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Full Length Research Paper

Reshaping engineering education curriculum to accommodate the current needs of Nigeria

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It has been observed that most engineering graduates, such as electrical, mechanical, civil, chemical, etc, end up taking employment with banks, accounting outfits and other non-engineering outfits. It has also been lamented by many graduates that they find little or no relationship with what was taught in school and what is obtainable in the job market. Industries who hire fresh graduates almost always have to retrain them before they could be gainfully employed in their various industries. All these phenomena are clear indicators that there is problem in the current engineering education curriculum. This paper looks at a number of areas where engineering education curriculum needs review and the benefits of such review and subsequent upgrade. The paper also discussed the importance of academia-industry-government collaboration in enhancing the quality of engineering education. It suggested the establishment of engineering education discipline in Nigerian Universities to engage in the study of engineering pedagogy best practices. The paper recognizes that fact that all these could be done only by first gaining proper understanding of the situation. It then calls for in-depth review of all aspects of engineering education in Nigeria – a study that should be initiated by COREN and sponsored by the government.

Key words: Engineering education, education review, curriculum review, collaboration, engineering pedagogy.

INTRODUCTION

Engineering and technology are critical inputs for economic development and competitiveness (Luiz et al., 2004). In evaluating the contributions of academic engineering research to national goals, a major question is the degree to which such research helps those individuals who will, whether they join academia, industry, or government, enhance and apply the knowledge base relevant to the technical problems facing the country (Forces Shaping the U.S. Academic Engineering Research Enterprise, 1995). A nation's educational program should, among other things, be aimed at solving the problems facing the nation and improving the economy through wealth creation. It is well known that engineers shape our future. Many nations, developped/underdeveloped are looking inward, studying the trends of change, suggesting and making modifications to their engineering education content in order to produce engineering graduates capable of carrying their nations through the change and challenges of time. For instance, the U.S. steering committee on the National Engineering Educational Research Colloquy asked the following question: "Will the U.S. have engineers prepared to collaborate and lead in a rapidly changing world?" They also said: "The answer to that question, in part, relies on our ability to transform how we educate our future engineers" (The Steering Committee of the National Engineering Education Research Colloquies, 2006). Despite the developmental progress in India, the Indian National Academy of Engineering (INAE) called for enhanced interaction between the academia and industry to the level obtainable in technologically developed countries ("Industry collaboration will improve education", http://www.ciol.com/content/news/). The Australian Academy of Technological Sciences and Engineering (ATSE) has, over the past year, conducted an extensive strategic review and planning exercise which included a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis and identified a number of important issues facing the Academy, one of which includes: "How to develop and promulgate Academy policies on key issues in the application of science, technology and engineering" (Issues of Concern, 2004). There are many more examples in literature, which confirm the fact that both developed and developing nations are constantly looking inwards to

see how they can improve their engineering education in order to be better able to solve their current problems and at the same time prepare for the future.

Education basically involves training, and training means equipping trainees with intellectual tools necessary to understand and solve specific problems within the society. The first aspect of training for problem solving is to understand the tools, identify where these tools could be applied and, know how to apply them to solve existing problems. It is also noteworthy that societal problems that require engineering solutions are not static, they are dynamic and time variant. Therefore, to enable engineering education input support economic growth, the tools for solving the problems must change as the problems changes. All of these mean that educational curriculum should be flexible, and should be frequently examined and modified to accommodate the societal needs of a given epoch. This modification should involve change in curriculum content - either addition or removal, change in teaching methods and, enhancement of the academia - industry collaboration. Everywhere around us, one senses the signals that indicate a great mismatch between the workforce produced by the universities and the input demanded by the industries. Fruitful amendment will only come from in-depth and systematic study of the dynamics in the academia-industry relationship. This paper therefore attempts to call attention to the fact that there is need to carryout critical studies in the area of engineering education in Nigeria. That is, to examine the past, evaluate the present, and project the future of engineering education with respect to changes in the technological needs of the Nigerian nation and how the engineering graduates meets these needs. In the Sections that follow, the paper tries to point out the areas of critical needs where these studies should focus. The paper is arranged as follows: Section 2 discusses curriculum modification, Section 3 presents collaboration between industry and academia, Section 4 presents engineering education discipline, while Section five concludes the paper.

CURRICULUM MODIFICATION

Some of the engineering programmes taught in Nigerian Universities include Electrical/Electronic, Computer engineering, Mechanical engineering, Chemical engineering, Civil engineering, Agricultural engineering e.t.c. The curriculum that guides these programmes consists mainly of the fundamental knowledge of mathematics, natural sciences and technology. There is also the aspect of student work experience programme, which permits an engineering student to spend a minimum of 6 months in the industry before graduation. This fundamental knowledge, which forms the basis for understanding and solving engineering problems, are good and very necessary, but we should not stop there. We seem to dwell too much on the fundamentals. There should be space in the curriculum to accommodate some aspects of application of engineering that are prevalent in today's environment. Signals received from employers of engineering graduates (indicated by high rate of retraining) are evidence that the application part is either lacking in the curriculum or inadequate. Since socio-economic and other factors that define an environment change with time, this aspect of the engineering curriculum should also vary to accommodate these changes. Literature cites many examples of developed nations who still modify and continue to study and discover areas of modification in their engineering curriculum according to the changes and challenges of time (Shirley, 2009; Committee on Prospering in the Global Economy of the21st Century, 2009; Committee on Education and Human Resources Task Force on National Workforce Policies for science and Engineering, 2003). For in-stance, when the United States of America had the September 11th, 2001 problem in their country, one of the things they did in response was to adjust the school curriculum to accommodate the study of homeland security. Again, the National Academy of Engineering Korea (NAEK) has identified the need to innovate engineering education to adapt industry needs. Despite the admirable extent of technological develop-ment in Korea, the NAEK discovered that "Engineering human resources face serious mismatches between needs by industries and supplies by universities, which have resulted in a growing unemployment rate in young engineers, and extra training costs for industries." They suggested that "close cooperation between the two parties is necessary to solve the mismatches. The NAEK is in the progress to implement the Enterprise Program which is designed for students to meet with industry group discussing not only current technological developments but also business and management issues (Issues of Concern, 2004). The Mexican Academy of engineering said "we have realized that there is a lack of leadership and commitment of our engineers for the benefit of our society, and this might be due to the lack of preparation of engineering students in human and social sciences, and in communications skills as well.

These useful discoveries of trends in engineering education vis-à-vis industrial and societal needs are achieved by careful and systematic study by selected professsionals. The United States have been exemplary in this respect by constantly funding such studies. Other nations also have been following the US lead. The author is of the opinion that it will do a lot of good for Nigeria to follow this trend. Any fund invested in a study of this nature will definitely yield a good return on investment. This paper argues that the council for the regulation of engineering in Nigeria (COREN) should not only have strong input in the Nigerian engineering education curriculum formulation, but should work together with the Nigerian National Universities Commission (NUC) in getting federal government to fund education reviews, especially engineering

education, on regular basis. These reviews will generate reliable statistics that will guide proper curriculum modification and workforce training plan. The author is of the opinion that, for example, practical applications and business models built into Electrical/Electronic engineering curriculum will give the graduates a good and realistic footing in meeting the current national challenges in information and commu-nication technology (ICT) and job creation. Teaching methodologies should also be modified to guide students towards acquiring basic tools such as ICT tools, very necessary in the study and work world of today.

It is always assumed that an electrical engineering graduate should have more than average knowledge of the use of basic ICT tools such as the usage of the Internet, simply because the underlying technology is rooted in his professional area. This expectation is not completely out of order, for though such tools as the internet should be used by all and sundry, a graduate of electrical/electronic engineering or computer sciences should have more than average knowledge. However, there is no place in the curriculum where he/she is specifically taught Internet usage or how he will find what he is looking for in the world wide web within the shortest time possible. This is taken for granted. The student relies on self-study or learning from friends where such opportunities are found. In the same vein, understanding applications of telecommunications networks, for example, in business will help an electrical engineering graduate better appreciate some limitations of these network systems that require research solutions - a knowledge that could spur him on to graduate studies; and to making meaningful research contributions. There are a lot of problems in our environment that require engineering solutions, yet, graduate students grope about in search of topics for research projects. At best they read international journals and formulate problems which are solved to satisfy academic requirements, with little or no local contents. This is yet another indicator of the need for review and evaluation of our engineering education, with a view to restructuring the engineering curriculum, such as to produce graduates of engineering who will not only be more productive in the job market but also more focused in R and D in a way that will benefit the national GDP.

COLLABORATION BETWEEN UNIVERSITY AND INDUSTRY

In the developed world, universities have a long history of contributing to industry and the economy in a variety of ways. The American National Academy of Engineering, in their assessment of the contributions of academic research to the performance of industry sector, discovered that there has been a growing recognition of the importance of Universities and academic research to industrial innovation and performance (Committee on the Impact of Academic Research on Industrial Performance, http://www.nap.edu/catalog/10805.html). Collaboration between industry and academia come in different flavors such as direct hires of students, graduates, and faculty; temporary exchanges of researchers; university/faculty consultancies; joint research involving industry and academic scientists and engineers; industry-sponsored research contracts and grants; a variety of institutional mechanisms at universities (e.g., research centers, consortia, industrial liaison programs), publications; conferences; and short courses. Industry stake holders can also be made members of university advisory board.

Interaction with the world of work, especially business and industry, is increasingly seen world-wide as a valuable component of science and technology education. An education manager in India laments of the poor and inadequate supply of technical manpower in their growing IT industry and worries about the negative effect it is going to have on this industry. He pointed out that only 25% of India's annual technical graduates are employable in the IT industry and that the university supplies far less than adequate manpower in certain critical need areas in the industry. He blamed this circumstance on the poor partnership between academia and industry. He calls on the industry to invest in building a resource pool of skilled technical professionals in partnership with Academia, because the responsibility is not on the education system alone (Krishna, 2007). Highly technologically developed countries in the world invested so much in technological innovation through partnership with academia. For example, the NAE report (Committee on the Impact of Academic Research on Industrial Performance, http://www.nap.edu/catalog/10805.html) showed how the Network systems and Communications industry drew from academic research for fundamental innovations, as well as using universities as test beds for new networking concepts that have provided the underpinnings of the Internet, the World Wide Web, and e-commerce. Figure 1 shows the complex pattern of academic and industrial research over many years in this industry according to Committee on the Impact of Academic Research on Industrial Performance (http://www.nap.edu/catalog/10805.html).

The foregoing is a clear indicator that countries of the world are reviewing different aspects of their science and engineering education. In Nigeria also, there is a need to study the level of interactions between universities and the industry, evaluate the outputs from these interactions, and then have statistical values with which to plan and advice government and private sector on the importance of university-industry collaboration. Relationship between academia and industry can only bring about good results. This fact needs to be demonstrated to government and industries using proper statistics, derivable from indepth study of collaborative systems in the country. Such studies should be initiated by COREN and sponsored by the

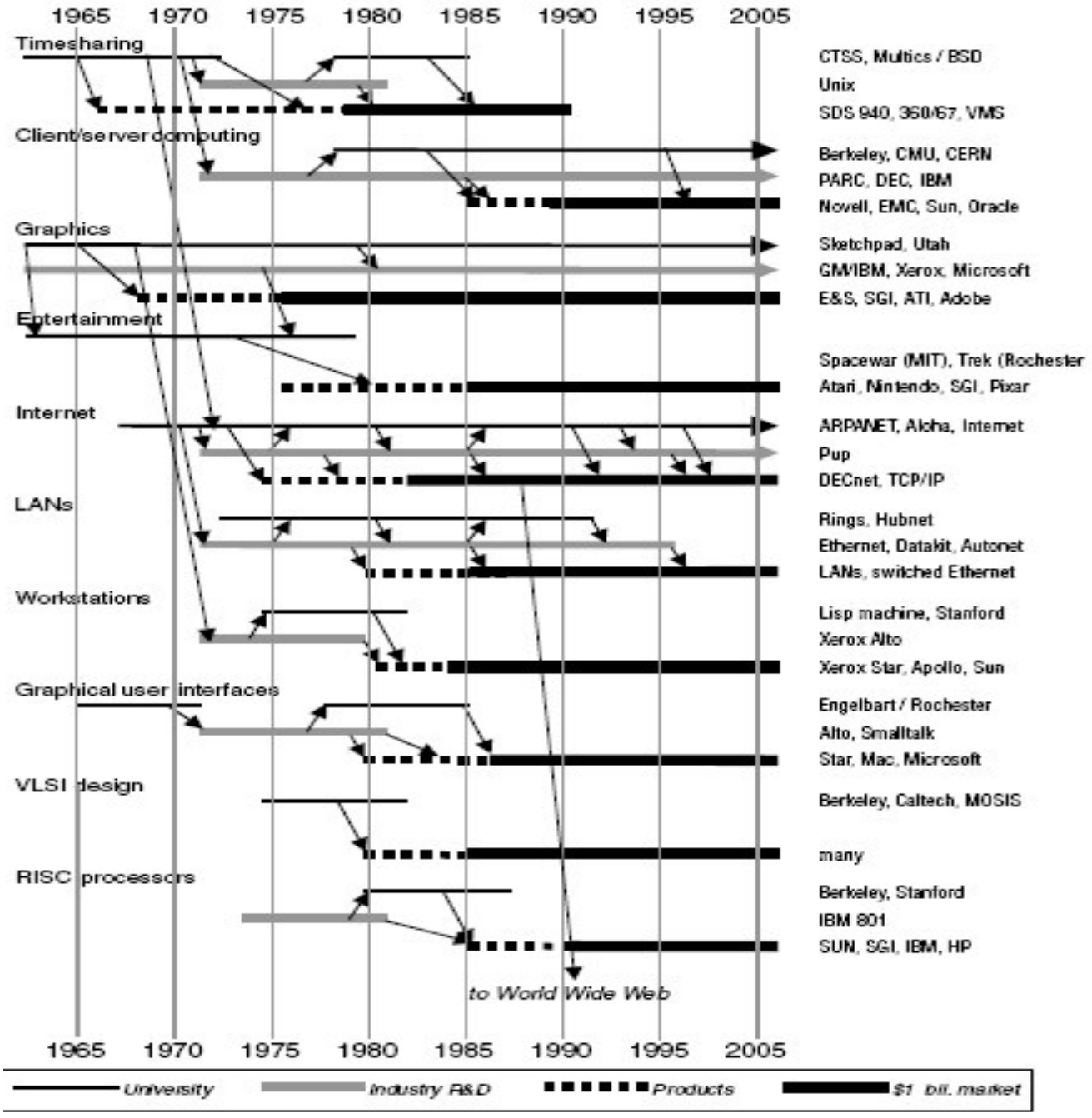

Figure 1. Examples of academic government-sponsored (and some industry sponsored) IT research and development in the creation of commercial products and industries. Source: (Committee on the Impact of Academic Research on Industrial Performance, http://www.nap.edu/catalog/10805.html).

federal government. Such studies should take into consideration, issues such as who or which sector generates research output; what is the quality of research output; who absorbs this output, and what impact have research outputs made in the area of absorption; who sponsors research; and to what extent is research sponsored by say, the government or, the private sector. Our nation is over-ripe for such a comprehensive study, which is inevitable in planning, restructuring and funding engineering education and shaping our future. This aspect is a major component in gaining the technological independence that our great nation Nigeria is yearning for. The Colleges and Universities have concentrations of tomorrow's business people together with great access to resources while the Industry has the need and the drive to get things done - creating an opportunity for them to work

together should therefore benefit everybody.

ENGINEERING EDUCATION DISCIPLINE

From the foregoing discussion in this paper, it is obvious that there is a mismatch between the product of the universities and the input to business and industry, yet these are supposed to form a contiguous link in the process of national development and wealth creation. While it is necessary to review and evaluate the engineering education curriculum and the impact of industry-academia partnership, it is equally necessary to review and evaluate the method of imparting engineering education in the light of changes in technology, society and teaching /learning infrastructure, and to study how these changes affect the human behavioral pattern and there-fore affect learning. In this respect, it may be necessary to create a department of engineering education in Nigerian Universities. The justification for this should be based on critical study with relevant statistics of the Nigerian engineering education system - a study that should be initiated by COREN and sponsored by the federal government.

The United State's NAE committee on engineering education has pointed out that "deteriorating urban infrastructures, environmental degradation, and the need to provide housing, food, water, and health care for eight billion people will challenge the analytical skills and creativity of engineers. Meeting these and future challenges", they said, "requires a transformational change rather than incremental improvements in how we recruit and educate engineering students" (The Steering Committee of the National Engineering Education Research Colloquies, 2006). The committee also noted that business, academic and government leaders from across the engineering enterprise have repeatedly remarked that systematic research of how we educate engineers must be the path to lasting solutions of declining qualitative education. These references are good indicators that nations of the world are having the same experiences we are having in the country, albeit at different degrees. The difference is that they are evaluating these problems with a view to finding solutions to them, while we here do not seem to have realized the effects of these problems to the future of our nation.

For instance, the current method of teaching, where the teacher is at the center acting as an embodiment of knowledge, that is, 'the sage on the stage', is phasing out. Advancement in ICT has made it possible for knowledge to be distributed in the current globalization. So the teacher is no longer the one who knows it all, but rather, he is more like a guide by the corner, pointing the general direction for learning, while the students, each takes for himself what he is able to take from the global pot of knowledge in the direction pointed out by the teacher. The scope of the knowledge the students acquires in a given subject matter is no longer limited by how much the teacher knows but by the student's ability to absorb knowledge. This method of teaching and learning emanated from the changes in technology and information dissemination. It is born of the dynamics of time. Our Nigerian environment doesn't seem to be responding to this dynamics, therefore there is bound to be a problem. This is because a systematic study of the situation has not been carried out. This study will help appreciate the impact of these problems, and also point to possible solutions.

Recommendation and Conclusion

To reshape engineering education in Nigeria for quality output that meets the nation's current technological needs and prepare for the future, the following recommendations are in order:

1.) There should be an in-depth review and evaluation of Nigerian engineering education curriculum. This study should take into consideration the current contents of the curriculum, the engineering graduates who were trained with this curriculum, the industries that absorbed them, the level of their contribution to this industries, the level of retraining undergone by the engineering graduates etc.
2.) There should be a critical study of academia-government-industry relationship with respect to engineering education, research input to the industries, funding etc.
3.) There should be a review of engineering pedagogy with a view to examining the relationship between the declining quality of engineering education and teaching methodology.
4.) The recommended studies are rigorous exercises, they should be initiated by COREN and adequately funded by the government.

This paper looked at the current disparity between the quality of engineering graduates in the job market vis-à-vis the expectations of employers of labor in the industries and businesses, and attempted suggestions to the possible causes of such disparity. It also suggested some measures for combating these problems. The paper disclosed that the problem of mismatch between content/quality of the knowledge gained in the university and that needed in the industry is not peculiar to Nigeria, but cut across the globe, both the developed and the developing countries, albeit at the different degrees. Various nations are also constantly making systematic studies to evaluate how much the output from the academia drives businesses and technological innovations in the industry. It is obvious that engineering education curriculum review, industry-government-academia collaboration, and reforms in method of teaching and learning engineering are inevitable in producing engineering graduates that are well equipped to provide solutions

to the varying engineering problems facing mankind now and, also be prepared for future challenges. However, all this can only be paid meaningful attention after a critical study of the situation has been carried out - studies that will place the problems in the proper perspective. The paper recommended a number of fundamental studies that must be done. These studies should be initiated by COREN and fully sponsored by the government, as a starting point.

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