extra resources such as time on the staff. Administratively too there is participation of staff in many matters through committees etc. This too increases time to be sacrificed out of directly academic work. The general administration also invites academics in many ways in a participate in non-academic work unrelated to direct academic work such as improvement of physical and administrative environment. This is partly because of the superior qualities of the engineering lecturers in both technical and certain non-technical matters but acts as a hindrance at times against the personal development of non-academic staff for effectiveness in their work. There is student representation at various levels both formally and informally. This provides avenues for greater involvement of students and staff in the decision processes. For the success of this system greater quantum of non-academic support manpower needs to be provided in order to relieve

the direct non-academic work load for the academics. Such manpower needs to be suitably trained and empowered for the operation of the system without much dependence on the academic staff and over-burdening academics to a point of poor academic productivity. The academic manpower is in short supply at the University and empowerment should not be confused with mere involvement in all types of non-academic work. A system to work smarter but not harder must be the slogan of all.

2.6 IMPACT OF INFORMATION TECHNOLOGY (IT) AND COMPUTERS

Vast strides have been made in Mechanical Engineering education in its IT orientation as a result of CAD and CAM entering into the curricula over 10 years ago. IT and computer Projects and assignments for the students in the design of Mechatronic systems, Data acquisition and process control and monitoring, design analysis and manufacturing planning have become an extremely popular choice of the students. Such wide coverage is in contrast to the directions taken by other disciplines and this has acted as a strong employment generator. With the recent trends in the development of internet, e-mail and electronic library access in the University even the old curricula have incorporated new developments and these will be formalised and structured under new curricula. This is a significant development from the days when computer programming was the only application of IT.

Mechanical Engineering professional in industry need to develop personal applications in addition to being able to handle application software (5). For those who graduated long time ago there is the need for continuing education in mechanical engineering and management applications of IT. This is hard to be provided effectively by a non-engineering educator. The use of IT based productivity tools is now considered as a requirement for world-class excellence of a business organisation. IT applications in the academic environment of the university has progressed faster than in the administrative system owing to the obvious reasons. The proper education of students should be by example rather than class-room teaching and this is a gap to be filled soon within the University.

There is a need to promote widespread use of IT and computer technologies in the process of teaching and administration. The student learning processes need to be overhauled with strong IT orientation. This approach has been proven to yield learning effectiveness in many subject areas taught by the department (3). The author estimates that simply by the use of e-mail for routine communication with students, staff and industry both local and overseas and the use of internet cut his work time by factor of nearly 5. This improved the quality and timeliness of response too. As a result he was able to perform a bigger quantum of academic work productively except for the marking of answer-scripts! The factor was higher during his sabbatical leave in the UK as the staff and student IT culture in the UK was more conducive to productivity. The University's plan for providing a major network of computer infra-structure facilities for

administrative, academic and student community needs to be expanded and expedited for developing the IT capability of personnel and students.

2.7 TOTAL QUALITY MANAGEMENT AND JUST-IN-TIME (TQM/JIT)

When designing educational programmes, in order to make proper use of the staff motivation to achieve high absolute standards of quality in education, one has to give serious regard to the satisfaction of student expectations and industry requirements. The involvement of everybody, students, academic and non-academic staff, administration and industry, in the educational system productively in action is of utmost importance. The involvement of the student is being made strong under the curricula reforms and there is more emphasis on student-based learning. Being a professional environment the characteristics of teamwork, academic quality and methods of assessment of staff as well as students are already in place but these need further refinement. The author is of the view that the main weakness is in the operational logistics that leads to wastage and poor productivity of the system.

The quality and productivity of the educational environment is badly affected by the supply logistics. Major needs for mechanical engineering education concern the procurement of industry projects, comprehensive training opportunities, educational material and equipment, computerised class rooms and up-to-date computers, reading material, specialised teaching staff and general infra-structure support. The mechanisms used for acquiring, maintaining and upgrading these are primitive and unscientific. As a result an enormous amount of academic resources are wasted in poor logistics of the operational system. There are no models or stable processes that lead to cost-efficient operation. Certain bottle-necks and overloads faced by both students and staff could be eliminated to create spare time for a greater quantum of work by a systematic approach.

To quote just a few examples, there is no long term partnership with industry for projects, visits, guest lecture, training places, and other collaboration except those occasionally result through personal contacts and interest. These have to be stabilised for continuity and quality. By a modular design of educational programmes the academics can offer a diversified (customised) range of training packages at different levels of undergraduate, postgraduate, certificate as well as for industry in-house training without much extra effort and even for small numbers of participants below the normal break-even number. The productive use of internet and electronic media in this work is essential. The planning of time tables and other programmes need to be done using productivity tools and models. The TQM/JIT approaches must be implemented as much as possible and this will serve to set good example to students too who too will be soon planners of logistics systems in industry. For example the industrial practices of safety and house-keeping by 5S practice is applicable in mechanical engineering laboratories. Both the industry as well as the University need to learn a lot on the implementation of TQM/JIT in the Sri Lankan context. An example has been set by the Marine Engineering division by obtaining ISO 9002 accreditation for quality assurance in their education system. Recently there have been initiatives

taken at the Faculty level for academic quality and discipline which certainly needs a totally changed work culture.

2.8 SUPPLY CHAIN MANAGEMENT (SCM)

There has been continuous dialogue and mutual support between the members of the industry cluster for mechanical engineering mostly through informal contacts. There are alumni who are in industry, staff who temporarily hold positions in industry and research organisations, links with overseas institutions both formal as well as informal. As there are severe resource limitations in terms of expert staff and specialised equipment, the need for strong mutual ties within the industry cluster is felt more than ever. Stable and formal contacts and commitments need to be made in order to safeguard the progress of mechanical engineering education in the country and make it globally competitive. Sharing of resources and know-how among the cluster is the need of the day. This requires supply logistics to be planned and established for this. There must be stable long term commitments for the provision of human resources and other support by specific organisations for mutual benefit.

At the delivery end the requirements of advanced research, specialised industries and general engineering careers in manufacturing and service industry have to be treated as unique market segments that have varied training requirements for mechanical engineers. This has to be catered for in the design of training processes.

To quote a few examples where interaction with industry is being implemented in a small way now is through students projects, in-plant training, industry visits and seminars for students, funding from industry for skill development programmes, occasional guest lectures (most of them unpaid!), lectures on Saturdays (perhaps Monday needs to be made a holiday for students) and outside working hours taken by industry experts, industry awards for best performance, technology transfer by alumni who are mainly expatriates, equipment, display panels and application software provided by industry. These practices are prevalent but they are quite ad-hoc and handled as piece-meal solutions. These need to be promoted and consolidated with curricula objectively using mechanisms of industrial partnership.

3. CONCLUSION

There has been significant continuous improvement efforts in mechanical engineering education in the past. In view of the drastic changes that have taken place with time, now the time is ripe for re-engineering the education process based on a management model for world class. The model proposed is based on eight salient characteristics of world class organisations in business.

The paper proposes action needed for world-class competitive performance in training for mechanical engineering profession. There are gaps to be filled in education as well as in local industry for providing challenging career opportunities for mechanical engineers. The need for

an active interaction with the industry and the setting up of a long term partnership for mutual benefit is identified.

In a negative sense, in the absence of a clear policy for addressing the requirements of a mechanical engineering base for the industry, the current trends for world-classing would be to lose more and more engineering graduates through brain drain if attractive career opportunities are not created within the country by both local as well as international investors. The promotion of self-employment for engineering graduates by training in innovation and entrepreneurship is certainly a sound strategy but this is subject to the national policy for industrialisation. The inevitable national economic consequences of brain drain that deprives the benefits of free education to the country need to be managed effectively by a national level policy. The past experience has been that any personnel development project that ignores such macro-economic requirements is bound to produce more brain drain than national development.

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