OUTCOME BASED ENGINEERING CURRICULUM DESIGN: A SYSTEM FOR CURRICULUM STREAMLINING AND GRADUATE QUALITY IMPROVEMENT IN ENGINEERING

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Abstract

Traditional methods of developing curriculum includes the transfer of past courses and topics taught in previous years or decades. These courses included in the curriculum were relevant when they were first taught but there is no attempt to evaluate their relevance and there is no justification for their inclusion in the current curriculum except for the historical perspective of the courses being traditional courses for the curriculum of such Engineering disciplines This approach at developing curriculum for engineering education is rapid, easy and less time consuming but it does not lead to the production of graduates who are relevant and current in the state of the are in the work place. It does not allow for the addition of relevant course which can better equip the graduates for the world of work. The previous curriculum focused on ensuring that the students had sufficient information, it focused on what the student were expected to know upon graduation but the advent of the internet made such skill irrelevant as most of the information can be sourced from the internet. This resulted in the production of graduates who needed to be retrained before the can be engaged in the industry. Outcome based Engineering curriculum design championed by the ABET focusses on what the student will be able to do upon graduation. This approach requires that a justification or mapping of each of the courses in the curriculum to the program objective. The courses have to align or satisfy one or more program objectives to be made a part of the curriculum. The blooms taxonomy which is also a key component in engineering curriculum design placed the ability to create as the highest quality that can be derived from the curriculum. A combination of the outcome based curriculum design and the blooms taxonomy will ensure that memory recall courses and topics are kept to the minimum while design based courses are given more prominence. This will enhance the quality of graduate produced especially in developing countries which are yet to adopt the outcome based engineering curriculum design methodology.

Keywords: Outcome Based Engineering, Engineering Education, Program outcomes.

1 INTRODUCTION

Curriculum typically refers to the knowledge and skills students are expected to acquire during the course. It is also defined as the total subjects and courses students take in the course of their studies in an educational institution.[1][2][3]

It includes the following:

1 Learning objectives the students are expected to meet;
2 The units and lessons to be taught
3 The assignments and projects to be given to students;
4 The list of books, materials, videos, presentations, and readings used in the course;
5 The tests, assessments, and other methods used to evaluate student learning

Engineering curriculum can thus be defined as the total number of course students are required to take in the course of their study of the engineering. The curriculum plays a critical role in the quality and the capabilities of the graduate as it provides the foundation for the students' contribution to the work force after graduation and should also be able to determine the students' ability to keep learning even after graduation.

The curriculum for a course should have the following key components

1 Foundational Theories
2 Mathematical Basis

3 Analytical Problems

4 Design Principles and Tools

5 Real life design problems

6 Possible application areas of the course

The central focus of the Engineering curriculum is to enable the students acquire relevant Design Skills and problem solving skills with which the can develop and innovate. The curriculum is expected to be responsive to the changes in the market space and the changes in technology [4][5]. The diagram in figure 1 shows the typical world class curriculum run by most world class universities and the curriculum approach currently being run in Nigeria. The world class curriculum is often times designed to be outcome based.

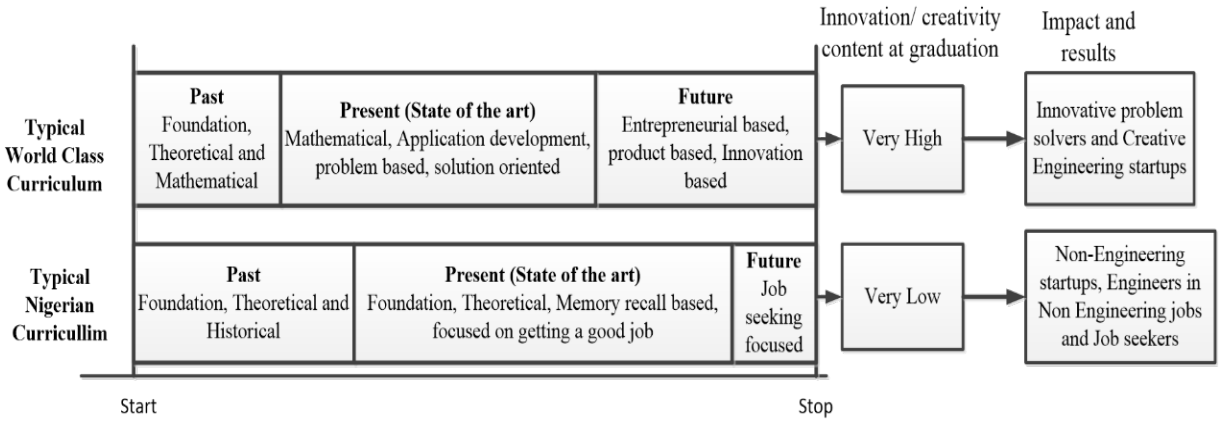

Figure 1: Curriculum deliverables and Focus for engineering graduates.

The diagram in Figure 1 shows the expected curriculum deliverables for engineering graduates. World class universities which run the outcome based curriculum focus on training the students to be able to do specific things. The focus on equipping the students with design skills and problem solving skills. This is accomplished by the nature of courses and the content of those courses. The current curriculum deliverable for Nigerian Engineering education on the other hand focuses on equipping the students with knowledge. The demand is placed on the students' ability to remember and as such the system rewards those who remember the most and the quality of the graduates is determined by the class of their degrees. This expected outcome is achieved by focusing on giving the student large volume notes and asking mainly memory recall questions, teaching courses with little or no experiments and having minimal application questions. One critical factor that reinforces this is the curriculum review process and the accreditation process for the courses. The Nigerian education system is regulated by the national Universities commission and there is a Benchmark minimum prescribed by the NUC which universities must meet in terms of the curriculum [6][7][8]. Failure to meet can cause the department to loose accreditation. The challenge with this system is the BMAS leaves very little room for innovation by the individual departments. A full accreditation lasts for 5 years and what this means is that the departments can run with the BMAS for 5 years but the rate of change of technology is shorter than 5 years. Experience has shown that the BMAS used in most accreditation exercises does not factor in the advances in technology and as such the students are trained using old or expired benchmarks and expected to function in an environment with modern technology. While the argument is that BMAS is a minimum academic standard, experience has shown that for departments to meet the BMAS, the will have very little room to introduce innovative courses or new courses which cater for the changes in technology.

2 METHODOLOGY

The relationship between the Industry and the academia is such that the output of the academia make up the workforce of the industry while the industry is expected to provide research problems and funding to the academia. This is reflected in Figure 2[9]

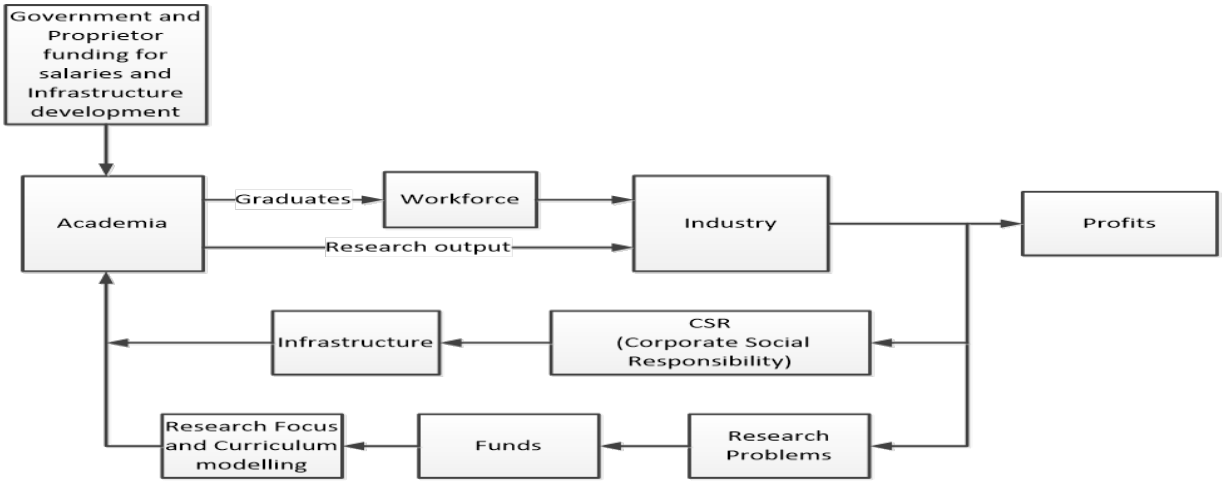

Figure 2: Industry academia collaboration [9].

Figure 2 shows the relationship between the academia and the industry. The industry being a profit oriented organizations requires a workforce of skilled graduates, knowledgeable graduates are good but a knowledgeable graduate with little or no skills is of little value to the industry. Most job adverts are focused on skills as the industry or the employer earns income by providing a skill based service. For the graduates to be relevant in the industry, the must have specific skills translated into an ability to solve problems. This is the one key reason why most multinational companies bring in Expatriates. For graduates to be able to fit in to the industry or to be able to develop products and form their startups, the must be trained in such a manner that the focus of their training is skill development and problem solving skill development. The curriculum must focus on skill development and this is what the Outcome based curriculum design delivers. Curriculum needs to be responsive to the industry's technology needs. The research in the academia must be focused on solving industry problem as that is the way the academia can attract the right kind of funding from the Industry. For engineering graduates to be relevant in the industry, greater emphasis should be placed on developing design competences using relevant design tools in solving real world problems

2.1 Blooms Taxonomy

Bloom's Taxonomy was created in 1956 under the leadership of educational psychologist Dr Benjamin Bloom to promote higher forms of thinking in education. It identified several levels of learning and identified key outcomes for each level. The blooms taxonomy is represented in figure 3. It is mostly used when designing educational, training, and learning processes.[10][11][12]

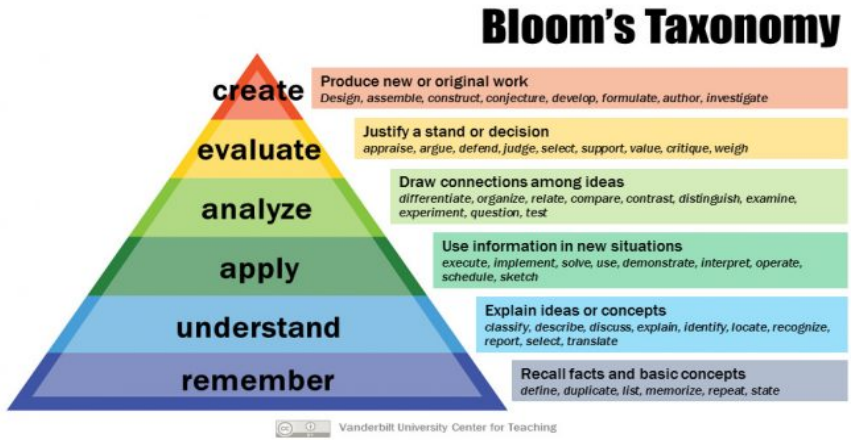

Figure 3: Blooms Taxonomy.

Bloom's Taxonomy provides a means for enabling the description of the degree to which we want students to understand and use concepts, to demonstrate particular skills, and to have their values, attitudes, and interests affected.

The level at which the teaching is implemented determines the quality of the questions set for the students. From the blooms taxonomy, the quality of the teaching increases from the remember level where the students are just expected to remember parameters, list, enumerate or repeat facts, to the highest level where students are expected to create, design, develop, etc.

The quality of the questions is to reflect the level for which the teaching was fashioned for and it provides an insight into the quality of the teaching. For quality questions to be set, the faculty must have developed learning outcomes which are aimed at enabling the student to develop capacity for design, analysis and application. As much as possible, there should be very minimal questions which are based only on the remember level. (Level 1).

Multiple choice questions are often times used as the assessment methods for 100 Level and University wide courses. While this may be convenient, it only assesses the students in the knowledge and comprehension/remember levels. It is not suitable and cannot be used to assess students' knowledge at the higher levels of synthesis and evaluation (levels 5 and 6).

2.2 Course Objectives & Learning Outcomes

Course objectives are clear and concise statements that describe what the faculty intends for the students to learn by the end of the course. Course objectives can also be described as the different topics the students will learn to be able to finish each particular module or course.

The learning outcomes describes what the student would have learnt after taking the course. It can also be described as the skills the students are expected to have acquired after taking the course. When writing outcomes, it is preferable to use verbs that are measurable or that describe an observable action. Such verbs help both faculty and students avoid misinterpretation. The learning outcomes are measurable capabilities that the student must demonstrate in order to pass a course. These are what must be assessed by the questions. The learning outcomes are to be aligned to the different levels of the blooms taxonomy. For each unit in a course module, the faculty is to identify the learning outcomes, (the specific skills that the student would have developed upon the completion of the course. This is put in a table and matched with the blooms taxonomy as shown in the table 1

Table 1. *Matching the learning outcomes to Blooms Taxonomy levels.*

Goal: The equip students with the required skills to be successful project managers	
Module: 1	
Learning outcomes	Blooms Taxonomy levels
Students should be able to identify what a project is and what it is not	Remember/Understand
Students are to be able to determine the parameters for determining a successful project	Understand
Students are to be able to undertake a break down a project into the different work packages and undertake task allocation	Apply/Analyse
Students are to be able to undertake task allocation for any given project	Evaluate

From the learning outcomes, the corresponding Blooms taxonomy level can be identified and this will enable the faculty identify the quality of teaching he or she would need to deliver to the students. It also provides the faculty with an opportunity to improve on the lecture plan

The topics/modules in the courses can also be organized such that the learning level expected from the students are mapped to the different levels as shown in Table 2.

3 RESULTS

3.1 Outcome based Curriculum

A curriculum that places more emphasis on what the student will be able to do rather than what the student will be able to remember. The focus of the outcome based Engineering curriculum is on the development of design skills and this helps in streamlining and improving the quality of engineering graduates. The program objectives are derived to align with the expectations of what the graduates

will be doing upon completion of the course (outcomes). This guides the development of the course objectives and the selection of the courses that make up the curriculum.

3.2 Outcome based Curriculum Development

The process of curriculum development for the Outcome based curriculum involves the process of identifying the required courses that will make up the curriculum. When these courses are identified, they are then mapped with the expected outcomes. This mapping provides a clear picture of the contribution of each course to the overall outcome that the course will accomplish. The faculty can determine from the mapping if the bulk of the topic address only the ability to remember, the acquisition of knowledge or the acquisition of design skills. This ensures that student are not loaded with unnecessary courses forcing them to spend time and energy learning things that will not be relevant to their careers while ignoring or giving little attention to the core courses. This mapping will show the courses that are relevant and also show the degree of relevance of the courses to the practice after graduation. Table 2 shows the ABET outcomes for engineering and table 3 shows the mapping of the different courses to the courses that make up the curriculum of the course.

Table 2. *Course outcomes.*

Outcome 1	Ability to apply Mathematical, Scientific and Engineering principles to the identification, formulation and solution of Engineering problems.
Outcome 2	Ability to design and conduct experiments and to analyse and interpret data using modern engineering tools and techniques
Outcome 3	Ability to design engineering processes and products to meet desired needs
Outcome 4	Ability to analyse important social and environmental problems and identify and discuss ways engineers might contribute to solutions including technological, economic and ethical considerations in the analysis
Outcome 5	Ability to communicate effectively in both writing and speaking in a variety of professional contexts.
Outcome 6	Ability to function effectively in both single-discipline and multidisciplinary teams
Outcome 7	Recognition of the need for and ability to engage in lifelong learning

Table 3. *Mapping of the outcomes to the courses topics.*

Outcome indicators & core courses	**outcome 1**	**outcome 2**	**outcome 3**	**outcome 4**	**outcome 5**	**outcome 6**	**outcome 7**
GEC310: Engineering mathematics	**3**						
EIE311: Electromagnetic Fields and Waves	**3**	**2**					
EIE312: Communication Principles	**3**	**2**	**2**				
EIE313: Physical Electronics	**3**	**2**	**2**				
EIE314: Electric Circuit Theory 1	**3**	**2**	**2**				
EIE315: Electric machines 1	**3**	**3**	**2**				
EIE318 : Laboratory Course 1		**3**	**2**				
GST 311: History and Philosophy of Science				3	1		
EDS311: Entrepreneurial Development studies				**3**	**2**	**2**	
TMC311: Total Man Concept					**3**	**2**	**2`**
1 = objective addresses outcome slightly, 2 = moderately, 3 = substantively							

4 CONCLUSIONS

Engineering is a practice oriented course and as such its education should be focused at producing graduates who are able to practice. These graduates are to be responsible for utilizing the findings of science to develop solutions to real world problems. This presupposes that the students must have an understanding of the basic and core principles of the science and also have design and application training to be able to produce relevant solutions and systems. The curriculum should therefore be fashioned in such a manner that engineering students do not spend the bulk of their time learning the principles, they should not spend the most of their time learning things that they will only have to remember. The training of engineers would be done with the outcome in view. The outcome of the engineering profession is the utilization of the scientific facts and concepts to solve problems. With this outcome in view, emphasis for engineering education should be placed on the skill acquisition and also the acquisition of problem solving skills. This is the core of the outcome based curriculum. The ABET accreditation will enable both faculty and students to work together in ensuring that the students we produce are problem solvers and also internationally competitive

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