ENHANCING ENGINEERING EDUCATION THROUGH PROBLEM - BASED/ STUDENT -CENTRED LEARNING

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ABSTRACT: The quality of engineering graduates from Nigerian universities and polytechnics has been a major source of concern to most industries in Nigeria. Most industries' complaints stem from inadequate skill requirement for most cutting edge technologies, low practical knowledge and lack of confidence. Hence, most Nigerian engineering graduates are subjected to several retraining programmes since most of them are considered non-employable going by the quality of training they acquired from their various institutions. Following the trend in rising population, economic recession and social dynamics, it becomes pertinent that engineers owe a duty to do designs and implement sustainable systems and technologies with multidisciplinary implications. The engineers/technologists will need to poses such skills as technical know-how, critical thinking, creativity, life-long learning and team work among others, which underpin performance effectiveness in a wide array of settings or contexts. These skills (born out of teachings) are an integral part of what is expected from universities/polytechnics and therefore it beholds on every engineering faculty/school to ensure that appropriate curriculum, instructional strategies and assessment are designed to meet these demands.

Keywords: Creativity, Critical thinking, Engineering, Team work, Technical know-how

INTRODUCTION

The traditional scope of engineering embraces the design, development, production and operation of physical systems. The study of scientific principles underlying the art of engineering is the study of workshop practice/laboratory experiments, an all important subject when one considers that it is skill in engineering that makes possible a standard of living beyond the widest expectation of previous generation. We are in a fast moving world replete with transactions and works to be done and hence the need for increased accuracy, speed and skill. In one of his papers entitled "planning in the dark", James (2007) explained that one of the major reasons why engineering projects fail to achieve key goals is that the very technology available for managing projects today is inadequate. He argued further that complex projects cannot be planned and executed using 50-year old project management tools. According to him, the current technology is lacking practical wise and needs to be changed. The need for educational framework that takes into account both the need for knowledge mediation and the development of the entire personality of the learner has been the pivot and propeller for a paradigm shift from Lecture–Based/Teacher-Centred/Content-Delivery-Based-paradigm (Instructional Paradigm) to Student-Centred/Learner-Centred (Learning paradigm). The learning paradigm, based on the cognitive/ constructivist learning perspectives, is for learning enhancement, fostering critical and sustainable thinking, promoting experiential learning and growth. The emphasis is no longer on teaching but on learning. Instructors are required to not only change their use of the lecture time but lecture must be used in conjunction with other methods and techniques in order to facilitate learning.

CURRENT TREND: from Teaching to Learning

Institutions of higher learning approaches to knowledge impartment are systematically and professionally designed to provide for the activity of teaching. Profoundly, there is a clear shift in purpose: to produce learning with every student. Learning should be holistic with knowledge as an interaction of inter-related parts. There is a huge amount of interwoven literature on teaching and learning. According to Falade (2002), 'Learning is acquisition of knowledge, ability, or skill through concept formulation involving mental process and the use of experience and practice '.This definition aptly captures the fundamental objective of student-centred learning and clearly highlights the deficiencies of Content/Teacher-based model of engineering education.

Student-centred Learning (SCL)

The student- centred learning paradigm seeks to improve the quality of learning through a redefinition of the learning environment, the roles of the instructor, the roles of the learner and the relationship among them. The emphasis is on participatory learning and understanding and increased responsibility and accountability on the part of the students. It advocates for reduction in amount of lecture hours and an increase in problem- based activities and student independence and self-reliance with decreased reliance on instructors in providing answers to problems and questions. Students take responsibility for their own learning and the instructor takes the role of facilitator, guide or mentor in the learning process. This is a significant departure from lecture–based learning which signifies a paradigm shift. Problem-based learning is a major student-centred teaching and learning tool which incorporates collaborative, active and experiential learning and has relevance where learning is not only real- world based but a function of activity, context and culture in which it occurs.

However, it is not entirely without critism. It has been cautioned against allowing individual learning concepts to overshadow the learning needs of the entire class as a single body, Barret(2005). Also, students expect and may prefer instructor-centred learning due to their dualistic nature and secondary school experiences and therefore may not fully appreciate SCL. Studies show that students hold very positive views of student-centred learning as a future of high quality education, (Felder and Silverman, 2007). Instructors on their own part may see it as a breach of instructional trading with general feeling that nothing beats the traditional teacher controlled classroom. This is why adoption of SCL calls for a paradigm change in instructors' professional profile and change in conception. An instructor's conception affects both her activities as in instructor and the learning outcomes of the students.

Current Strategies and Tools

Problem – Based Learning (PBL)

PBL is about giving students repeated practice in formulating solutions to genuine real- life technologically and socially relevant problems, which is one of the best ways to inculcate the culture of lifelong learning. Learning results from working towards the understanding and resolution of a problem, where the problem is encountered first and students are forced to identify what they need to learn to solve the problem. Finding a solution to the problem requires students to think, reason, research, evaluate and engage in peer tutoring and self- and peer- assessment.

Problem-based learning (PBL), has been a successful strategy for higher education programmes at Maastricht University. The suitability of PBL as an innovation in engineering is analyzed, given the characteristics of this particular domain. Project work and guided small group work also present themselves as alternatives conventional engineering education. PBL has been implemented as a partial strategy for mechanical engineering at Technische University Eindhoven. PBL offers good prospects in the first few years of programme, especially if group work tutorials and some directive teaching are added.

PBL originated from efforts to find an alternative to the traditional approaches of preparing engineers. The profession is often faced with new types of complex ill-defined problems requiring analytical and reasoning skills. Huntzinger (2007) identified the main elements of PBL as the essential ingredients of student-centred learning enumerated bellow:

- Students must take responsibility for their own learning.
- Problems should be ii-defined and allowed for free inquiry by students. Problems must be multidisciplinary.
- Student collaboration should be encouraged in both group and self directed work.
- Students must constantly re-analyze problems as individuals and as a group.
- Students must take part in self and peer assessment.
- Problems must have value in real world.
- Students must reflect on what they have learned from the problem.
- Students' assessments must evaluate problem solving and other skills.
- PBL must be rooted in the curriculum, not episodic.

Problem based learning has achieved adaptation and is so important that higher institutions of learning facilitate PBL staff development initiatives.

Collaborative Learning (CL)

Collaboration is a philosophy of (group) interaction not just a classroom technique. It suggests a way of dealing with people which rejects and highlights individual group members' abilities and contributions. There is a sharing of authority and acceptance of responsibility among group members for the group's actions. This is said to be distinct from cooperative learning, a classroom technique, in which students work in teams, with defined roles for each student, to accomplish a specific task at hand, while each student is assessed individually. Cooperative learning is usually not an integral part of the curriculum, unlike collaborative learning. 'Learning is enhanced when it is a (collaborative) effort. Sharing one's ideas and responding to others' improves thinking and deepens understanding. A basic criterion is that a collaborative situation should be quite interactive to a certain extent to which the interactions influence the peers' cognitive processes.

The instructor is able to identify learning gaps. The most famous Continue Assessment Test is the minute paper which requires students to stop and think about what they learned, to synthesize and articulate an important piece of learning.

Needs for Change in Engineering Curriculum

Fostering development among characteristically diverse students, faced with an unprecedented choice of values, rapid changes in technology and a dynamic society with demand for new competencies presents a challenge to engineering faculties. Transforming an educational system to embrace student-centred learning in order to impact sustainable skills and thought equates to a redesign or reform of the curriculum at all levels, as against 'bolt-on' or 'build-in', which affords an opportunity to redress problems entrenched in a content-centred, teaching-based engineering curricula. A learner-centred curriculum is intended to give students an increased sense of autonomy. The overall aim is to provide a multi-dimensional curriculum that will help in developing multi-skilled individuals that can relate to the demands of their fields within a dynamic social and economical environment. The specific goals of such a curriculum will be to:

1. De-emphasize the linear sequencing of courses and gradual spacing over years to transform the educational experience of students.

2. Adopt the iterative revisiting of concepts in a 'spiral' model.
3. Incorporate thread of process and product design concepts over the entire curriculum
4. Introduce appropriate instructional materials

PROPOSED MODERN APPROACH TO TECHNOLOGY

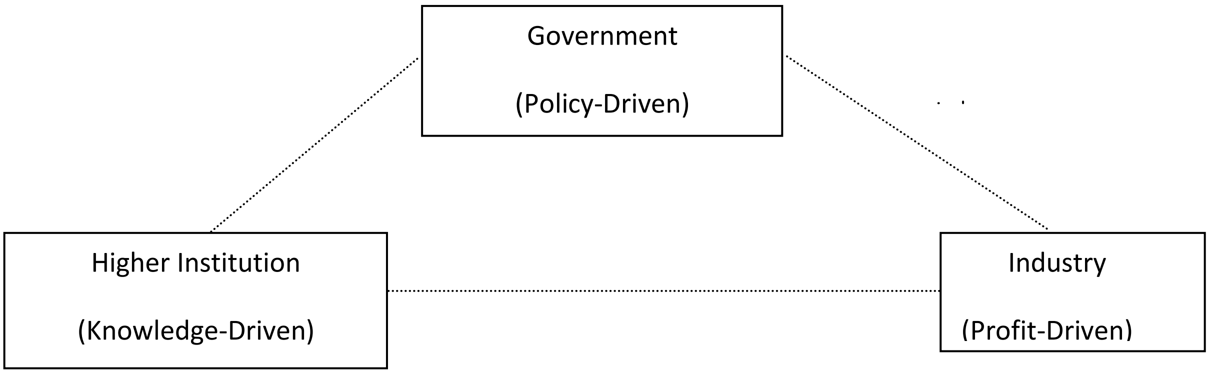

Fig. 1: Government-Higher Institution-Industry Interaction

In order to build strong partnership between the tertiary institution and industry towards engineering education transformation, the following are suggested as the way forward to adequately tackle the problem:

Management

Nigerian engineering and construction firms will need broader and more sophisticated management skills capable of adjusting rapidly to changing global challenges and market forces. Detailed strategic planning is now mandatory for all. The focus must be on markets, long term understanding of the industries, countries and regions served; global competitor analysis and will need to be integrated and managed effectively.

Project Creation and Development

More should be done to create demand for services. Major efforts are necessary to differentiate services through continuous development of unique capabilities and through innovative applications of proven technologies. Skill in taking and managing risk is an important element of project development requiring creativity, superb work execution and capital resources. This important competitive tool extends to construction operation cost, schedule, warranties, plant availability, maintenance and even financing. Project development skills are also important differentiating competitive factors. Many projects will proceed only through development efforts involving project capitalization and economic evaluation, arranging partnerships, organizing, financing and investment, finding markets and even operating and maintaining facilities. Pricing mechanisms that most fairly compensate us for value geared towards operating results, project profitability or other measures that satisfy the value determined of the customer will need to be developed.

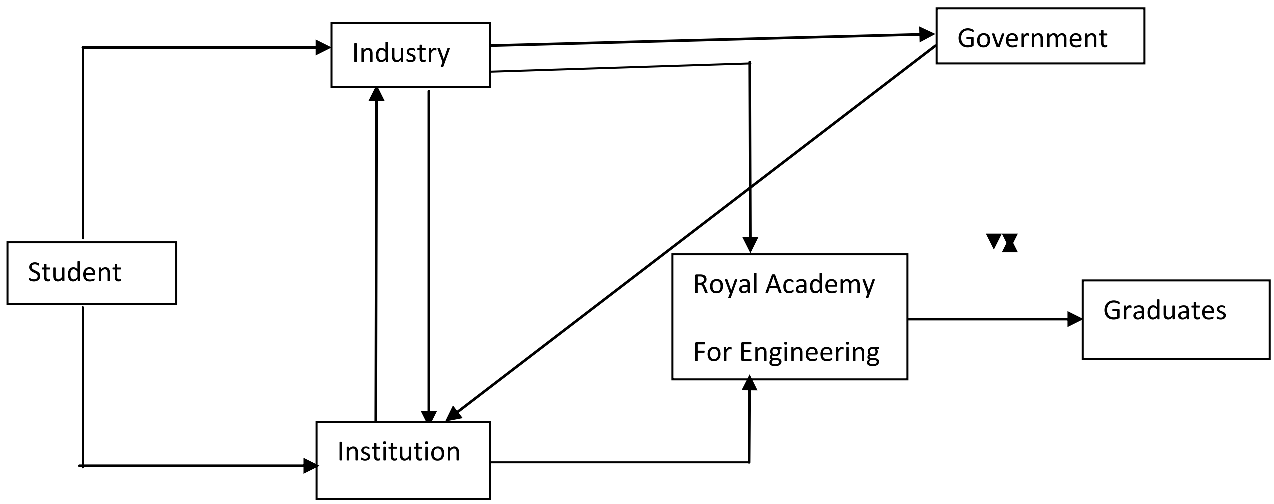

Fig.2: Suggested Model in Government/Institution and Industry for Sustainable Engineering Education.

i The model suggested in (fig2) provides a platform of relationship where government role is only a facilitator. The model engages the enrolled students in engineering education to go through 5 years programme between the institution and the industry and 1year internship at the Royal Academy for engineering before graduation as presented in the curriculum table.

ii Renaissance of talent- based education from elementary school.

iii E-learning which consists of practical demonstrations, motion pictures, workshops seminars, conferences and industrial visits.

iv Curriculum review is an essential ingredient towards attaining sound engineering education. Courses such as technology in sustainable development, academic engineer as social engineer, cultural change in engineering education are suggested. This should be coordinated by hybrid lectures with the following overall objectives provided:

- To develop consciousness among the students for the challenge that sustainable development poses to engineers.
- To develop students understanding of the role technology plays within the society at large, and more specifically in the process of sustainable development.
- To develop knowledge of the most relevant concepts, models and tools regarding sustainable development and basic skills for application during their professional life.
- Integration of sustainable entrepreneurship. The development of personal skills connecting social aspect of technology, management and entrepreneurship are of increasing concern for engineers for in-depth engineering education. Options adopted to evolve entrepreneurial and personal skill among engineering students include:

Training studies in micro-economy, business administration, marketing and financing. Integrating management and environment in the industry, Engaging students in management games, Encouraging students to prepare business plans for starting a company or developing new product design. These factors are major targets to produce entrepreneur engineer that will posses the adequate knowledge of core engineering and demonstrable technical competence with intellectual foundation. This intellectual base will be applied in the context of local environment towards industrialization.

Table1: Proposed Curriculum Table

Class	Level	Curriculum	Location	Duration
1	100 (ND1)	Basic Engineering principles	Institution	1Year
2	200 (ND2)	Practical Training	Industry	1Year
3	300 (HND1)	Core Engineering Principles and Applications	Institution	1year
4	400 (HND2)	a)Core Engineering Principles and applications continued. b)Engineering Project studies c)Commencement of students' projects	Institution Industry	6 months 6 months
5	500 (HND3)	a)Students' project continues. b) core specialized courses.	Industry	6 months 6 months
6	Graduation Class	➢ Internship programme ➢ Entrepreneurship.	Royal Academy Institute	1 Year

CONCLUSIONS AND RECOMMENDATIONS

Industry-institution partnership in training research, curriculum development, funding and facilities upgrading is a major missing link in the quest for industrialization in developing economy like Nigeria. Most training programmes in major institutions are not in tune with modern facilities, which only the multi-nationals can afford. Many of our services are still predicated on an earlier material-centered world. Our engineers must adapt to the challenges of "de-materialized" demands. This adoption requires much more emphasis on design, creativity, appropriate technology, flexibility, materials sciences and electronics, productivity, efficiency, quality and value added concept.

The following are subsequently recommended:

(a) Industries should participate actively in the establishment of Engineering workshops and laboratories for undergraduates to enhance quality training and research.

(b) There should be industry/academic co-operation in the areas of research and development with a view to establishing pilot projects, plants to enhance industrial experience of both teachers and students.

(c) Regulatory and professional bodies such as Nigerian Society of Engineers (NSE), Council for the Regulation of Engineering in Nigeria (COREN) should be engaged in the moderation, standardization of quality assurance of various industrial-institutional collaboration for students, teachers and facilities.

(d) There should be establishment of industrial-institutional sabbaticals for both teachers and company technocrats.

(e) Re-introduction of handicraft in primary schools to catch the future engineers young is important.

(f) Alternative to practical in secondary schools should be removed and the actual practical re-introduced to acquaint the students with the expected practical life in engineering and technology.

(g) Emphasis should be more on practical than theory in engineering and the related programmes.

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Reference to this paper should be made as follows: J.B. Otuu & I. Nnanna (2017), Enhancing Engineering Education through Problem - Based/ Student -Centred Learning. *J. of Engineering and Applied Scientific Research*, Vol. 9, No. 1, Pp. 21 –34.