International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 6, June - 2013

Engineering Mathematics Issues In University Education: A Review

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1.0 INTRODUCTION

Mathematics is the science of number and space, and the language of science and technology. It is an essential requirement by every field of intellectual endeavour and human development to cope with the challenges of life. It is also described as the queen and servant of all school subjects, since it cuts across the school curricula (Fajemidagba, 1986; and Akpan, 1987). Mathematics as a school subject affects all aspects of human life at different degrees. For instance, mathematics is relevant in economics, political, geographical, scientific and technological aspects of man because it centered on the use of numbers which is an integral component of every aspect of knowledge. Other areas where the use of numbers is predominant include: statistics, accounts, arithmetic, engineering, and so on. For example the earliest civilization of mankind came through mathematical manipulations through the use of numbers.

Mathematics is seen as the language used to describe the problems arising in most branches of science and technology. It is a subject that is related to other school subjects in areas like number and numeration, variation, graphs, fractions, logarithms and indices, algebraic processes, solution of equation and also in area and volume.

Mathematics is a key element in engineering studies and serves as language of expressing physical, chemical and engineering laws (Sazhin, 1998). Mathematics is the heart of engineering, being both a language for the expression of ideas and the means of communicating results. Engineering mathematics has always been the fundamental and important courses in engineering curriculum. Engineering students are required to understand the fundamental of mathematics and apply this knowledge to solve real world problem. The requirement for engineering mathematics for the different branches of engineering is more or less the same at the first and second year level, but tends to be more specific and complicated at the later years. The understanding of fundamental concepts and ideas in engineering mathematic is very crucial for mastering engineering discipline. It is a subject that is related to other engineering courses such as: basic mechanics, mechanics of materials, mechanics of machines, engineering statistics, design, engineering economics. It equips engineering students with the basic skills and techniques for handling engineering design problems. Having strong foundation in mathematics for an engineering student is very important to gauge success in engineering. The objective of teaching mathematics to engineering students is to find the right balance between practical applications of mathematical equations and in-depth understanding of living situation (Sazhin, 1998).

In spite of its importance, the performance of students in the subject has been a great concern to the society. In the course of this research, the department of mechanical engineering, Nnamdi Azikiwe University Awka revealed a shocking development of 62% failure, with only 4% scoring above average in Engineering Mathematics IV in 2011/2012 session. Similarly, the results obtained from other departments do not portray otherwise. Aremu and Sokan (2003) submitted that the search for the causes of poor academic achievement in Mathematics is unending. Some of the factors identified by them are: motivational orientation, self-esteem/self efficacy, emotional problems, study habits, teacher consultation and poor interpersonal relationships among students.

It is important that Engineering students still receive a solid, foundational understanding of mathematics (Cardella 2008). Cardella also asserts that beyond the mathematical content knowledge that is necessary for engineering practice, educators should consider problem-solving strategies, resources and use of resources, beliefs, mathematical practices and the environment in which mathematics is taught. 'There is clear agreement that mathematical skills are essential. … There is also the need to resolve how changes could be made to the teaching of the engineering sciences, in particular to allow students with different mathematical skills at entry to flourish.**'** (Haryott, 2003).

2.0 CONCEPTUAL UNDERSTANDING

Studies such as Bell (1993), Canobi (2005), Hiebert and Carpenter (1992), Mason and Spence (1999) and Yager (1991) showed that students' conceptions of understanding mathematics are important in their success in mathematics learning. Students seem to hold a variety of views of mathematics in the classroom. Across the academic levels, elementary students see that effort, regardless of ability, is the key to learning mathematics, but when they advance to high school level; they see the lack of ability as a significant impediment in mathematics learning (Kloosterman & Cougan, 1994). In the classroom, some students may believe that a good grade is important in mathematics assessment, while others may not (Hurn, 1985). Some students view mathematics learning as interesting, others may believe that it is a form of tedious and monotonous work (Cooney, 1992; Cotton, 1993). Others may even see mathematics as a subject that causes them negative emotions such as fear, anxiety and anger during lesson (Hoyles, 1982). Some students feel that they learn mathematics because of their intrinsic interest in it (Kloosterman, 2002). At the same time, some students may view mathematics learning as being forced on them by schools and teachers (Ainley, Bills, & Wilson, 2005;

Cotton, 1993). These students may possibly feel that they do not understand the "purpose" of the mathematics tasks assigned to them, and thus, see no meaning in doing these exercises (Ainley & Pratt, 2002). Students may also feel that some of the so called real-world contexts used by teachers to relate to mathematics concepts may not be interesting to them, and even create confusion in their problem-solving (Ainley, 2000; Silverman, Winograd, & Strohauer, 1992). In terms of learning mathematics effectively, Kloosterman reported that students view procedures as more important than concepts. They also feel that memorization is an important part of mathematics learning (Kloosterman). In relation to social influences in mathematics learning, some students may believe that teachers make learning mathematics difficult to understand and give little guidance to their mathematics learning (Kloosterman). On the other hand, other students may view mathematics as a subject where failure to achieve the right answers is usually met with disapproval and criticism by their teachers (Ernest, 2004). At the same time, some students may recognize that peers can help or impede them in their mathematics learning (Perret-Clermont & Schubauer-Leoni, 1988; Sternberg & Wagner, 1994; Zimmer & Toma, 2000). The various studies above showed that students can hold a huge diversity of views about mathematics learning at personal, social, conceptual, procedural, cognitive and emotional levels. Such views might possibly influence how well they are able to do mathematics. Attempts to relate the engineering mathematics learning to the above studies might not be useful for two reasons. First, most of these views are only representative of primary and secondary mathematics students, and do not fully characterize those of tertiary students studying engineering mathematics. Second, all these studies are not conducted in the context of Nigeria where this research is carried out. Thus, it may be shown there is a lack of such research in Nigeria with regard to understanding engineering mathematics learning. This further emphasizes the importance of this study in allowing practitioners (such as engineering students, teachers, researchers and policy makers) to understand the perspectives of students in engineering mathematics learning.

3.0 THE MATHEMATICS PROBLEM

"Each year, the A-level results come out showing increased pass rates, yet we do not see any improvement in the ability of students to tackle the mathematics of engineering degree courses. … The situation is serious, and getting more so. Most university engineering departments now find it necessary to provide remedial teaching for students whose mathematical foundations are not adequate for university first-year maths." (Pyle 2001). Mustoe, 2003 asserts *'For many years, concern has been expressed about the decline in mathematical skills possessed by entrants to engineering and science degree programmes.' 'The mathematics problem is usually described as a skills problem, but this has two aspects: the knowledge of mathematical techniques and facts, and the confidence to make use of them'* (Kent and Noss, 2003). Under the present circumstances, it is natural for academics to focus on the 'mathematics problem' at the interface between secondary school and university, because of the pressing need to recruit students into engineering courses, and to retain them (Cutler & Pulko 2001). The common complaint is that students, sometimes even those with a good grade in A-level Mathematics, lack fluency and 'comfortability' with mathematical symbolism and its manipulation; this compromises the whole development of engineering understanding from a mathematical basis. From the perspective of professional practice, the 'mathematics problem' can be viewed somewhat differently. There are opinions that academics might fruitfully consider the place of mathematics at the other 'interface', between university and industry. The role that mathematics plays in practice has undergone radical changes in the last 30 years, in terms of mathematics as explicit work by individual engineers becoming mathematics as a distributed (and more implicit)

activity across design teams and the computers which support them. This argument is often expressed in terms of the usefulness (or not) of knowing mathematics in engineering practice.

4.0 FACTORS AFFECTING STUDENTS' UNDERSTANDING AND PERFORMANCE IN ENGINEERING MATHEMATICS.

4.1 Education System Related Factors

4.1.1 Education system

According to Vasudha (2012), "Based on the education system, the problem begins right from school days. Students are spoon-fed by schools and private tuitions. Thus, they lack in the development of their ability to think logically and apply the concepts practically, which is very critical when it comes to engineering studies." He explains further that without a strong knowledge in the basis of mathematics and sciences, the engineering students will find difficulty in learning concepts.

4.1.2 Poor admission process

The present system of admission into engineering universities leaves much to be desired. Anyone who can '*mug,*' gets admission into a reputed university. It should not be surprising that the Nigerian education system under the present support cannot move forward. "One of the most important reasons for this is **quota system**; so, finally we all think beyond politics, then there will be some positive results" (Vasudha, 2012). Vasudha further asserts "… if admission is given to all irrespective of merit, then failures in exams will be inevitable."

4.1.3 Lack of qualified lecturers

The dire shortage of lecturers to teach engineering mathematics in many public and private engineering universities also seems to be affecting the results. Quoting Ramamurthy, Vasudha (2012) asserts "most senior professors refuse to teach first-year students because they are all in one bunch, and yet to be segregated into branches; The best among the trained personnel are sent to the top branches of engineering.

4.2 Student-Related Factors

4.2.1 Mathematics anxiety

Mathematics anxiety is defined as a feeling of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in both everyday life and academic situations (Richardson & Suinn, 1972; Tobias, 1994). The negative effects of academic anxiety on students' learning performance have long been recognized (Levitt, 1980). Since the early 1970s, an extensive amount of research has been carried out on mathematics anxiety. The causes of mathematics anxiety fall within three major factors: dispositional, situational, and environmental (Baloglu & Kocak, 2006). The *dispositional* factors deal with psychological and emotional features such as: attitudes towards mathematics, self-concept, and learning styles. The self-concept refers to students' perception of their own ability to perform well in mathematics, and to learn new topics (Sax, 1994; Townsend & Wilton, 2003). The situational factors are direct features that result from their particular mathematics courses: the nature of the course, and how it is designed and carried out; the availability of, or conversely, the lack of feedback; the pace of instruction, etc. The *environmental* factors are characteristics that affected the students prior to their mathematics course: for example, age, gender, academic major, and previous mathematics experience.

The two most commonly used measures of mathematics-anxiety-related instruments are the Fennema-Sherman Scale (Fennema & Sherman, 1976) and the MARS scale (Richardson & Suinn, 1972). The Fennema-Sherman Mathematics Attitudes Scale measures the various dimensions of attitude towards mathematics. One of the dimensions assesses students' feelings of anxiety, dread, and nervousness when performing mathematics. The Fennema-Sherman Scale has been used with various groups such as middle school, high school and college students, college teachers, high-ability students, and matriculation students (Cates & Rhymer, 2003; Norwood, 1994; Swan, 2006; Yeo, 2004; Yong, 1993; Zakaria & Nordin, 2008). The Mathematics Anxiety Rating Scale (MARS) by Richardson and Suinn (1972) has been developed solely to measure mathematics anxiety. The original one-dimensional, 98- item MARS scale measures anxiety associated with the manipulation of numbers and the use of mathematical concepts. Since the MARS scale has been the most commonly used and well validated instrument, it has also undergone periodical revision (Capraro, Capraro, & Henson, 2001). The MARS scale has been applied to populations ranging from elementary students to undergraduate and graduate college students – especially those who major in statistics, psychology, and education (Alexander & Cobb, 1984; Capraro et al., 2001; Hembree, 1990; Hopko, 2003). On the other hand, a minority of MARS studies have been conducted on groups of students majoring in mathematics and science (Baloglu & Kocak, 2006; Hembree, 1990). Hembree's (1990) meta-analysis showed that mathematics and science majors expressed the lowest anxiety levels, whereas the highest levels occurred in students preparing to teach in elementary school. Hence, in recent years, many MARS studies have been conducted on mathematics and science majors, with particular emphasis on pre-service teachers (Austin & Wadlington, 1992;

D'Ailly & Bergering, 1992; Gresham, 2007; Gresham, 2008; Malinsky, Ross, Pannells, & McJunkin, 2006).

4.2.2 Self-efficacy

Self-efficacy is the degree to which a student believes they can accomplish a goal (Pintrich, 1999). Albert Bandura and Edwin Locke (2003), from Stanford University and University of Maryland respectively, report "…perceived self efficacy and personal goals enhance motivation and performance attainments"(p. 87). Bandura and Locke understand "…efficacy contributes significantly to the level of motivation and performance" (p. 87). Pajares (2002) believes self efficacy to be intuitive. Self-efficacy influences choices in three ways. Students choose tasks they feel confident in, but avoid tasks they don't feel confident in; choose how much effort, resiliency, and persistence will be expended on an activity, and feel an amount of stress and anxiety, from serenity to great apprehension based on self efficacy. Indirectly, teacher behavior and learning strategies have an effect on self-efficacy and student motivation (Bandura & Locke). Bandura and Locke cite evidence from nine large bodies of methodology and strategies, including work in laboratories and field studies done by Sadri & Robertson in 1993, and investigations where Boyer (2000) controlled efficacy beliefs experimentally. The studies conducted in the 1990s and early 2000s have encompassed diverse populations, using different formats and different instruments. Bandura and Locke powerfully state that self-efficacy beliefs predict how a person will act, either positively or negatively. Self-efficacy determines how a person will make decisions at important points, and also, how effectively a person self motivates. Also, self-efficacy determines how a person perseveres in difficulties. Bandura and Locke went on to state emotional well-being and vulnerability is also dependent on self-efficacy. Howard Zimmerman (1996) states that "…efficacy apparently is largely induced from contemporary classroom experiences" (p. 11). Self-efficacy is influential in the choices students make (Pajares, 2002). For example, when a student is free to choose activities, they tend to choose activities they feel confident in, and avoid activities where confidence is lower. Self-efficacy determines the amount of effort, persistence, and resilience students expend. Whether serenity or apprehension exists is due to self efficacy (Pajares)

Pintrich and deGroot (1990) developed and used a 56 item self reporting questionnaire to look at correlations between motivation beliefs and the use of cognitive learning strategies. The results of their study indicated self regulation, self efficacy and test anxiety were the best predictors of student performance. The findings indicated cognitive learning strategies and self regulation are related to high performance. Pintrich and deGroot (1990) found students with high efficacy rates reported more use of cognitive learning strategies such as rehearsal, elaboration, and organization. This indicated self efficacy is facilitative to acquiring cognitive learning strategies (Pintrich & deGroot).

4.2.3 Student motivation

Motivation facilitates students to become cognitively engaged. “Motivation refers to the incentive for goal directed behavior,” writes Dr. Susan Davis (2007), and is developed through socialization. Interestingly, motivation can be attained in varying ways and is adaptive. Motivation is dynamic and multidimensional. Motivation can also be content specific (Linnenbrink & Pintrich, 2002). Different motivational beliefs effect students’ ability to successfully complete algebra by promoting, sustaining or facilitating learning. One motivational focus is student perception of ability to complete the task; self efficacy, “Can I do this task?” (Pintrich & DeGroot, 1990). A second motivating focus is task value belief, or intrinsic motivation; the individual’s perception of the task’s importance, “Why am I doing this task?” The third focus is goal orientation (Pintrich, 1999). “How do I feel about doing this task?” (Pintrich & deGroot). Three general goal orientations are identified; mastery learning, extrinsic motivation, and relative ability orientation.

4.2.4 Students' participation

Classroom participation is associated with the generation and promotion of higher order thinking skills, and this cognitive stimulation provides students with a different environment which promotes positive and effective learning experiences (McKeachie, 1990). Further, a pleasant classroom learning environment helps students learn better, and different seating locations provide students with access to learning resources, such as the teacher and clear lines of sight to the board (Douglas & Gifford, 2001; Jamieson, 2003; Sztejnberg & Finch, 2006). Classroom seating arrangements also have the ability to affect the communal environment within the room (Jamieson, 2003; Sztejnberg & Finch, 2006). Students who find their classroom to be pleasant and comfortable generally demonstrate an increase in participation leading to higher achievement (Douglas & Gifford, 2001). Seating arrangements refer to the layout of desks and chairs within the classroom. This reflects both where students choose to sit and where they are assigned to sit. Seating arrangements identified in this paper include rows and columns, u-shape, semi-circle, fan-shape, and clusters, also known as small groups. Therefore, the examination of the impact of seating locations on student classroom learning has important educational implications. Its impact on classroom participation is to be carefully considered because active engagement and participation in the learning experience positively affects students' learning and promotes students' use of higher order thinking skills (Flynn, Vermette, Mesibov & Smith, 2009; McKeachie, 1990; Stronge, 2007).

4.3 The Learning Environment

4.3.1 Lack of learning facilities

The availability of adequate learning facilities is a sine-qua-non for an effective learning experience. Poor learning environment, insufficient lecture halls, lack of speech aids, poor ventilation, poor lightening, and insufficient seats adversely affects on students' understanding. The timing of the lecture period is of great importance. Early morning period is ideal for engineering mathematics learning because of minimal noise and distraction. However adequate illumination and ventilation system must be provided. Mid-Afternoon lecture may be employed, provided that noise and distraction from the immediate environment are kept minimal. Evening lectures should not be encouraged because students may have been exhausted from the day's work; this will inhibit their concentration and understanding.

4.3.2 Sitting location vs students' participation

It seems that there is a common belief that where students decide to sit within a classroom reflects upon their motivation, engagement, and willingness to learn (Benedict & Hoag, 2004; Betoret & Artiga, 2004; Budge, 2000; Burda & Brooks, 1996; Daly & Suite, 1982; Marx, Fuhrer, & Hartig, 2000; Perkins & Wieman, 2005; Wannarka & Ruhl, 2008). Though this belief has become an anecdotal comment, there are indicators suggesting that student location within the classroom affects academic performance (Burda & Brooks, 1996; Holliman & Anderson, 1986; Perkins & Wieman, 2005; Sztejnberg & Finch, 2006). Over the past decades, research has explored whether it is the good student who selects the seat at the front of the class or if the seat at the front of the class creates the good student (Burda & Brooks, 1996). Research shows that seating locations are related to academic achievement and classroom participation (Budge, 2000; Marx, Fuhrer, & Hartig, 2000; Wannarka & Ruhl, 2008; Weinstein, 1979).

Seating locations concern how students are seated within the classroom environment. They can vary in size and formation; however, they learning conditions impact their engagement and participation in the classroom (Budge, 2000; Marx, Fuhrer, & Hartig, 2000; Wannarka & Ruhl, 2008). Research has begun to show that active engagement and participation in the learning experience positively affects students' learning (Flynn, Vermette, Mesibov, & Smith, 2009; Stronge, 2007).

4.3.3 Classroom seating position vs grades

Research shows that, in all subject areas, the majority of test questions on college exams come from the professor's lectures and that students who take better class notes get better course grades (Brown, 1988; Kierwa, 2000). The method of instruction most commonly used by university professors is the *lecture*, whereby the instructor speaks continuously for an extended period of time the students' job is to listen and take notes (Bligh, 2000). The lecture method places great demands on students' ability to listen carefully and take notes that are accurate and complete. Thus, in order to obtain good grades in college, you have to do all that you can to pay close attention during lectures and record lecture information in your notes because that information is likely to show up as questions on exams.

Studies show that students who sit in the *front and center (middle)* of the classroom tend to achieve higher average exam scores (Rennels & Chaudhari, 1988). One study discovered a direct relationship between test scores and seating distance from the front of class: students in the front, middle, and back rows of class scored 80%, 71.6%, and 68.1% respectively on course exams (Giles, 1982). These finding occurs even when students are assigned to these seats by their instructor, which indicates that it is not simply due to the fact that more motivated students tend to sit in the front and center of the room. Instead, the higher academic performance of students sitting front and center is most likely due to the fact that there are learning advantages provided by these seating positions, such as the following:

- better *vision* of the blackboard,
- better *hearing* of what is being said by the instructor,
- better *attention* to what is being said because there are fewer (or no) people between them and the instructor to distract them, and
- Greater *eye contact* with the instructor—which may increase their sense of personal responsibility to listen to, and take notes on, what their instructor is saying.

There is one other advantage of sitting in the front of class. The student is likely to feel less nervous about asking a question or making a class contribution because there will be no students sitting in front of him to turn around and stare at him when you does.

4.3.4 Impact of seating locations on student-student and teacher-student relationships

Different seating locations have the ability to influence teacher-student and student-student interaction (Marx, Fuhrer, & Hartig, 2000). As such, teachers are often led to have different perceptions about student locations within the classroom. Different classroom seating arrangements create various social interaction opportunities. For example, non-linear seating arrangements such as semi-circles or a u-shape increase the possibility of face-to-face communication between students and teachers (Sztejnberg & Finch, 2006). Such seating arrangements promote positive student-student and teacher-student interaction. Furthermore, non-linear seating arrangements, such as those above mentioned, often allow for students to have better access to learning resources, such as the teacher (Wannarka & Ruhl, 2008). This in itself can promote not only teacher-student interaction, but also better understanding and access to learning experiences.

Another aspect of social relationships within the classroom is those formed between students. Student-student interaction affects classroom participation (Fassinger, 1996). The implementation of different seating arrangements either reinforces or diminishes the availability of social interaction within the classroom. Research has shown that where students are located within the classroom can influence the amount of non-academic activity, off-task behavior, and socialization they engage in (Benedict & Hoag, 2004; Budge, 2000; Davis & Fox, 1999; Edwards, 2000; Granstrom, 1996; Perkins & Wieman, 2005; Wannarka & Ruhl, 2008). Notable among them include: chatting, playing games, listening to music, surfing the web for social networks such as: Facebook, 2go, Twitter, Linkedln etc. These tendencies are higher when the student is far from the teacher.

4.3.5 The front of the class versus the back of the class

One may interpret a student's decision to sit near the front of the class as an indicator of deeper interest in the class, and to secure that student's ability to participate in the class activities. If this is the case, then student personality is a key motivator in the selection of seating location. Earlier research has indicated that students who choose to sit near the front of the class, or in central seats, more often exhibit creative, assertive, and competitive personality traits (Totusek & Staton-Spicer, 1982). The most prevalent trend suggests that students who sit front and center within the classroom will participate more than those who sit at the back; and so, they are perceived to be better students (Benedict & Hoag, 2004; Burda & Brooks, 1996; Daly & Suite, 1982; Perkins & Wieman, 2005; Weaver & Qi, 2006). As such, student participation is related to the teacher's impressions of the student. Other studies have noted that students who self-select seats near the front of the class also exhibit a sense of increased attentiveness (Hillmann, Brooks & O'Brien, 1991). One can argue that such student traits are desirable in the educational field, and later when entering the employment field. Thus, one may conclude that students who select to sit near the front of the class may recognize the need to obtain learning conditions which will best allow them to achieve their desired results. The opposite may be concluded for those sitting near the back of the class. However, other conditions will also affect the availability of such desirable seating locations. Students who enter the classroom first may be in the position to select desirable seats first; thus, those who are unable to come first may be left with seats they do not desire, but are left with no other option (Benedict & Hoag, 2004). Diminished access from desirable seats has the potential to place students in a position where they are left with undesirable seating location which increases psychological and physical pressures in the learning environment (Xia, 2006). Evidently, this is a factor to keep in mind. The availability of limited resources within the classroom, including seating location, should not be neglected.

Keeping this in mind, one may wish to consider seat preference versus actual seating location. Benedict and Hoag (2004) noted that seat preference versus actual sitting location was an indicator of academic motivation and achievement. As such, seating preference may be an indicator of learning motivation and interest. Aside from being an indicator of student motivation and interest, seat selection within the classroom can also be linked to territoriality and the desire to feel comfortable in the learning environment. A study by Kaya and Burgess (2007) examined the tendency for seat preference and territoriality within the college level classroom. Upon having labeled each respective seat with a number, a Likert scale based survey was conducted to determine which seats students preferred and what their feelings were about seat territoriality within their classrooms. Student seating preference was also noted within this survey. The results of this study demonstrated how exterior seats are more desirable due to commonly being more spacious (Kaya & Burgess, 2007). The more items a student may need to have present during class can influence his/her subsequent seating location decision. Sitting in the front and center may now pose difficulties and discomfort which can also detract from the learning experience.

The study conducted by Ruoff and Schneider (2006) illustrates another aspect of seating location within the classroom. This study focuses more on the personal and social reasoning behind seat selection versus the accessibility to learning resources or the students' motivation to learn. The peer conditions presented within the classroom influence not only seating selection, but also, the amount of interaction and participation elicited by students, all factors which affect teachers' perceptions of students (Weaver & Qi, 2005). Seat selection is seen in this study as a result of social and repetitive actions. Seating is seen as an interactive process, where the decisions of the individual are influenced by the decision of those before him or her (Ruoff & Schneider, 2006). Social pressures may in fact influence students' seat selection. There may be a fear to be perceived as anti-social or pressure may be felt to join the larger group (Ruoff & Schneider, 2006). Again, the topic of convenience and comfort becomes a factor in this study. Individuals who have access to seats closer to the exit often select these seats. Such seats often offer the student more comfort and less constriction when attempting to leave the class. Nevertheless, such a location can also be interpreted as giving the student an easy way out of the class due to his/her disengagement and disinterest in attending the full class period. The process of selecting seats within the classroom poses an interesting situation in itself. Teacher perspectives towards students and where they select to sit may also pose an interesting dynamic in the learning environment. The availability of resources, in this case the information the lecturer offers students, becomes very important for the success and growth of students. The main way to convey this information is through communication. Communication occurs in many forms; some of the most prevalent include verbal, written, and illustrated. Nevertheless, the most common within the classroom is still verbal communication.

4.4 Economic Factors

There is no gainsaying that Nigeria, being a third-world country, does not have the basic facilities for the majority of its citizenry. According to Ngoddy (2012), "… figures as high as 60 to 80 percent have been reported for Nigeria (World Bank/UNDP, 2000) as the proportion of our citizenry who live below the poverty-line." Students require finance to cater for some basic necessity such as; tuition fees, text books, feeding , accommodation transportation etc. A survey conducted in the course of this research revealed that "about 42% of engineering students come from families who cannot take full responsibility of their basic needs." Hence, it is not uncommon that some students engage in various economic activities, within and outside the campus, in order to meet up with their financial obligations. This poses a serious threat to their learning of engineering mathematics, as the attention of such students may be divided. The students' performance is most likely to suffer.

4.5 Teaching Methods

The students' motivation, participation, learning and retention rate largely depends on the teaching method employed by the lecturer. Researchers have shown that most students understand a course better if the lecturer is able to carry them along. Teaching mathematics is difficult; teaching engineering mathematics is even more difficult. Hence, an appropriate method that will ensure that students participate fully in lectures is imperative. For a large lecturer-student ratio, as the case in Nnamdi Azikiwe University Awka, concerned lecturers should ensure the prompt availability of relevant resource materials; an Interactive approach can be very helpful. Poor teaching strategy will result to poor understanding of the course; consequently, this will result to poor performance of students in the course.

5.0 ARRESTING ENGINEERING MATHEMATICS PROBLEM

5.1 UK Engineering Council

The role of mathematics in Engineering has been acknowledged and established from early studies (Teachers of College Mathematics 1936). However, there are concerns about the mathematics ability of students entering higher education. In the United Kingdom, the diminished mathematics ability of students in higher education is perceived as a lowering of standards of the A-Levels, a reduction in entry requirements on some courses with a strong mathematical component and the wide-ranging educational backgrounds of many of the students (Bamforth 2008). In light of the growing 'mathematical problem', the UK Engineering Council (Hawkes and Savage 2000), in 2000 recommended that 'students embarking on mathematics-based degree courses should have a diagnostic test on entry' and that 'prompt and effective support should be available to students whose mathematical background is found wanting by the tests' (Hawkes and Savage 2000). Many UK universities have taken up the practice of diagnostic testing and follow-on support (Bamforth 2008). These support strategies are not only dealing with the fact that engineering modules are assuming mathematical knowledge and skill but they are also attempting to address the mathematical diversity of the student intake (James 1995). Thus, there have been many efforts to improve the teaching and learning of mathematics among engineering students.

5.2 Engineering Math Advancement Program (E-Map)

E-MAP is a unique, informal, interactive, and interdisciplinary five-week summer residence program developed by the University of Alabama USA in their effort to reduce the withdrawal rate of engineering students due to mathematics.

The program aimed at increasing retention by preparing students to be successful in calculus, and excited about engineering. In addition to a nontraditional math class, the program included hands-on "Living-Lab" experiences, field trips and a community service project led by professional engineers. The non-math aspects of the program strengthened mathematical skills indirectly through engagement of the students in laboratory and real world engineering problems, in the idea that solving skills are best nurtured through hands-on experiences. E-MAP improved retention of students in STEM fields overall by approximately 12% after three years with 36% increase in retention of students who entered with placement scores within the target math range for the program.

5.3 The 'Mathematics Support' Approach

This approach was adopted by Harper Adams University College to solve the persistent poor performance of students in engineering mathematics. Diagnostic testing was employed to identify the weak students; Regular small groups and individual appointments to help engineering students with mathematics (called Extra Maths) were available on demand from a learning support tutor employed college-wide for this purpose. Noticeable improvements obtained are summarized as follows:

- High Engineering Mathematics marks
    - Many A's and Distinctions
    - Very few Maths failures
- Success Cycles = Student progression
- Greatly improved student retention
- Positive Student Feedback
- Good student effort and attitudes

5.4 The Pisa Approach

The first PISA assessment, carried out in 2000, revealed wide differences in the extent to which countries succeed in equipping young adults with knowledge and skills in reading, mathematics and science. PISA starts with a concept of mathematical literacy that is concerned with the capacity of students to analyze, reason and communicate effectively as they pose, solve and interpret mathematical problems in a variety of situations involving quantitative, spatial, probabilistic or other mathematical concepts. This approach to mathematics contrasts with a traditional understanding of school mathematics which is often narrower, as the usefulness of mathematics in the real world may be given little attention. The PISA approach to assessing mathematics was therefore designed to place the real-life use of mathematical knowledge and skills closer to the centre of a concept of mathematics learning. The intention is to encourage an approach to teaching and learning mathematics that gives strong emphasis to the processes associated with confronting problems in real-world contexts, making these problems amenable to mathematical treatment, using the relevant mathematical knowledge to solve problems, and evaluating the solution in the original problem context. If students can learn to do these things, they will be better equipped to make use of their mathematical knowledge and skills throughout life. They will be mathematically literate. Students' mathematics knowledge and skills were assessed according to three dimensions relating to:

- the mathematical content to which different problems and questions relate;
- the processes that need to be activated in order to connect observed phenomena with mathematics and then to solve the respective problems; and
- the situations and contexts that are used as sources of stimulus materials, and in which problems are posed.

6.0 SUMMARY

Mathematics is the bedrock of scientific and engineering principles. Sound knowledge in mathematics is very vital for a good understanding of scientific and engineering concepts. The fundamental laws of nature such as; gravitational laws, law of floatation, laws of motion etc. are best simplified, explained, and understood using mathematical expressions. Hence, engineering mathematics is a prerequisite in all fields of engineering. However, it seems like a paradox that despite its importance to engineering profession, a large number of engineering students perform poorly in engineering mathematics. This age-long problem has attracted the attention of many scholars who have tried to establish the causes of poor performance of students in engineering mathematics. No doubt, the causes of students' poor performance are varied, multi-dimensional with complex inter-relationships. Nevertheless, researches show that poor background in mathematics at infant age orchestrated with the lack of proper motivation from parents and teachers forms the bedrock of this problem. These factors induce lack of interest, mathematics anxiety, lack of self-efficacy and determination, and other rebellious behaviours towards mathematics. Such students lack the cognitive reasoning required to understand and appreciate mathematical concepts. They perceive mathematics as a nuisance and stumbling block to their academic progress. Poor students' participation and their choice of sitting position also reflect their lack of interest in mathematics. The physical environment where engineering mathematics is taught also affects students' participation; hence, their performance. Poor lightning, poor ventilation, lack of speech aids, noise and distractions adversely affects students' performance. Laziness, lack of frequent practice, and poor study habits are prime factors that result to failure of students. Corruption in the educational sector further complicates the problem. Deserving students are denied admission while non-deserving students are 'mugged' into the university. Quite often, these students lack basic prerequisite knowledge in mathematics; they cannot cope with the heat, and tend to exhibit woeful performances in engineering mathematics. It is an indisputable fact that some engineering students, who have passion for other disciplines, are compelled, against their wish, to study engineering due to the prestigious and lucrative nature of the profession. In most cases, such students develop negative attitudes towards engineering mathematics, and tend to perform very poorly. Above all, the teaching method adopted also influences the level of motivation, understanding, and participation of students during engineering mathematics learning; hence affects their performance. Sometimes, lecturers are of the habit of solving simple problems during lectures, but set very difficult problems in the examinations. Students may find difficulty in applying their knowledge in solving such complex problem. The fact that some lecturers have obscure standard of assessing students, and marking examination papers, and its effect on the performance of students cannot be over-emphasized. No doubt, engineering mathematics forms an integral part of the engineering discipline; therefore, a sine-qua-non for all engineering students. It is important that workable improvement models are developed; effective methods and techniques employed so that students from different mathematical background can flourish.

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