DEVELOPMENT OF INVENTIVE, INNOVATIVE AND DESIGN ABILITIES. WHY? AND HOW?

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ABSTRACT

A strong manufacturing industry is essential for the development of a country. Sustainability of a manufacturing industry, in the present highly competitive environment depends on innovative product and process design. Paper analyses why strong inventive, innovative and design abilities are important in this context. Present position, with reasons for same, are analyzed and discussed in detail. Both Universities and Industry are responsible for this situation. How this situation can be rectified, steps already taken, with recommendations on measures that should be taken are discussed. The importance of developing an "Inventive and Innovative Design Culture" is stressed. It is shown that the country can achieve "Industrialized nation" status rather early if due recognition and priority is given to create an innovative, inventive and design culture in Sri Lanka, and work according to a plan with commitment, courage and confidence, with correct identification of priorities.

1. INTRODUCTION

1.1 Background:

Professor Peter Hills says [1], "If a country has the intellectual resources to design what it's people want, and the will to invest in the creation of those products, then it can avoid exploitation by others and provide the wealth that can ensure a happy, healthy and well educated population. It raises itself above being merely a provider of cheap labour and gives its people the means to reap the prime benefits of modern industry". Aren't these two sentences telling us, of our problem in a nutshell, and how to solve it?

Let us be frank and ask ourselves, i) Do we design what our people or country need? ii) Do we (industrial community including government) have the will to invest in creation of those products? The answer to both these question, in general - except in a few isolated cases, seems to be a big "NO". Another question that comes to my mind is "**for whom**" and "**for whose benefit**" are we having our education system and industry? This question was asked from several policy makers, both on education and industrial development. They did not answer, at least not in public. Not that they do not know the answer, but it seems that from their responsible positions better keep silent.

It is crucial to clearly answer these two questions. Recently there was a gathering of 1968 - Engineering batch mates. It was not possible to gather

even 30, including those who have come home for a holiday, out of a batch of 155. What does this mean? Aren't we training our best brains and talents to provide their services to foreign countries and at what cost? Say at least Rs. 400,000/- per engineer. Well, isn't Sri Lanka a fantastic donor agency, donating to developed countries? What about our industry? Are we producing for our people, and what they need? Somebody in a high position recently said that the government's vision is to make Sri Lanka a service oriented nation. Well in a way this goal is already achieved. (We do provide domestic slave labour to Arab world, cheap blue collar labour to same area, and from recent time - with the so called IT explosion - pretty cheap white collar labour as well to multinationals).

Can a country develop without its own industry, an industry to produce the needs of the people? Let alone development, no country can even survive unless it produces the needs of its people. I remember somebody saying "The great king Dutugemunu would have been still fighting the Vijithapura battle if he depended on imported armaments and provisions to fight that battle". (Well doesn't the present war prove that?) Even in Japan 80% of the industrial output is said to be coming from small and medium scale industries [2]. But in Sri Lanka we observe the gradual strangulation of medium and small scale industries, while the import and sell business thrives. Well, the west (WB, IMF etc.) advocates Macro Industries, while east advocates Micro - including medium and small scale – industries [3]. After careful and an in depth study and analysis of the Taiwan, Malaysian, Singaporean, Indian, and also the Japanese strategies, both successes and failures, the draft "10 year master plan for the Industrial development of Sri Lanka" produced by JICA [3] has clearly identified the Micro scale industrial development, with identified priority sectors, as the best strategy for Sri Lanka. (However this plan too has not been implemented.) They reckon machinery industry (or machinery building industry) as the mother industry for all the other industries.

No manufacturing industry can profitably survive in a country unless it manufactures, at least to a certain degree, its own machinery and equipment. We had a substantial machinery industry some 50 years ago. We were world leaders in Tea and Rubber machinery and most of our agricultural machinery were developed and made here. Rubber Machinery made in Sri Lanka can still be found not only in India but in Malaysia as well. Patented "Fluidized Bed Drier For Tea" with innovative features, developed in Sri Lanka some 35 years back was the most modern at that time and was sold to several countries. But now we import Fluidized bed driers, with further minor improvements, from India and other sources. This shows the pathetic situation we are in today. Above details were given to show where we have gone wrong with our industry and education system, as some of our industrialists, policy makers and educationists are still reluctant, or even refuse to, accept this unpleasant reality. Isn't there some thing radically wrong, and an immediate solution needed? (That solution is the development of an innovative and inventive culture in Sri Lanka.)

1.2 Priorities:

Have we identified our priorities correct? Policy makers often talk of an IT explosion and give priority, pumping scarce resources to train more and more IT personnel. **"For whose benefit"? Do we have a manufacturing industry to sell our products using IT and internet**? An EDB source- who wouldn't like to divulge his name-says that 98% of the internet queries they get from foreign parties are from supplier to sell their products in Sri Lanka. Even the balance 2% regarding what we can offer are not really to buy, but to see how they can kill that too by providing cheap substitutes or even by changing consumption patterns and attitudes. This is a common strategy used by multinationals and is carried out through massive advertising campaigns, sometimes utilizing even false scientific data, a good example being the case of coconut oil. Need for development of industry, particularly the Mechanical Engineering industry, which is the mother industry for all other fields of industries, is forgotten by the planners. Well, aren't we to blame ourselves for not educating them? (or will it be of any use any way?)

2. WHY DESIGN:

2.1 Design

No Idea, Concept, Innovation, or an Invention will be of any use unless, and until, it can reach the user, say people, in the form of a product. (Here a product means an item, equipment, machine, system or a process.) To convert them to usable or tangible products, it is essential for them to be taken through the design phase. Then only can it be produced or manufactured. Production processes used in developed countries may not be the most appropriate in our context. The cost of production may be substantially reduced by innovative design, to suit our conditions and facilities. Thus it is clear that the Design and Production / Manufacture are the most important and vital factors for the development of a nations. Both these need Mechanical engineers, directly in the production floor, or as design team leaders to convert ideas from other disciplines too, to usable products. So we discuss here about Mechanical Engineering Education beyond 2000.

2.2 Technology - Import or Innovate:

Some time back a planner declared, "Import the technology, it is faster. Let multinationals come with modern technology". (To improve our industry and produce what our people need?) He even wanted the "Patent Law" changed to accommodate the masters wishes, made stronger to provide the so called "protection" for the so called "modern technology expected to be brought in" by the masters. A casual glance through our patent registry shows that **hardly any new technology, which couldn't have been developed in Sri Lanka, was patented in our registry** (It is not referred to pharmaceuticals here as the author is not competent to comment on same). How many Multi-nationals are manufacturing with "patented" novel

technology in Sri Lanka? Novel technology, if any, will be kept as trade secrets. The attraction is our cheap labour, both blue collar and white collar. Well, there was a period when real technology transfer was carried out through government enterprises such as Steel Corporation, Tyre Corporation, Hardware Corporation etc.

It is not intended to say that foreign technology is not needed, or should not be brought in. But let it not be brought in blindly, or with massive pollution, and once imported do not just continue without improving it. Technology imported from USA to Japan was innovatively improved to suit their conditions and needs, thereby superceding even USA technology in certain fields. American missiles tested in Iraq were guided by Japanese electronics, it is said. Similarly in Korea and Singapore too very good success is reported in certain areas through technology adaptation. We here in Sri Lanka too have some isolated cases of such success, but no body even appreciates that. Way back in early 1970s I saw, as a post graduate student, how the then Czechoslovakia used to get down one each of most of the latest model of metal forming machinery put to market by West Germany, Sweden or USA, their rivals in metal forming machine industry, strip them and do all the possible tests and analysis. Then come out within a very short period an improved and modified machine with better features from CSSR at a lower price. This is what is called innovative re-engineering.

2.3 Can we survive without Innovative Design and Modifications:
It seems that many of our local industries are satisfied if they can just meet the "bottom line". They realize the mistake only after being overtaken by the competitors or imports (including "dumpings" after the so-called liberalization). Well, then it may be too late. Number of companies in Sri Lanka, which "called in" that fate could be identified. A classic example is the automotive battery. We had a reasonably good battery, perhaps of world class, many years back. It was selling well virtually enjoying a monopoly. So why bother about R & D seems to be the philosophy of the company till the markets were opened for imports. With the liberalization came in a number of foreign makes with far superior quality thus almost crashing the market of the old giant. Then only perhaps they realized the importance of continuous product improvement and modification. Examples are many if you look at Tea and Rubber machinery, where hardly any development is seen for the last several decades. Earlier during their hay days under British, major Tea and Rubber machinery manufactures had strong R & D departments, commanding high respect, run by qualified engineers. Came the era when the accountants took over the management, and the R & D departments were only for the namesake, headed by ranker engineers or perhaps glorified technicians.

Present day reality in manufacturing industry is **"either innovate or get perished"**. Continuous innovative design and development of products and processes is fast becoming recognized as a basis for securing competitive advantage for manufacturing business, essential in the present highly competitive environment. Government initiatives too are provided for it even in developed countries [4]. Designing is actually a

tactical planning for manufacturing. All successful companies have fully appreciated the importance of creative and innovative design, and are allocating a substantial share of their budgets for continuous product and process improvement. Like "Sunrise" and "Sunset" industries often talked about by Japanese, the products too are either "Sunrise" or "Sunset". After best market period profits may start dwindling due to competition from other manufacturers, and from new and superior products. Today's sunrise may be tomorrow's sunset and one's sunset may be another's sunrise depending on the size and the technology of that organization. Thus it is essential for all companies to be vigilant and conduct continuous self-assessment not only for their prosperity, but also for survival.

Above details were given to show the importance of creative and innovative design for the prosperity, and even for survival, of manufacturing industries. Now, with an appreciation of, a) the need for manufacturing industry (and not mere service industry), and in particular machinery building industry, and b) Innovative and creative product design, development and improvement, let us go back to what Prof. Hills said as given in page 1 [1].

3. DO WE HAVE THE INTELLECTUAL RESOURCES TO DESIGN WHAT OUR PEOPLE NEED:

We have a vast intellectual resource at our universities and as graduate engineers in industry and elsewhere. They are extremely bright and can shine well amongst any, including those from any developed country. But are they designing what our people need? (Not necessarily what they want), or are they using their talents to satisfy the needs and requirements of some developed countries?

It is said that the number of "Patents" registered in a country by its people, is a very good measure of that country's industrial growth during that period. **A "Patent" is a step forward from the "state of the art" or the "Forefront" of the existing technological level anywhere in the world**, while papers published in "learned (and indexed international) journals" give the forefront of the "theories and scientific principles" which are usually, except in very rare instances, not of much - or hardly any- use to our countries. They are useful only for the advancement of science, unless designed and put out as a product, at which stage very often a patent comes in to existence, most probably in a developed country, with hardly any contribution to upliftment of living standards of our people or improvement of our industry. Yet our research workers are more than happy to make such a publication as they get the prestige and more marks, (than for a contribution to local industry) for their promotions.

Well, by that statement it is not intended, by any means, to undermine a Sri Lankan scientist or an engineer who may develop a fuel cell - which might do away with power cuts we are experiencing now, or come up with a practical "cold fusion technique" which would produce all our energy needs - and export too, or a Solar cell which will cost One rupee a watt to power our village homes and industries. But how about the really brilliant

engineer who solves highly complicated problems in a turbo jet engine, taking up a project for the development of a product, which our countrymen desperately need. (Even the armaments -not only mortars, artillery shells and ammunition etc., but also multi-barrel rockets, tanks, fighter planes etc., for which it is said that the taxpayer is spending in billions of dollars. All these, or at least a substantial portion of this expenditure could have then been saved and retained in the country. What about the employment opportunities that would have been thus created, and reaching the forefront in a number of technologies? Only disadvantage may be the loss of commissions some privileged people get at the sacrifice of the lives of our valiant soldiers).

4. CONTRIBUTION OF OUR ACADEMICS TO INDUSTRIAL GROWTH OF SRI LANKA:

4.1 Present Situation:

Just as the "number of patents registered by local people" indicate the country's industrial growth, the contribution of academia to the industrial growth is reflected, or can be judged, by the number of patents registered by them. During year 2000, academics from all 3 engineering faculties in Sri Lanka have registered ONE patent. Last 10 years are not much different. Let the reader to come to his own conclusions. **But isn't it time to open your eyes?**

Engineering Research Unit (ERU) at Moratuwa University conducts an annual symposium -"Research for Industry". There were 31 publications in 1999 and 22 in the year 2000. An attempt was made to classify them as;

a) With direct relevance to solve an existing specific industrial problem in Sri Lanka -qualifies as Patentable,

b) With improvements of a general nature - may be usefully applied for improvement of certain industries in general - Not patentable,

c) With moderate industrial application, but more of a scientific analysis or a survey etc.,

d) With no direct application or relevance to Sri Lankan industry - scientific analysis or survey etc.

Results are as follows:

Type	1999	2000	1999+2000
a	04 (03 of which from one person)	03	07
b	09	03	12
c	12	10	22
d	06	06	12
Total	31	22	53

Results are self-evident. Even all the patentable works have not been patented. Is it due to lack of interest - about industry?

Well couldn't they have applied their talents more to solve actual and practical industrial problems? Solving industrial problems could bring not

only marks for the promotions, but also could reap good financial benefits if properly done. Well is it due to lack of intelligence or analytical mind? Definitely cannot be. Then it should be due to one or more of the following:
a) Lack of industrial experience to appreciate and/or understand the needs and problems of industry, with correct evaluation of the potential of saving that could be accrued to the industry, and thus the value and income potential of such work,

b) Lack of innovativeness, and

c) Attitude and feeling that "we know every thing, there is nothing for us to learn from industry". (Fortunately now it is only among a few compared with the majority some 15 years back).

4.2 Need of Industrial Experience for Academics:

Don't think that we can offer much to industry unless and until we have sufficient industry experience. On the other hand remember that there is so much we can learn from industry, even for the well experienced. Our academics are bright. So they can catch up fast if they are really interested. Proper interaction of academia and industry is a "must" which is of mutual benefit to both parties. It is not conducting workshops and seminars, but actual working in industry seeing their day-to-day life and problems. The author can remember the vehement objections and shouting he received at a faculty board meeting some 15 years back when he said, as an external member of the faculty board, that all academics should be given a two year industrial training or assignment before they are being promoted to the senior lecturer grade. But now, most probably the majority would agree with what he said at that time.

4.3 What could then be done?

Well, all academics should be encouraged to serve a stint in industry. Though one or two years are preferable, even short assignments such as 2 or 3 months, and also consultancy assignments too could be of much use. Sabbatical leave, it is normally presumed, is to be spent in another University or a Research Institute supposedly for the improvement and revitalization of their academic skills. Is this really true? Cannot this sabbatical leave be much profitably spent in industry, local or foreign? Such would provide the academics an opportunity to gain the much needed first hand experience in industry, to know its needs and problems, to develop an appreciation and liking to solve actual problems of industry. As Kapila [5] says: "to generate cross-pollination".

It is said that in companies such as General Electrics, it is compulsory for R & D executive to serve a stint in their manufacturing facilities. They realize this as an essential cross pollination thus not only improving manufacturing operations through their participation with practical problem solving at factory floor, but also getting new ideas for future research and development. Somebody may ask "then what about the academic furtherance expected during sabbatical leave?" Well, academic gain from

other institutions including universities should not be left to be done only after seven years, but should have been an ongoing and a continuous process. More frequent short spell assignments may be more useful. Further, with the present advances in communication, and with internet etc., is it essential to work on an R & D project, or a teaching assignment for one year in a foreign university to acquire the required academic gain?

4.4 From teacher to student:
Once the academic staff realize the importance and joy of innovative and inventive problem solving, it is much easier to transfer it to students. Teacher should first be convinced before trying to develop an enthusiasm in student. It was mainly the reverse so far. What success can be expected when the teacher was not convinced of the importance of innovative design and problem solving? We should create a culture of innovative and inventive problem solving. Then it can be "infected" to the industry through our young graduates.

5. INNOVATIVE ABILITIES AND THE YOUNG ENGINEERS:
An often heard complain from industry, often exaggerated, is that our young engineers do not fit well into industry. So said by some senior engineers too. Today's senior engineers were fresh graduates some time back. Well, then do they think they fit in well to the needs of industry now, and if so how? Some times we hear somebody saying that the young man can't even operate a lathe. Is this the correct job expected from him? If so what is the job of a skilled machinist? Well, how may industries use graduate engineers for product, process or management development, where they should really be? There are a few, but the vast majority still not. Some private sector bosses still think that maintenance, or shouting at workers to get the work done are the only jobs expected from engineers. On the other hand some public sector organizations seem to think that signing leave chit is the only thing engineer has to do and the management is for a the accountant or the MBA. **Design is often left for foreigners.**

The industry too should take a part of the blame for often not providing the young engineer with the opportunities and the needed guidance to get involved in creative and innovative design. Our engineers are much better than you think. Give them a chance and see. On the other hand can the universities be happy that they have trained the young engineers to be inventive and innovative. Can the young engineer confidently handle a machine or process improvement. Upgrading of machinery in lieu of replacement is a very attractive alternative in the context of industries like ours. Upgrading may be done at a fraction of the replacement cost while getting the same productivity and quality improvements [6]. But such upgrading needs not only technical skills, but innovative and inventive design skills too. So isn't it imperative to provide young engineer with such skills and abilities as well in addition to basic theory, a lot of which we try to pump in within a very limited time?

What is more important, is it trying to impart a very high theory base sacrificing innovative design abilities, or to sacrifice some theory, at

undergraduate level, to impart a good innovative and inventive ability, to sharpen their natural talents in theses directions? Well, it is the best if both could be achieved without sacrifice of the other. However when there is no option, it may well be that some of the theory be postponed to postgraduate level, to ensure that sufficient time is made available to sharpen the student's innovative and inventive abilities and to train them on scientific methodologies of modern design. Very often it is thought that innovativeness is only for technological matters. It can be equally applied for improvement of management and many other fields. It is not intended to go into those details here, but it should be kept in mind that the scope and applicability of innovativeness is very wide.

6. INNOVATIVE CULTURE:

6.1 Our Student:

All the students entering Sri Lankan universities are very bright. Only about 1000 out of 12,500 qualified, get the chance of admission to an engineering faculty in Sri Lanka. Balance 11,500 too has more than enough intelligence to follow an engineering course successfully. All those who can afford do so in foreign universities. Criterion for the students to select engineering field is simply that they were good at mathematics and that their parents were keen to ensure their children become engineers. The real admission criteria thus is how best they can run in the GCE A.L rat race, not whether they have the capacity and liking for engineering. Yet we find that a substantial number of students are really keen in engineering. There are some who have even won awards for their inventive abilities. Part of these abilities was crushed during A.L. rat race.

6.2 At University:

Is the situation any better at the university? It may not be wrong if it is said that it is worse. First year it is a worse rat race to enter the so-called high demand fields, a wrong notion created by a wrong industrial policy. Thereafter, they are worried about getting a good grading at examinations aiming for a class. So who can be worried about inventions and innovations? Instead of developing inventive and innovative abilities of students aren't they being simply killed by this examination structure? Continuous assessment may reduce this problem slightly. Yet it is human nature to give priority for subjects, that will generate points for the final grading, than acquiring skills which are recognized at present as extra curricular. Thus the only practical way to create enthusiasm of students in innovative aspects is by providing substantial amount of points for those aspects as well.

7. INNOVATIVE PRODUCT DESIGN AND A DESIGN CULTURE:

7.1 Engineering Product Design:

As explained earlier no idea or concept is of any use unless it is developed as a product. For this a substantial knowledge, at least of basics, of

product design is essential. It is a wrong notion that product design is a mechanical engineering subject though it is true that the mechanical engineering graduate is at an advantage with his knowledge of manufacturing engineering. In the present context engineering product design is a field, which must be studied by every engineer at least to get an appreciation of scientific design principles and wider perspectives covering aesthetics and ergonomics etc., involved in modern design. Thus it was proposed to introduce "Product Design" as a first year subject common to all fields. It was introduced but was then shifted to the vacation semester and down graded as a non-GPA subject. In other words marks scored in this subject will not be counted for the grading of the student, and a mere pass would suffice. With this rat race during the first year for the so called preferred fields, who would care to spend time on a subject which will not contribute any point for that selection?

7.2 ENGINEERING DRAWING

Can design be done without even a basic knowledge of engineering drawing, the universal language of engineers? Without design can we effectively create a design culture? It is pity that Engineering Drawing had been removed from the first year curriculum. Isn't this due to lack of industrial experience and inability to comprehend the needs of innovative and inventive abilities. Repercussion of this decision will be seen only after several years. Well, then it may be too late. I wish to remind the question asked at the beginning **"for whom, and for whose benefit are we having this teaching system"? If it is to produce cheap white-collar labour to multi nationals then forget about design culture. If it is to produce engineers to serve our people, our country and our industry, forget about the multinational opportunities and create a design culture.**

7.3 MANUFACTURING TECHNOLOGY

Removal of the subject "Workshop practice" from the first year curriculum is also due to similar reasoning, which would yield similar results. It is true that the practicals conducted at the workshops were long outdated, but the theory syllabus was modified to suit present day needs and to give the student an overview of production processes, an essential basic knowledge to select the best process at the design stage of a product. What should have been done was to modify the practicals too to suit current needs and to modify the subject content to cover "Manufacturing technology". Proposals to that effect were submitted, yet the subject was dropped from the first year curriculum. Now the non mechanical engineering students have absolutely no way of getting even the essential basic knowledge of Manufacturing technology and Engineering Drawing. Even the mechanical students will have to cram in during balance years what should have been completed in the first year thus causing further difficulties during subsequent years.

I remember very senior electrical and electronics engineers discussing basic manufacturing processes with me when they were involved in product design. How can any body think of developing a design culture, whether innovative or not, without giving a basic background of

engineering drawings and basic manufacturing processes to the students. **I wish to take this opportunity to request the university authorities to seriously reconsider the decision to delete engineering drawing and workshop technology (perhaps revised as "fundamentals of manufacturing technology") subjects from first year curriculum.**

8. THE MECHANICAL ENGINEERING STUDENT:

8.1 Present position:

Now leaving aside other disciplines, let us consider the position of the Mechanical engineering undergraduate. What are the opportunities we provide them to acquire skills in practical designs and innovative and inventive abilities. During "part I" they are given a reasonably good understanding of the principles underlying the design of basic machine elements. "Part II" has a design project, known among students as the killer project, in which a gearbox is designed. Here the basic design principles of machine elements, and their assembly is taught. It is the same old gearbox that has been done for, perhaps, the last 25 years or so. Though, this provide some useful training, it still fails to provide the student with;

a) the skills needed to design basic machine systems,
b) comprehensive understanding of the analytical methods available for optimizing a design,
c) the ability to innovatively think and look at a machine or a design with exploring mind,
d) ability to convert an idea or a concept to a practical design,
e) confidence to handle the design of an actual industrial machine or an equipment.

8.2 CURRICULA REVISION

Having recognized and appreciated above deficiencies of the existing syllabi, a curriculum revision is underway with the intention of rectifying those defects and to generate an innovative and inventive design culture to the best possible extent within the limitations of time and facilities available in a four-year degree course. The "part I" syllabus has been modified, effective next semester, to give effect to introduction to, and an appreciation of, design requirements outside purely technical, as well as a thorough understanding of the underlying principles of designing basic machine elements. With the basic knowledge so imparted, it is expected to take the student further in "part II" to enable him to design, select and assemble the basic machine elements to make a complete machine. He is to get a good understanding of areas such as Design Methodology, Optimization of Design, Innovative and Creative Design, Hydraulic and Pneumatic components and systems, Sensors and control equipment etc., with a thorough understanding of their working principles, selection and applications. A mini project to be introduced on innovative and creative design is expected to give the student an opportunity to sharpen and apply his innovative talents. It is expected to create and develop self-confidence and competence of students to design simple industrial machinery through a comprehensive design project where broad industrial design concepts

are integrated with engineering design. A continuous assessment scheme will ensure the students grasp of all related aspects.

8.3 INDUSTRIAL TRAINING

In addition to above all students during their part III are given a compulsory industrial training for 6 months. How effective and how useful this training is questionable. Author's experience in evaluation of these trainees is that the majority is learning hardly any useful thing during this period. It is therefore strongly suggested that this be changed to an industrial attachment where he will really work in industry, where he will be required to complete an assignment (and not a mere observer). This assignment may either be in management or on a technical project, where his inventive and innovative abilities could be enhanced and sharpened by practical problem solving in an actual industrial surrounding. Assignment may be the study, and innovative modification, improvement or upgrading of an industrial machine, equipment or a process, the results of which could be profitably and immediately applied in the industry, thus mutually benefiting both the trainee and the supporting industry. Further, unless the assessment of the training or assignment would carry marks, which will be counted in their final grading, no industrial training or assignment will be of much practical use.

Senior engineers in industry should take up the responsibility in this matter mainly in:

a) Identifying possible innovative projects and assignments in their industries, and
b) Encouraging and assisting the young undergraduate, and building their confidence in handling such an assignment.

Believe me, you can find enough such innovative projects and assignments in your factory floor if you walk there with your eyes open. For the young engineers in the field I wish to say, "more the experience with practical innovative problem solving design you get, more the options you will have at your finger tips for the solution of your next problem". This is true whether it is for an innovation, adaptation, an inventive design, a mere modification, or a major re-engineering. It is observed that a large majority of students are very keen in developing and sharpening their inventive abilities, and a substantial number has some background as members of young inventors clubs at their schools. Every encouragement and facility, including workshop services and financial support should be provided to them if and when needed.

9. DEVELOPMENT OF INNOVATIVE ABILITIES:

9.1 Responsibility:

Thus it can be seen that the responsibility of development of inventive and innovative abilities of our young engineers rests squarely on both universities and industry. Development of such abilities will be to mutual benefit. While the industry will benefit with more innovative products,

processes and management, thus better profits - more Rs & cts-, the university too will be benefited by acquisition of more knowledge base. **So let us get together and develop an inventive and innovative culture.**

9.2 Compulsion:

However, it is seen that there are many industries, be them large, medium or small, who will not realize or appreciate the advantages or importance of innovative product and process design. Only way to take them to correct track is by compulsion. I propose that a CESS like charge, say 0.5% of the turnover, to be levied from all manufacturing industries to finance an innovative design and development fund. (Well this cannot be an impediment - compare this with the defense levy they pay). Companies and organizations which have their own in-house development and design departments should be allowed to use this levy directly to fund such activity, but properly monitored with justified results. Balance fund to be used with Universities and other suitable organizations for projects for industry, where the industries can come to get their problems solved. Small and medium scale industries, who cannot afford their own design facility would find this arrangement very attractive and will thus be encouraged to continuously improve and upgrade their products and processes. However, it should not be completely free, as anything given free, will not be appreciated. Perhaps 25% of the cost of the project may be charged to the company concerned, while the balance 75% to be provided from the fund.

9.3 Ability:

It is not necessary to have a high level of academic background to be an innovator. It is the ability to see in to details with an investigative mind thinking how to do better. However a person with a good knowledge of engineering fundamentals will be at a definite advantage as he can easily distinguish between what is practically possible and what is not. So any engineer, irrespective of whether he has a good class at the final examination, or whether a Ph.D., or an M.Sc. etc, can be a good innovator if he has cultivated the above characteristics and has the will.

9.4 Potential and My Vision:

I wish to end this article with a small calculation. Let us say that half of the engineers graduating from all three engineering faculties from this year onwards will come up with one innovation or invention per year, we can then see 500 innovations with possible patents registered next year. The year after will get an additional 500 while the earlier batch too produce another 500 innovations, and patents, i.e. 1000 patents for the second year. The third year similarly will see 1500 inventions. Thus in FIVE YEARS we should see more than 7,500 innovations and new patents. That is quite handy in comparison with any country. Thus, we should be on the way to industrialization within five years, if we only create a proper innovative culture.

In 10 years (even at present rate of university out put of engineers) it could be a massive 27,500 innovations and patents. Compare this with present

rate of about 20 to 30 patents per year or 200 to 300 for the next ten years. If the innovations are available, industry will invest to exploit them. Even the multi nationals will come begging. Prof Higgins statement will come true. It will lead to a chain reaction and an industrial explosion leading to achieving industrialized nation status within 10 years.

This is no joke. It is realistic and practical. **We only need courage, commitment, confidence, and backing.** Singapore has shown that **results can be achieved if you have a proper plan, stick on to that plan and execute it with commitment. So why can't we?**

This is MY VISION for the future.

10. OBSEREVATIONS AND RECOMMENDATIONS:

... It is essential to clearly keep in mind "for whom" and "for whose benefit" we should gear our education system and industry.
... No country can prosper, or even survive, without a manufacturing industry, which would produce the needs of its people.
... No industry can prosper, or even survive, unless they innovatively improve and upgrade their products and processes.
... Sri Lanka had a reasonably good machinery industry 50 yrs back, but it is now almost extinct due to shortsighted policies.
... We have a substantial intellectual resource at our universities and industry. But their contribution to development of local industry is minimal.
... Both academia and industry can mutually benefit through better interaction and understanding.
... Sabbatical leave could be more gainfully spent in industry.
... Teacher should realize and fully appreciate the need and importance of innovative design before he can inculcate and develop innovative habits among students.
... Both Universities and industry should share the blame for lack of innovative abilities among our engineers in general.
... It is very important to develop an innovative and inventive culture at the University, and transfer it to industry.
... Innovative and inventiveness are not confined to product and process development. It can achieve very good results in management and related fields as well.
... Innovative abilities of students are crushed by the present education system both at A.L and at University.
... Innovative product design knowledge is a must for all disciplines of engineering.
... No inventive product design could be effectively done without sufficient knowledge of Engineering Drawing and Basics of Manufacturing Technology.
... Design syllabi at the Mechanical Engineering Department are being modified and updated with development of innovative and practical design skills kept in mind.
... Though it is not necessary to have high academic qualifications to become a good innovator, good knowledge of basic engineering principles

and manufacturing technology will be a definite advantage in achieving success as an innovator.

--- Academics should be encouraged to give priority to handle problems related to our own country in their R & D work.
--- University academics should be given compulsory industrial experience through both long term and short term assignments in industry, and through industrial consultancy.
--- Exchange of specialists of industry and universities must be encouraged.
--- Industry should encourage young engineers to handle innovative designs of products and processes or management during their compulsory training assignments in industry.
--- Senior engineers in industry should encourage and assist young engineers and graduands to improve their innovative abilities by providing them suitable opportunities in their industries, and proper guidance.
--- Innovative product design should be taught as a compulsory subject to all disciplines of engineering with the marks being counted for their grading.
--- Engineering drawings be re-introduced to first year curriculum.
--- Deleted "Workshop Technology" subject should be modified as "Basic Manufacturing Technology" and reintroduced to first year curriculum.

--- Inventive and innovative work among total student population should be encouraged and all facilities needed should be provided to help develop an innovative culture among the university community.
--- Present industrial training should be changed to "Industrial attachment" where student is given an assignment of solving a real industrial problem exposing them to real industrial conditions.
--- Project for industrial assignment preferably should be an innovative solution of an existing practical problem in industry either in technology or in management.
--- Senior engineers in industry should play a more active role in selecting suitable assignment for undergraduate trainees, and in guiding them.
--- A charge, such as a CESS, to be levied from all manufacturing industries to be compulsorily used for innovative development and upgrading of products and processes.

11. CONCLUSION:

Country could be put on the path to industrialization within five years, and achieve industrialized status too within a short period, if due recognition, priority and encouragement is given to develop an Innovative and Inventive culture in Sri Lanka, have our priorities properly identified and work according to a plan with commitment.

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