HBRP PUBLICATION

Recent Trends in Production Engineering
Volume 4 Issue 2

Mathematic, A Categorical Imperative for the Training of the Engineering Students in the 21st Century

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ABSTRACT
Professionally, engineering is presently the most important discipline mathematically. Innovative development in engineering has stimulated new grounds of mathematical research. Coding theory, signal processing, control theory etc. the interwoven nature between engineering and mathematic creates a mathematic relevance, in the engineering education. In the last thirty years, demands of the engineering profession and adequate mathematical ability of the engineering students has resulted to a change in the scope of the mathematics education. Computers and technological developments have resulted to various methods if teaching mathematics, cumulating into the use of modern techniques and method to deliver the engineering student. This research aims at mirroring the mathematical education and reflecting its important nature to engineering education for the 21st century engineers. This must be by critically evaluating the curriculum, teaching and measurement-assessments method which is categorically imperative in training engineers.

Keywords:-*Education, profession, discipline, research, development.*

INTRODUCTION

The increasing rate of technological development has activated the quest or engineers in seeking frequent update in their areas of specialization. This cumulates into mastering new techniques and having a grasp of the new theoretical concept due to the constant disintegration to various fields of engineering specialization. A grounded knowledge and fluent mathematical practice becomes a very imperative weapon in modern graduating Engineers. [9].

Recent demands of the Engineering profession and dwindling ability of the Engineering students have led to a big alteration in the scope of the mathematics education. In the last twenty years, the development in computers and technology has caused variation in teaching mathematics for engineers, introduced modern techniques and methods of teaching.

Insufficient knowledge in basic mathematics cause problems for those majoring in engineering at university level. A big portion of students seems to be able to find correct solution to test and exam questions using familiar steps and procedures. Yet they lack deep conceptual understanding of the underlying theorems and sometimes have misconceptions (Norbert & Klymchuk, 2002). One of the most important skills required of engineering students are problem solving, creative thinking, sensitivity analysis and critical evaluations, but they have some difficulties in these issues [1]. Furthermore, the student profile has been changed and the number of international students has been increased. Almost all branches of engineering profession, in

parallel with changes in technology, new demands arise.
The mathematics education for engineering students has greatly been affected by the engineering profession's profile, the expected new demands on student's mathematical capabilities, profile differences and the development in educational technology.

In this study, this metamorphosized changes in mathematics education for engineers are discussed in terms of curriculum, teaching and assessment methods.

METHODOLOGY

A survey method was employed in this research with the aim of critically evaluating the changes happening in the mathematics teaching for 21st century engineers. This was also assisted by questionnaire and pilot study.

RESULTS/FINDINGS AND DISCUSSIONS

Curriculum

The imperative nature of mathematics education for engineering was highlighted in many studies. While there is no consensus on the amount and content of the mathematics for different engineering disciplines, there is a consensus on the need for a basic mathematics in all of them [2]. The most effective subjects for engineering mathematics must be a part of an engineering program which must give the chance to see the main development in the concepts and understanding for related subjects. The way mathematics is included in different engineering educational institutions curricula varies, but there are some basic requirements to be fulfilled [9].

Mathematics Working Group of the Nigeria Society for Engineering Education (NSEE) is nonexistence, so we conducted an extensive study on the content of engineering mathematics in 2014 – 2016. At that study a core program was developed which has four levels. These levels represent an attempt to reflect the hierarchical structure of mathematics and the way in which mathematics can be linked to real applications of ever greater sophistication as the student progress through the engineering degree program as reflected in [7]. The schematic diagram of the proposed structure is shown in Figure 1.

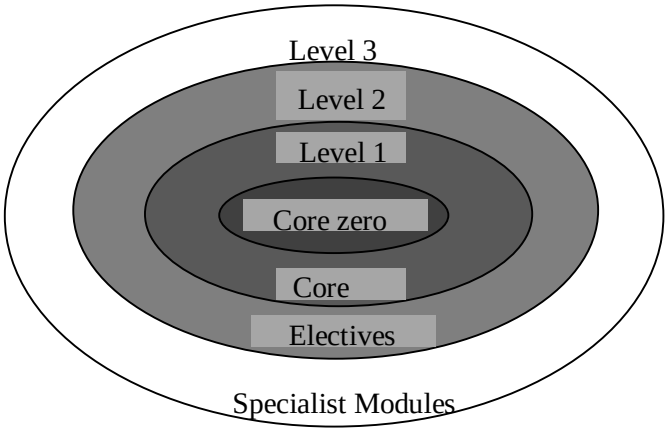

Fig.1:-*The schematic diagram of the proposed structure*

Within these three main levels the material has been arranged under five sub-headings: Analysis and calculus, discrete mathematics, geometry, linear algebra, statistical and probability. The core zero consists of the material that the fresh students should study before entry to an undergraduate engineering degree

program. The core zero contains material which together forms a solid platform on which build a study of engineering mathematics at university. The material in Core Zero has been grouped into five areas: Algebra, Analysis & Calculus, Discrete Mathematics, Geometry & Trigonometry, and Statistical & Probability [7].

It is imperative to know that the courses at core level 1 builds on core zero and is regarded as basic to all engineering disciplines in that it provides the fundamentals of mathematical principles. The material in core level 1 can be used by engineers in understanding and the development of theory and in the sensible selection of tools for analysis of engineering problems. This material will be taught in the early stages of a university programme [9].

The material at level 2 builds on core level 1. The material is advanced enough for simple real engineering problems to be addressed. Different disciplines will select different topics from the material of level 2.

Level 3 is the one at which the mathematical techniques covered should be applied to a range of problems encountered in industry by practicing engineers under the registration of Nigeria Society of Engineer and COREN (Council for Regulation of Engineers in Nigeria). These advanced methods build on the foundations laid by levels 1 and 2 of the curriculum. It is quite possible that much of this material will be taught not within the context of dedicated mathematical units but as part of units on the engineering topics to which they directly apply for the betterment of engineering in Nigeria.

THE METHODS OF TEACHING AND ASSESSMENT

Lopez [8] found an outsized body of research highlighting the necessity for educators of engineers to adapt to changing nature of both the engineering profession and therefore the student population within the 21st Century. A more diversified student population requires a more comprehensive learning network. Therefore, there's much debate on how these changes should be addressed [2].

The engineering institutions are faced with various problems in learning, impacting and practicing such as

- A decline in the mathematical ability of entering engineering students
- The lowering of entry standards and increased number of international students (it has also led to the increased diversity of students' mathematical background),
- The reduction of mathematical content and course hours,
- To cater mathematical needs for all engineering disciplines in one subject and thus the problem of reaching a shared understanding between the mathematics and engineering departments about what's to be included within the curriculum,
- The matter of teaching large classes with inadequate facilities,
- The shortage of mathematics staff.

In resolving these, new methods have to be employed by institutions. Some examples of these are problem/project based learning, support programs for the students, online support, visual sources, mathematical software programs, online instructional materials, computer –aided assessment, flexible, formative and summative assessment, entrepreneurship studies [2].

To overcome the difficulties faced by the students in mathematics lessons, many engineering institutions should offer

academic support services. The Mathematics Support Centers (MathCentre) of many universities in Nigeria or rather the mathematics Department of all the universities in Nigeria should give online courses, lecture notes, tests, videos for mathematics teaching at their web site for free. All Engineering students can also use the mathematics laboratories of some of the universities in Nigeria, The National Mathematical Centre facilities and Laboratories etc.

From a survey of recent (from 1990 up to the present time) literature in mathematics education for engineering students, following are notable means for teaching and learning to adapt to 21st century needs and conditions:
Use advanced computer based methods-web based interactive, software applications, or both,

- Address student variability,
- Take a multidisciplinary approach,
- Use a haul Based Learning Strategy [8].

Learning is by doing. Active learning broadly encompasses all learning driven by the learner. The student's success will become higher when they participate in the learning process more [8,10]. Problem based learning and computer based learning is also classified as active learning.

With the rapid progress of technology in last few decades, software applications and therefore the web became important elements of the engineering mathematics education. The widely used software programs are Matlab, Excel, Minitab, Mathematical, Mapple, Mathcad [2].
Cooperative learning in engineering mathematics education is one the methods used and promotes the high success [6]. Variations and combinations of some learning methods such as project–based learning, the integrated approach, and the four–leaf clover model are also used [8].
Naturally, the changes of teaching and learning methods have affected assessment methods.

Additional assessment methods include a combination of some of these assessment methods; class tests, group projects, individual projects, written assessment and computer–aided assessment to mention a few. The Continuous assessment gives the educators a chance to having continuous information about the needs of the students and the class as a whole as against the new practice of static assessment also referred to as mid-semester examination. With flexible assessment method student chooses his own evaluation method. This forces the student to have the control of his own learning and choosing the best method to show his success as much as possible [11].

As an example, mathematics courses content, teaching and assessment methods in the Industrial and Production Engineering Department of Ambrose Alli University. The Industrial and Production Engineering Program is shown in Table 1 [7].

Table 1:-*Industrial and Production Engineering Program*

Module	**Credit**	**Pre req**
Mathematics for Mechanical Engineering (MAA 310)	20	None
Mathematics for Mechanical Engineering (MAB 110)	10	MAA 310

CONTENT
Algebra of complex numbers, vectors and matrices. Solution of system of linear equations, determinants, matrices and Gauss elimination. Iterative solution of nonlinear (Newton Raphson). Elementary

functions including hyperbolic functions. Ordinary and partial differential equation: techniques and applications including stationary values and errors. Integration; analytical techniques and Simpson's rule, applications (area, mean value, RMS, volumes of revolution). Ordinary differential equations: first order separable and linear equations, second order linear equations with constant coefficients, applications. Laplace transforms: application to solving ordinary differential equations. Sequences and series: infinite series, convergence, Binomial, Maclaurin and Taylor series.

Method of Teaching and Learning: Total student effort for the module: 24 hours on average.
Teaching & Learning: A combination of 24 two–hour lectures and 24 one hour tutorials with the remaining time for private study, working on problem sheets and revision for exam. Tutorials are where no new material is covered. Either students work through problem and get help from the staff on hand or else the lecturer goes through worked examples.
Assessment: Coursework: Eight computer-based or in class tests (8x5% = 40%). Summative Examination (60%) (3 hours).

MAB 110: Mathematics for Mechanical Engineering
Content: Elementary probability and statistics. Matrix eigenvalue problems, with application to solutions to Ordinary Differential Equations, for example vibrating systems. Optimization of functions of several variables, with and without constraints. Fourier series and partial differential equations.

Method of Teaching and Learning: Total students effort for the module: 100 hours on average. A combination of 24 two-hour lectures and 24 one-hour tutorials with the remaining time for private study, working on coursework assignments and problem sheets and revision for exam.
Assessment: Coursework–2 equal computer based tests (20%). Formal Examination (80%) (2 hours).

CONCLUSION

Engineering education is an important circuit in higher education and natural development. Mathematics teaching has imperative role in engineering education. The recent developments in technology and computers have caused variation in teaching mathematics of engineering students and have brought with them the utilization of recent techniques and methods. Computer and internet can't be ignored in engineering education.

This research shed some light on how the mathematics education, which is an important circuit of the engineering education for the 21st century engineers, must be, by investigating the curriculum, teaching and assessment methods.

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