*ORIGINAL ARTICLE*

# Perception of Civil Engineering Extension Students of Addis Ababa University Institute of Technology in the Teaching of Applied Mathematics

**Mulugeta Atnafu[1], Zelalem Teshome[2] & Kassa Michael[3]**

***Abstract***

***The purpose of this study was to assess how applied mathematics was taught at Institute of Technology (AAIT) of Addis Ababa University. 53 extension civil engineering students were selected by purposive sampling from the population of all engineering extension students in the Institute. The data were collected by self-responded Likert scales of teaching applied mathematics which were divided into five components: classroom instruction, additional support, methods and approaches, visualization techniques, and assessment of students. The data were analyzed by correlation, independent t-test, one and two way ANOVAs. The results from the responses of the students revealed that: the practices of delivery of the course outline, showing the necessary and sufficient conditions when clarifying the concepts in applied mathematics, giving worksheet for each chapter where questions help in developing mathematical concepts, problem solving method and traditional method of teaching, concept map visualization technique, assessment using quizzes, tests and exams were the most frequently used. Lack of invitation of professionals in the appropriate places of the courses, the coverage of the courses, worksheet were not done by individual students and discussing in groups in the tutorial class, focus given to independent and collaborative mathematics activities, implementing animation or simulation, experimentation and manipulative techniques of visualization, assessment using class activities and self or peer assessment of students were also problems observed in the teaching of applied mathematics.***

***Keywords:*** *classroom instruction, student support, methods of teaching, visualization techniques, assessment of students*

***[1] Department of Science and Mathematics Education, College of Education and Behavioural Studies, Addis Ababa University***

***[2]Department of Science and Mathematics Education, College of Education and Behavioural Studies, Addis Ababa University***

***[3]Department of Science and Mathematics Education, College of Education and Behavioural Studies, Addis Ababa University***

**INTRODUCTION**

The Ministry of Education (MoE) of the Federal Democratic Republic of Ethiopia, in its Education Sector Development Program IV (ESDP IV) (2010/11-2014/15) states that "achieving the vision of transforming Ethiopia into a middle-income country in 2015 demands transformation of the economy through application of science and technology as instruments to create wealth." (MoE, **2010**; p.13). In the Document, it is further indicated that this demand calls for a continued expansion and equitable access to high-quality general education with promising foundations in science and mathematics and special efforts to improve the science literacy level of the population (ibid).

In 2008/09 the Ministry of Education of the Federal Democratic Republic of Ethiopia also developed a working guideline stipulated by a policy document for professional mix of 70-30, with 70% enrolment for Science and Technology (of which 30% for science and 40% for engineering) and 30% for Social Science and Humanities in the Country's Universities.

The traditional and conventional teaching of engineering mathematics encourages learning by demanding students sit in isolation and learns by repetition, echoing and memorizing the steps taken by their instructors to solve very theoretical problems in applied mathematics. Without a strong mathematics background, students usually have a great level of difficulty in other engineering subjects ultimately resulting in a very low level of satisfaction with the overall engineering program. Albeit this demand, however, in reality, engineering courses at most elite institutions require students to learn a large amount of theory that involves the teaching and learning of complex and advanced mathematics with very little practical component (Andrew, 2007).

Mathematics has been vital to the development of civilization. From ancient to modern times mathematics has been fundamental to advances in science, engineering, and philosophy. Mathematics is utilized in almost every discipline of science, engineering, industry, and technology. Through mathematical modeling, numerical experiments, analytical studies and other mathematical techniques, mathematics can make enormous contributions to many fields (Verdiana, 2003).

According to Wikipedia, the free encyclopaedia (2012), applied mathematics is a branch of mathematics that concerns itself with mathematical methods that are typically used in science, engineering, business, and industry. Thus, "applied mathematics" is a mathematical science with specialized knowledge. The term "applied mathematics" also describes the professional specialty in which mathematicians work on practical problems; as a profession focused on practical problems, *applied mathematics* focuses on the formulation and study of mathematical models.

**The importance of applied mathematics in engineering**

Mathematics has always been the universal language of science and engineering. Today, the role of applied mathematics is growing rapidly, applying new methods, and providing solutions to problems in a wide range of sciences; technology, engineering, social, biological, behavioral, economics and management, etc. As a tool, mathematics is necessary in understanding and expressing ideas in science, engineering, and even human affairs. Mathematics is integrally related to computer science and statistics, which have proven invaluable in furthering the advance of research and modern industrial technology (Wolfgang, 2001).

During the first half of the 21$^{st}$ century, the terminus applied mathematics was used for teaching mathematics to engineering students. But in the second half, the most striking development in engineering has been the increasing use of mathematics in the analysis of engineering problems. No longer is skill in the use of a slide rule sufficient mathematical equipment for a practicing engineer. For instance, control engineers use sophisticated, and very often abstract, mathematical concepts, some electrical engineers have to be acquainted with quantum mechanics, others with transform theory, and civil and mechanical engineers reading research papers on continuum mechanics encounter a bewilderingly wide range of mathematical techniques (Wolfgang, 2001).

Similarly Wolfgang (2001) explained that, all engineering fields, the modern tools of electronic computers led to the new branch of scientific computing and simulation in applied mathematics which now is indispensable in computer tomography, geometric design, reconstruction and visualization, direct and inverse scattering of electromagnetic and acoustic fields, heat transfer and radiation, stress and damage analysis in solid mechanics, all branches of fluid mechanics from aircraft design to sedimentation and groundwater pollution, signal processing, network analysis and planning, chemical processing, etc., and the combination of several field models to multifield problems resulting in new technologies such as the intelligent wing, nondestructive thermography, or noise reduced helicopters.

According to Ronald (1990) also there are three key reasons why mathematics is important for engineers:

1. The laws of nature are mathematical expressions. Mathematics is the language of physical science and engineering.
2. Mathematics is more than a tool for solving problems; mathematics courses can develop intellectual maturity. It is critical that engineering students learn to visualize abstract concepts.
3. Numerical simulation on a digital computer is a powerful and effective tool that is being used by an increasing number of engineers. However, computers do not make traditional mathematical analysis obsolete!

**Teaching applied mathematics for engineering students**

Mathematics education should enable engineering students to communicate their ideas in an unambiguous and understandable way and should equip them with the analytical skills they will need as practicing engineers. But mathematics is more than just a collection of tools that can be used to solve certain well-defined problems. Mathematical thinking and modeling give engineers the ability to approach new problems with confidence.

Donald (1999) discussed how mathematics should be taught for engineering students. According to Donald instructors have altered their roles, decreasing the presentation role and increasing the guide, coach or facilitator role. Small-group work is widespread in mathematics curricula-both in terms of in-class group activities and out-of-class group projects. Real-world applications and hands-on experimentation pervade many curricula today. Use of multiple representation-graphic, numeric, symbolic and verbal-has become standard procedure in the majority of calculus courses. Development of communication skills has become accepted as a legitimate objective of mathematics courses.

Rosa (2007) explained that a good mathematical education will challenge thinking in a number of ways including:

- Engineers should view mathematics as a way of thinking and communicating rather than as a set of tools.
- Students need to develop skills in using mathematics to solve problems and they also need to see mathematics as an integral part of engineering

applications and not as residing in a separate compartment.

- Mathematical modeling is a fundamentally important engineering activity which is neither purely abstract nor necessarily deriving from an existing complete body of knowledge.
- Engineers may sometimes need to develop new mathematics in order to solve certain problems.

Charles, Paul & Geoff (2010) stated that an active and interactive teaching approach, combined with a continuous assessment scheme to encourage student learning has been shown to improve attainment. Furthermore, the formative feedback from the students is very positive in relation to all the teaching and learning methods employed.

Employing the best practice in relation to the pedagogy appropriate for teaching mathematics to engineering students involved fully supporting the students by: diagnostic testing at outset; using Learning styles inventories; implementing an active and interactive approach to learning and teaching; continually highlighting the relevance of mathematics to engineering; integrating the mathematics module with the other engineering modules; exploiting the relevant available texts and online resources; and promoting learning through the assessment strategy (Charles, Paul & Geoff, 2010). The active and interactive learning approach, combined with the continuous assessment strategy, provided instant individual and collective feedback to the students and the staff. In addition, it offered an enjoyable and constructive learning environment which fostered a more positive attitude towards learning mathematics.

Norbert & Sergiy (2003) explained that to enhance students' critical thinking skills, help them understand concepts and theorems' conditions better, eliminate common misconceptions and encourage active participation in class, give to students incorrect statements and ask them to create counter examples to prove that the statements were wrong.

'The method essentially used to involve *showing* examples for which the misconception could be seen to lead to a ridiculous conclusion, and, having established a conflict in the minds of the students, the correct concept was taught' (Swedosh & Clark, 1997). Mason & Watson (2001) used a method of so-called boundary examples, which suggested creating by students examples to *correct* statements, theorems, techniques, and questions that satisfied their conditions.

The literature review conducted for the project *Mathematics Education for 21st Century Engineering Students* (Henderson & Keen, 2008), reports on a range of subject designs and teaching methods that demonstrate adaptations to the needs of 21st Century engineering students. These include (1) using computer based methods such as web-based delivery, computer algebra systems and interactive software, (2) using flexible delivery, and support through tutoring and drop-in centers that are provided to address the issue of variability in students' mathematical preparation, (3) taking a multidisciplinary approach in various ways, such as team teaching of subjects designed by mathematicians and engineering academics working together, and (4) using problem based learning strategies.

There is some evidence of students' conceptual understanding by using GeoGebra in the tutorial period that they drew many graphs on one set of axes without obvious critical awareness of what they represented or how they were related (Barbara J and Janette M, 2011). Hamide (2004) discussed the effect of use of Mathematical as a visual aid in introducing basic linear algebra concepts, and the findings support the use of visual instruction in advancing the learning of abstract concepts, especially for students with limited prior preparation for abstract thinking.

Barbara & Janette (2011) explained alternative forms of questions (open, close, inquiry-based) did seem to engage students. According to Sazhin (1998), formal lecturers should be supplemented by compulsory reading, handouts, elements of small group teaching and formative assessment. The analysis of self-assessment forms completed by students show that their progress in understanding physical concepts is much more visible than their progress in understanding mathematical concepts.

The points discussed above justify the need to investigate the method of teaching and seek to identify menu of methods/approaches that enhance better understanding of engineering students. Thus, more than 80% of the extension program in AAIT of Addis Ababa University is Civil Engineering Program for the year 2013/14 academic year and the program is delivered at the evening time from Monday to Friday and day time for Saturday and Sunday.

**Statement of the Problem**

Engineering has always been underpinned by mathematics as a language both for the expression of ideas and a means of communicating results. Furthermore, mathematical thinking gives engineers a means of formulating, analyzing and solving a wide range of practical problems. The current rapid pace of technological change has increased the importance of mathematics to engineering.

According to Rosa (2007), the main problems relating to the mathematical education of engineers are:

- The tension between ensuring basic skills are mastered and developing conceptual thinking and modeling skills;
- Appropriate use of new software (such as computer algebra systems) so that mathematical education is improved;
- Developing assessment methods that focus on higher level abilities not just routine application of standard methods.

One difficulty engineering students may have in applying mathematical knowledge is in translating situations dealing with words, figures, and data tables into mathematical terms and equations (McDermott, 1984). In an engineering course, problems are often presented in real world contexts, using words, figures, and tables to organize and communicate the situation to be solved. Students are expected to take these situations and to create mathematical equations from which they can perform procedures. Students also need to dissect equations and to describe relationships between multiple variables.

Inadequate mathematical skills present a widespread problem throughout engineering undergraduate programs; however, specific, well-documented examples of student difficulties are often lacking, and the exact nature of the difficulty is frequently uncertain. Moreover, there is often little communication between engineering and mathematics faculty dedicated to or addressing mathematics skills related issues. Engineering faculty assume that certain concepts are taught in the mathematics courses, but they are often not familiar with the specifics of the mathematics curriculum, or the methods utilized (for example: terminology and context of use).

When mathematics instructors introduce the mathematics topics in lectures, they usually did not make any reference practical problem that lead to the mathematical equations. Engineering students thus find it difficult to recognize the relevance of learning all these difficult methods to solve a set of equations. One of the reasons for this problem is because mathematics is usually taught as an isolated subject, distancing itself from the engineering science subjects that generate mathematical equations and uses the solution to the equations.

Another problem associated with the teaching of mathematics subjects to all engineering students is that the class sizes are usually big which is 60-80 students per class. This, together with mathematics usually being taught in a lecture manner, is an undesirable situation as it is not conducive for creating a good learning environment. Therefore, this study tries to assess how civil engineering students perceive the way they are taught engineering mathematics. With this view, the study tries to answer the following questions:

1. To what extent are each of the components such as classroom instruction, additional support, methods and approaches, visualization techniques and assessment of students implemented in teaching of applied mathematics?
2. To what extent are each of the items in each component implemented?
3. Is there a significant difference in the variables such as classroom instruction, additional support, methods and approaches, visualization techniques and assessment of students with respect to sex and background qualification?
4. Do background qualifications and sex each seem to have an effect on teaching applied mathematics, and do background qualification and sex interact?

**Objective of the Study**

The general objective of this study was to assess how applied mathematics was taught in AAIT of Civil Engineering of extension students at Addis Ababa University.

The specific objectives of the study were

1. To analyze the extent of how each of the items in each component were implemented,
2. To analyze the extent of implementation of each of the components such as classroom instruction, additional support, methods and approaches, visualization techniques and assessment of students in teaching of applied mathematics,
3. To check whether there are significant differences in the variables such as classroom instruction, additional support, methods and approaches, visualization techniques and assessment of students with respect to sex and background qualification.

**Delimitation of the Study**

The study was delimited only to the responses of civil engineering extension students, since the main problems were observed in the extension program where the students come from diverse areas some of them have diploma, some are degree, some are direct from preparatory program and some are from technical and vocational training (TVET). Civil engineering classes were considered since above 80% of the classes was civil engineering.

## MATERIAL AND METHODS

**Research Design**

The present study used exploratory survey design. The method used for this study was quantitative research method. The quantitative research method focused on a Likert scale questionnaire.

**Population and Sampling Method**

The population for this study consisted of all civil engineering extension students in Addis Ababa University. Using purposive sampling all civil engineering students were selected, since above 80% of the extension students are civil engineering students. In the second semester of 2013/14 academic year only freshman students take applied mathematics and there were a total of five civil engineering classes in the extension program and the students were arranged or assigned in their sections randomly without any discrimination. Since all the five sections have similar in their gender, achiever level and degree level mix, then one section was randomly selected using simple random sampling by lottery method. The researchers considered all the students in the selected section. The participants of the study were 53 students.

**Instruments**

A Likert scale on teaching of applied mathematics which was divided into five components namely classroom instruction, additional support, methods and approaches, visualization techniques and assessment of students in applied mathematics were used for this study. The teaching of applied mathematics scale was used to assess how applied mathematics is taught for engineering students. The scale contained 46 items. The classroom instruction component was used to assess how the mathematics teachers taught in the classroom and contained 14 items; the second component was additional support given by the teacher to support classroom teaching containing 7 items; the third component was methods and approaches implemented in teaching applied mathematics containing 7 items; the fourth component is visualization techniques applied in teaching applied mathematics containing 7 items; and the fifth component was assessment of students containing 7 items. All the scales were a 1-5 Likert-type scale and the respondents were asked to respond to each item using a five point scale ranging strongly agree to strongly disagree. The likert scale coded for positive statements, 5 for strongly agree, 4 for agree, 3 for undecided, 2 for disagree, and 1 for strongly disagree. For negative statements, the coding is 1 for strongly agree, 2 for agree, 3 for undecided, 4 for disagree, and 5 for strongly disagree.

The scales were reviewed based on the comments of professionals for the face and content validity. A pilot study was conducted to determine the validity and reliability of the scales. Thirty students from first year engineering were chosen randomly from Addis Ababa University. From the pilot study the alpha coefficient of Cronbach yielded 0.957 for the teaching of applied mathematics scale, 0.891 for classroom instruction scale, 0.801 for the additional support scale, 0.847 for methods & approaches scale, 0.846 for visualization techniques scale, and 0.879 for assessment of students scale. Cronbach Alpha Coefficients of reliability for the components indicated that they have high internal-consistency reliability.

The likert scale was administered to the participants at the end of applied mathematics course with the permission of the applied mathematics teacher. All the participants were requested to volunteer in the survey.

**Method of Analysis**

Since the scale was an ordinal scale of 5 levels Likert scale and the skewness of the distribution for all 46 items and each component lied between -1 and +1, this indicated that the data is not significantly different from normal. These justify that the variable is distributed approximately normally and we can use inferential statistics. Therefore, the data analysis techniques used for this study were correlational, Independent t-test, One and Two way ANOVAs.

**Ethical Issues**

The consent of all teachers and students involved was obtained and an official letter was secured from Department of Science and Mathematics Education, AAU.

## RESULTS

For the teaching of applied mathematics for engineering class to be effective the following conditions should be implemented: appropriate classroom instruction applied, additional support given to the student, appropriate methods and approaches of teaching mathematics used, different visualization techniques in teaching mathematics employed and finally appropriate assessment of students' learning in mathematics utilized. Though the other components were implemented, offering additional support to students and the incorporation of visualization technique for teaching applied mathematics needs to be critically addressed.

The first research question was the extent each of the components: classroom instruction, additional support, methods and approaches, visualization techniques and assessment of students was implemented in teaching of applied mathematics? Table 1 presents the descriptive statistics of the responses of engineering students on teaching of applied mathematics and its components.

**Table 1:** Descriptive statistics of the responses of engineering students on teaching of applied mathematics and its components

| Components | N | M | SD |
|---|---|---|---|
| Classroom instruction | 53 | 3.2918 | .79552 |
| Additional support | 53 | 2.8892 | .78165 |
| Methods & approaches | 53 | 3.4016 | .86989 |
| Visualization techniques | 53 | 2.9515 | .86894 |
| Assessment of students' progress | 53 | 3.5214 | .78429 |
| Teaching of applied mathematics | 53 | 3.2437 | .70107 |

Inspection of the means of the six components indicates that the average response of the engineering students on assessment of students in applied mathematics (mean score, 3.5214) was the highest average and additional support (2.8892) was the least. The other responses in the order from the highest to the lowest were methods & approaches (3.4016), classroom instruction (3.2918), teaching of applied mathematics (3.2437), and visualization techniques (2.9515). This indicated that assessment of students was relatively frequently used.

In order the classroom instruction to be effective, mathematics teachers should perform each of the stated components: delivering course outline, informing the aims & objectives of the course, giving the structure of the course, stating the necessary and/or sufficient conditions of the concepts, giving practical and sufficient examples, teaching with the appropriate pace, considering individual differences, covering the course with the specified time and inviting appropriate professional in the appropriate topics to a larger extent. In line with this, the second research question was the extent each of the items in each component was implemented in teaching of applied mathematics. Below is the descriptive statistics of the items of classroom instruction in the teaching of applied mathematics for the engineering students.

**Table 2:** Descriptive statistics of the items of classroom instruction in teaching applied mathematics for engineering students

| Items | N | M | SD |
|---|---|---|---|
| Mathematics teachers delivered course outline before beginning the class | 53 | 3.96 | 1.372 |
| Mathematics teachers informed the aims & objectives of the course | 53 | 3.43 | 1.152 |
| Mathematics teachers gave the structure of the course or chapters at the beginning of the course or chapters | 53 | 3.58 | 1.84 |
| Mathematics teachers stated the necessary and/or sufficient conditions when clarifying the concepts whenever necessary | 53 | 3.79 | 1.081 |
| Mathematics teachers gave practical examples focused to engineering to clarify the concepts whenever necessary | 53 | 3.43 | 1.294 |
| Mathematics teachers gave (or ask students) examples to clarify the concepts whenever necessary | 53 | 3.45 | 1.294 |
| Mathematics teachers gave examples with missing concepts to clarify and students filled the concept gap whenever necessary | 53 | 3.64 | 1.178 |
| The chapters were arranged in the appropriate sequence that helps you to apply for the engineering topics | 53 | 3.62 | 1.390 |
| Mathematics teachers taught the different chapters or topics with the same pace | 53 | 3.26 | 1.303 |
| Mathematics teachers asked students to give examples that do not fulfil the whole concept whenever necessary | 53 | 3.08 | 1.328 |
| Mathematics teachers considered individual differences in the classroom | 53 | 3.23 | 1.250 |
| The presentation of the mathematics topics were to the understanding of students' capacity | 53 | 3.55 | 1.136 |
| All the chapters in the applied mathematics course (s) were covered with the specified time in the semester | 53 | 2.70 | 1.339 |
| The time allotment for the course was enough | 53 | 2.38 | 1.289 |
| Mathematics teachers invited professional to the class when appropriate | 53 | 2.26 | 1.318 |

Table 2 indicates that most of the mathematics teachers delivered the course outline ($\overline{x}$ = 3.96) and gave the necessary and sufficient conditions when clarifying the concepts in applied mathematics ($\overline{x}$ = 3.79). But there were limitations in the time allotment of the courses of applied mathematics and inviting professionals in the appropriate places of the courses. That is, the time allotment for the courses was not enough, which made it difficult to cover the courses in the specified period of time.

Teaching the course in the class only is not sufficient for the students to become successful in learning applied mathematics, therefore, support of students in the class and outside of the class is important. Below is the descriptive statistics of each item of additional support that was given to the engineering students and methods and approaches employed during the teaching of applied mathematics.

**Table 3:** Descriptive statistics of the items of additional support and methods and approaches in teaching applied mathematics for engineering students

| Items (Additional Support) | N | M | SD |
|---|---|---|---|
| Mathematics teachers gave handouts to support the class teaching | 53 | 2.62 | 1.535 |
| Mathematics teachers gave worksheets for each chapter to support the class teaching | 53 | 3.91 | 1.213 |
| The mathematics worksheet included questions that focus on concepts | 53 | 3.87 | 1.161 |
| The mathematics worksheet included real-life applications to engineering | 53 | 3.26 | 1.112 |
| The mathematics worksheets were done only by the teacher in the tutorial period | 53 | 2.15 | 1.063 |
| The mathematics worksheets were done by the individual students in the tutorial period | 53 | 2.36 | 1.145 |
| The mathematics worksheets were done by groups of students in the tutorial period | 53 | 2.45 | 1.153 |
| The answer key for the mathematics worksheets were given by the teacher | 53 | 2.49 | 1.234 |
| **Items (Methods and Approaches)** | **N** | **M** | **SD** |
| There was active participation of students in the class | 53 | 3.15 | 1.081 |
| Independent mathematics activities were given to be done in the class or outside of the class | 53 | 3.06 | 1.216 |
| Collaborative mathematics activities were given to be done in the class or outside of the class | 53 | 3.08 | 1.238 |
| The mathematics teachers applied traditional approach (definitions and formulas or rules given, theorems proved and examples solved) | 53 | 3.89 | 1.382 |
| The mathematics teachers applied modelling approach (starting from real life engineering data then changed to the mathematical problem and solving the problem by discussing the mathematical concepts and procedures) | 53 | 3.38 | 1.197 |
| The mathematics teachers applied problem based learning approach (starting from problem then to solve the problem, mathematical concepts and procedures were discussed) | 53 | 3.55 | 1.202 |
| The mathematics teachers applied problem solving method (after the mathematical concepts, formulas and procedures were discussed, word problems were given and solve using the four steps: understanding the problem, changing to mathematical equations, solving the equations and checking the answer) | 53 | 3.72 | 1.099 |

As presented in table 3, the students responded that most of the teachers gave worksheet for each chapter to support the class teaching where the questions helped in developing mathematical concepts. The worksheets were not done only by the teachers in the tutorial class but also by individual students and discussing in groups in the tutorial class.

The responses of the students towards methods and approaches also indicates that presentation of the teachers in the class are mostly problem solving method and traditional method of teaching where definitions and formulas or rules are given and then theorems are proven and examples are solved. It is realized that less focus is given to independent and collaborative mathematics activities.

Apart from the findings elaborated above, one of the focus areas in the teaching of applied mathematics in particular and engineering in general is problem solving. Problem solving involves reasoning and analysis, argument construction, and the development of innovative strategies. These abilities are used not only in advanced mathematics topics-such as algebra, geometry and calculus-but also throughout the entire mathematics curriculum beginning in kindergarten, as well as in subjects such as science. Moreover, these skills have a direct impact on students' achievement scores, as many state and national standardized assessments and college entrance exams include problem solving. In AAIT the effort to implement problem based approach was found to have mean score $\bar{x}$ = 3.55 which seems to be at a better level. But, since the focus of education in Ethiopia is towards producing problem solvers, it is worth mentioning the need to enshrine this approach in the teaching of applied mathematics, supported by independent and collaborative activities, which was found to have less focus.

In addition to, the capacity to visualize something is making first hand step in solving problems. How do teachers exploit visualization techniques, hence deserves to be addressed. Assessment is also a key during teaching-learning. Accordingly, below is the descriptive statistics of the items of visualization techniques and assessment of students applied in the teaching of applied mathematics for the engineering students.

**Table 4:** Descriptive statistics of the items of visualization techniques and assessment of students in teaching applied mathematics for engineering students

| **Items (Visualization Techniques)** | **N** | **M** | **SD** |
|---|---|---|---|
| The mathematics teachers applied concept map visualization technique (*representing concepts and their relationships in graphical form and diagram showing the relationships between concepts*) | 53 | 3.72 | 1.063 |
| The mathematics teachers applied animation or simulation visualization technique using computer or software like mathematical, math lab, etc. | 53 | 1.92 | 1.190 |
| The mathematics teachers applied real life applications visualization technique (*applying real life application*) | 53 | 3.09 | 1.079 |
| The mathematics teachers applied experimentation visualization technique (*applying experiments*) | 53 | 2.53 | 1.353 |
| The mathematics teachers applied manipulative visualization technique (*using concrete objects*) | 53 | 2.79 | 1.215 |
| The mathematics teachers applied graphic and pictorial visualization technique | 53 | 3.40 | 1.335 |
| The mathematics teachers applied multiple representations visualization technique (*concrete, semi-concrete, graphic, symbolic/algebraic*) | 53 | 3.21 | 1.166 |
| **Items (Assessment of Students)** | **N** | **M** | **SD** |

| | | | |
|---|---|---|---|
| The mathematics teachers assessed students' understanding by using question & answer | 53 | 3.40 | 1.364 |
| The mathematics teachers assessed students' understanding by using class activities | 53 | 3.09 | 1.197 |
| The mathematics teachers assessed students' understanding by using homework and assignment or project | 53 | 3.43 | 1.118 |
| The mathematics teachers assessed students' understanding by using quizzes/tests and exams | 53 | 4.09 | 1.005 |
| Mathematics teachers gave feedback for all assessment | 53 | 3.15 | 1.350 |
| Mathematics teachers gave chance for self or peer assessment of the students | 53 | 3.00 | 1.092 |
| Mathematics teachers considered all the assessment as a part of overall evaluation | 53 | 3.49 | 1.234 |
| Questions that appeared in exams represented proper concepts in the course | 53 | 3.91 | 1.043 |
| All contents in chapters are proportionally represented during tests/quizzes/exams or assignment | 53 | 3.92 | 1.174 |
| The questions that appeared in an exam were composed of different types (workout, fill in the blank, multiple choice, true/false etc) use of multiple approaches of assessment | 53 | 3.60 | 1.214 |
| Mathematics teachers assessed the learning of students formatively | 53 | 3.64 | .963 |

Table 4 indicates that the teachers implemented concept map visualization technique in most mathematics topics, but less implementation of animation or simulation, experimentation and manipulative techniques in teaching mathematics.

Effective instruction should enable students to investigate the connections between various concepts and topics within mathematics. The use of concept maps can provide one avenue for a teacher to emphasize this often neglected learning objective in a way that actively engages students in constructing and communicating the depth of their knowledge visually. While concept mapping cannot be considered a comprehensive means of assessing a student's understanding of a particular body of mathematical topics, they do provide a unique view into each student's interpretation of the material. The use of concept maps offers numerous benefits to students and teachers: they can involve significant mathematics in a wide range of introductory level to upper division courses; allow for individual differences in the organization of the terms and in expressing the connections between terms; can be motivating to students; and provide the teacher with a unique view of student thinking (Bolte, 1999a, 1999b; Williams, 2002).

The use of manipulative in teaching mathematics has become as almost commonplace as the use of textbooks. And with good reason, as Ruzic and O'Connell (2001) found that the long-term use of manipulative has a positive effect on student achievement by allowing students to use concrete objects to observe, model, and internalize abstract concepts. Manipulative not only allow students to construct their own cognitive models for abstract mathematical ideas and processes, it also provides a common language with which to communicate these models to the teacher and other students. In addition to the ability of manipulative to aid directly in the cognitive process, manipulative have the additional advantage of engaging students and increasing both interest in and enjoyment of mathematics. Students who are presented with the opportunity to use manipulative report that they are more interested in mathematics. And, long-term interest in mathematics translates to increased mathematical ability (Sutton and Krueger, 2002). In this regard, manipulation in teaching mathematics was found to be not frequent ($\bar{x}$ = 2.79) to be used in teaching mathematics.

Additionally, teachers and students may have a clear idea of how to solve a mathematical problem using multiple representations, as multiple representations include such things as graphs, tables, or written explanations that may help students to visualize the bigger idea of the mathematical task. However, if teachers and students are not familiar in solving problems through multiple representations, then coming to understand the mathematical ideas could become problematic. "Solving modeling problems can be complex, particularly when students do not have representations and strategies at hand" (Izsak, 2003). Associated with this idea, thus task was performed with $\bar{x}$ = 3.21, but needs to be enhanced!

Table 4 also indicates the type and frequency of assessment techniques the teachers of applied mathematics use. From this one observes that class activities ($\bar{x}$ = 3.09) and self or peer assessment of students ($\bar{x}$ = 3.00) were comparatively less used; better assessment practices can be seen using quizzes, tests and exams ($\bar{x}$ = 4.09). In aggregate most of the assessment techniques were applied though it seems that summative assessment dominates the role.

Formative assessment, unlike summative assessment, is a systematic process of gathering evidence about student learning, while it is happening (Wiliam and Black, 1996). That information is then used to inform teaching practices and serves as a guide for how to move students forward toward a learning goal. If student learning is the goal of education, this type of assessment is vital; formative assessment and the teaching process are inseparable, one cannot happen without the other.

Ideally, assessments also allow students to monitor their own progress throughout a course. This is especially important, because if students are to be lifelong learners, they need to be able to monitor and control their own process of learning. Paper-and-pencil assessments (multiple choice, true/false, fill in the blanks, short essays, etc.) are most useful for determining what students know; performance tasks (demonstrations, presentations, etc.) are often more suited to assessing what students can do with what they know.

Generally, feedback has to be given as soon as possible after the completion of the learning task. Students also need to see that feed-forward comments can be incorporated into subsequent performance and overall influence the quality of their learning in positive ways. At the same time, in some instances, temporarily withholding feedback is needed to allow the students to internalise and process the demands of the task (Hattie & Timperley, 2007). In this regard assessing the learning of students formatively was found to have $\bar{x}$ = 3.64 with small SD = 0.96 showing that the effort of mathematics teachers is promising. Although giving feedback is important, "Teachers give feedback for all assessments" was found to be implemented ($\bar{x}$ = 3.15) which was comparatively less frequent. This needs to be put in place.

The fourth research question was to check whether there were significant differences in the variables such as classroom instruction, additional support, methods & approaches, visualization techniques, assessment of students and teaching of applied mathematics with respect to sex and background qualification. The following presents the findings related to this question.

**Sex**

The first step was to check whether there were significant differences in the teaching of applied mathematics and components of teaching applied mathematics for engineering students such as classroom instruction, additional support, methods & approaches, visualization techniques, and assessment of students with respect to sex. Table 5 is the descriptive statistics and the independent samples t-test for the response of engineering students about the teaching of applied mathematics and its components with respect to sex.

**Table 5:** Descriptive statistics and the independent samples t-test for the responses of engineering students about the teaching applied mathematics and its components with respect to sex

| Components | Groups | N | M | SD | df | t | P |
|---|---|---|---|---|---|---|---|
| **Classroom instruction** | Male | 42 | 3.3317 | .77613 | 51 | .710 | .481 |
| | Female | 11 | 3.1394 | .88817 | | | |
| **Additional support** | Male | 42 | 2.9107 | .79599 | 51 | .389 | .699 |
| | Female | 11 | 2.8068 | .75491 | | | |
| **Methods & approaches** | Male | 42 | 3.4048 | .91441 | 51 | .051 | .960 |
| | Female | 11 | 3.3896 | .71168 | | | |
| **Visualization techniques** | Male | 42 | 2.9830 | .85610 | 51 | .512 | .611 |
| | Female | 11 | 2.8312 | .94937 | | | |
| **Assessment of students** | Male | 42 | 3.5173 | .77854 | 51 | -.074 | .941 |
| | Female | 11 | 3.5372 | .84448 | | | |
| **Teaching of applied mathematics** | Male | 42 | 3.2639 | .70515 | 51 | .406 | .686 |
| | Female | 11 | 3.1667 | .71334 | | | |

The descriptive statistics showed that the mean or average of the males and females responses on each of the five independent variables and one dependent variable. From the descriptive statistics the responses seemed that males outperformed the responses of females in classroom instruction, additional support, methods & approaches, visualization techniques, and teaching of applied mathematics; but the responses of females were higher than the responses of males in assessment of students. In table 5, the independent sample t-tests, the p values show that there is no significant difference in teaching of applied mathematics and the components of teaching applied mathematics with respect to sex. That is, the responses of males and females were not significantly different in the variables classroom instruction, additional support, methods & approaches, visualization techniques, assessment of students and teaching of applied mathematics.

**Background Qualifications**

The second step was to check whether there were significant differences in the teaching of applied mathematics and components of teaching applied mathematics with respect to background qualification. Table 6 presents the descriptive statistics of the responses of engineering students on teaching applied mathematics and components of teaching applied mathematics with respect to background qualification.

**Table 6:** Descriptive statistics of the responses of engineering students on teaching applied mathematics and its components with respect to background qualification

| Groups | N | Classroom instruction | | Additional support | | Methods & approaches | | Visualization techniques | | Assessment of students | | Teaching of applied mathematics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD |
| **TVET** | 10 | 3.58 | .990 | 3.23 | 1.105 | 3.61 | 1.406 | 3.46 | .998 | 3.53 | 1.140 | 3.50 | 1.016 |
| **Preparatory** | 18 | 2.95 | .662 | 2.47 | .584 | 3.12 | .740 | 2.66 | .930 | 3.23 | .796 | 2.92 | .601 |
| **Diploma** | 8 | 3.23 | .884 | 2.72 | .499 | 3.23 | .687 | 2.93 | .760 | 3.28 | .396 | 3.12 | .560 |
| **Degree** | 7 | 3.51 | .682 | 3.21 | .660 | 3.66 | .598 | 2.98 | .682 | 3.94 | .461 | 3.50 | .507 |

Table 6 shows the mean or average of the responses with respect to background qualification of the students (which are preparatory, TVET, diploma and degree) on each of the five independent variables and one dependent variable. From the table, the responses of students who have TVET background revealed higher group score than the responses of the other groups in classroom instruction, additional support, visualization techniques, and teaching of applied mathematics. The students who have degree background had higher group score than the responses of the other groups in methods & approaches, assessment of students and teaching of applied mathematics. The responses of students who have preparatory background were the smaller group scores than the responses of the other groups in all the component variables.

Table 7 show one-way ANOVA for the responses of engineering students on teaching applied mathematics and its components with respect to background qualification. That is, it shows whether there is a significant difference in the variables such as classroom instruction, additional support, methods & approaches, visualization techniques and assessment of students with respect to background qualification.

**Table 7:** One-way ANOVA for the responses of engineering students on teaching applied mathematics and its components with respect to background qualification

| Components | | df | SS | MS | F | p |
|---|---|---|---|---|---|---|
| **Classroom instruction** | Between groups | 3 | 3.746 | 1.249 | 2.098 | .113 |
| | Within groups | 49 | 29.163 | .595 | | |
| | **Total** | **52** | **32.909** | | | |
| **Additional support** | Between groups | 3 | 6.275 | 2.092 | 4.020 | .012 |
| | Within groups | 49 | 25.496 | .520 | | |
| | **Total** | **52** | **31.771** | | | |
| **Methods & approaches** | Between groups | 3 | 3.215 | 1.072 | 1.453 | .239 |
| | Within groups | 49 | 36.135 | .737 | | |
| | **Total** | **52** | **39.349** | | | |
| **Visualization techniques** | Between groups | 3 | 4.113 | 1.371 | 1.911 | .140 |
| | Within groups | 49 | 35.150 | .717 | | |
| | **Total** | **52** | **39.263** | | | |
| **Assessment of students** | Between groups | 3 | 5.004 | 1.668 | 1.668 | .551 |
| | Within groups | 49 | 26.982 | .551 | | |
| | Total | 52 | 31.986 | | | |
| **Teaching of applied mathematics** | Between groups | 3 | 3.832 | 1.277 | 2.881 | .045 |
| | Within groups | 49 | 21.725 | .443 | | |
| | **Total** | **52** | **25.558** | | | |

There is no significant difference in the responses of students whose background is preparatory, TVET, diploma and degree in terms of classroom instruction, method &

approach and visualization techniques and assessment of students, but there is a significant difference in their responses to additional support and teaching applied mathematics.

Since the responses of the students had significant difference in additional support and teaching of applied mathematics with respect to some of the background qualifications, then the next question was which of the background qualifications made more significant difference. To find these paired comparisons Games-Howell test was used, since the assumption for Tukey test failed. That is the Levene test was significant indicates that the variances are unequal then the Games-Howell test was used instead of Tuky test and the result is given in table 8.

**Table 8:** Games-Howell test for the responses of engineering students on additional support, assessment of students and teaching of applied mathematics with respect to background qualification

| Components | Background qualification (I) | Background qualification (J) | MD (I-J) | SE | p |
|---|---|---|---|---|---|
| **Additional support** | Preparatory | TVET | -.75278 | .37564 | .240 |
| | | Diploma | -.24653 | .22374 | .694 |
| | | Degree | -.74101* | .21105 | .007 |
| | TVET | Diploma | .50625 | .39149 | .583 |
| | | Degree | .01176 | .38438 | 1.000 |
| | Diploma | Degree | -.49449 | .23813 | .198 |
| **Teaching of applied mathematics** | Preparatory | TVET | -.57917 | .35115 | .388 |
| | | Diploma | -.19792 | .24334 | .847 |
| | | Degree | -.58578* | .18744 | .019 |
| | TVET | Diploma | .38125 | .37741 | .746 |
| | | Degree | -.00662 | .34403 | 1.000 |
| | Diploma | Degree | -.38787 | .23294 | .380 |

* The mean difference is significant at the 0.05 level.

From table 8, for the variables additional support and teaching of applied mathematics, the responses of the students with background of degree level qualification made more significant difference with those responses of the preparatory level of qualification.

To assess whether sex and background qualification each seem to have an effect on teaching applied mathematics, independently and by interaction, Table 9 shows the mean and standard deviations for teaching applied mathematics separately for the two sexes and background qualifications and table 10 presents the analysis of variance for teaching applied mathematics with respect to sex and background qualifications.

**Table 9:** Descriptive statistics for teaching applied mathematics for the two sexes and background qualifications

| Groups | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | **N** | **M** | **SD** | **N** | **M** | **SD** |
| **TVET** | 11 | 3.4958 | 1.01621 | 0 | - - - | - - - |
| **Preparatory** | 10 | 2.7604 | .61050 | 8 | 3.1120 | .56431 |
| **Diploma** | 7 | 3.2768 | .34647 | 1 | 1.9792 | - - - |
| **Degree** | 15 | 3.4389 | .49891 | 2 | 3.9792 | .32409 |
| **Total** | 42 | 3.2639 | .70515 | 11 | 3.1667 | .71334 |

The descriptive statistics of table 9 indicates that there is no female students whose background was TVET and it can be easily seen that average of the responses of female students are greater than male students for preparatory and degree background and the average of the responses of male students are greater than female students for diploma background.

**Table 10:** Analysis of variance for teaching applied mathematics as a function of sex and background qualifications

| Variable and source | df | MS | F | p | $\eta^2$ |
|---|---|---|---|---|---|
| **Teaching applied mathematics** | | | | | |
| **Background qualifications** | 3 | 1.517 | 3.636 | .020 | .192 |
| **Sex** | 1 | .085 | .204 | .654 | .004 |
| **Sex*Background qualifications** | 2 | 1.134 | 2.720 | .077 | .106 |
| **Error** | 46 | .417 | | | |

*R Squared = .249 (Adjusted R Squared = .151)

**Fig 1: Estimated Marginal Means of Teaching**

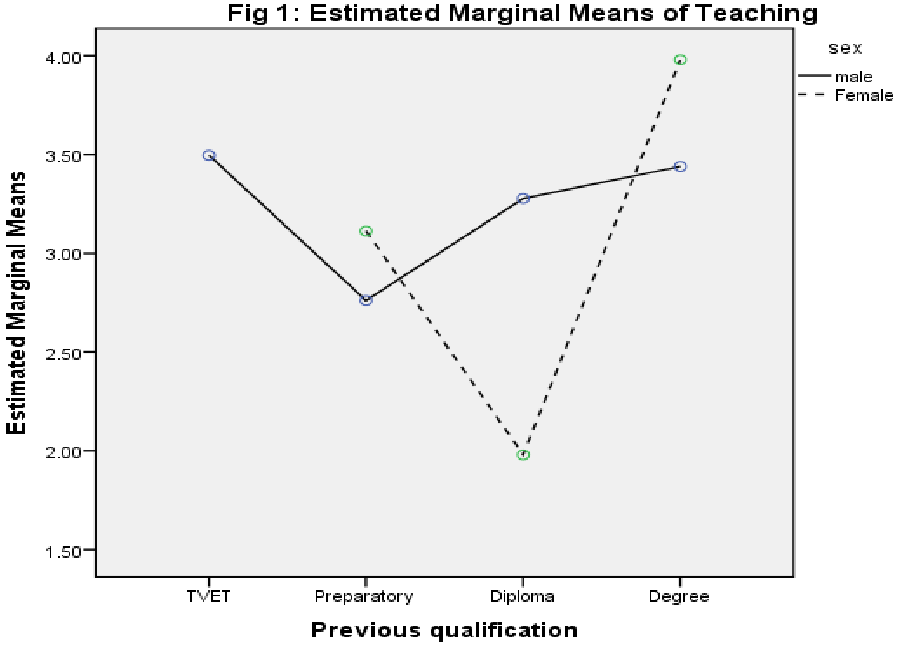


Table 10 shows that there was a significant main effect of background qualification on teaching applied mathematics, $F(3, 46) = 3.636$, $p < 0.05$. Eta for background qualification was about .192, which, according to Cohen (1988), is weak effect. But there was no significant effect of sex on teaching applied mathematics, $F(1, 46) = .204$, $p > 0.05$. Furthermore, there was no significant interaction between sex and background qualification on teaching applied mathematics, $F(2, 46) = 2.720$, $p > 0.05$. This means the interaction between sex and background qualification on teaching applied mathematics is not significant, that is, the effect of background qualification on teaching applied mathematics is the same for both sexes. Also from the profile plots and differences between the cell means, males have larger mean than females for diploma background (difference cell means = 1.2976), but the difference between males and females is small for preparatory background (difference cell means = 0.3516) and degree background (difference cell means = 0.5403) in which females have larger mean than males.

## DISCUSSION

Research has shown that team teaching is an effective way of constructing deep learning of concepts while learning alternative ways to teach the same subject-matter. Developing co-generative dialoguing occurs to further develop existing understandings of the teaching situation (Roth, Tobin, Zimmermann, Bryant & Davis, 2002). Team teachers also create material and social resources that allow subsequently for new forms of agency (Roth, Tobin, Carambo & Dalland, 2005). Effective professional growth must be collaborative, involving the sharing of knowledge among teacher communities of practice rather than concerning individual teachers (Roth et al., 2002).

Important emphasis should also be given in connecting mathematics to everyday life. When students find that they can use mathematics as a tool for solving significant problems in their everyday lives, they begin to view it as relevant and interesting. Effective teachers take care that the contexts they choose do not distract students from the task's mathematical purpose. They make the mathematical connections and goals explicit, to support those students who are inclined to focus on context issues at the expense of the mathematics. They also support students who tend to compartmentalize problems and miss the ideas that connect them.

As teachers, we all want to make the mathematics we teach more 'alive', more 'realistic' and more 'accessible'. By making it more 'alive' we want to attract our pupils to learn mathematics, simply to make it more interesting and by making it more 'realistic' we want to show that we need mathematics in everyday life, although we very often do not realize this. By making it more 'accessible' we want to make mathematical skills available to as many pupils as possible, although everyone has different potentials and possibilities in this area.

In realizing these, teachers need to collaborate to teach the topics in the same pace and sequence and offer sufficient time whereby students can cover contents in time. In these regard, teachers taught the different chapters or topics with the same pace ($\bar{x}$ = 3.26) and the time allotment for the course was enough ($\bar{x}$ = 2.38). From these it is vivid that courses are not covered in time and these may cause teachers to seek options to fail to work in team or collaboratively, and proceed teaching haphazardly. The effort the teachers do to state the necessary and/or sufficient conditions when clarifying the concepts whenever necessary; and the effort to give examples with missing concepts was promising. The overall mean score ($\bar{x}$ = 3.29) of classroom instruction was found to be sufficient, though some of its components such as "All the chapters in the applied mathematics course (s) were covered with the specified time in the semester" ($\bar{x}$ = 2.70), "The time allotment for the course was enough" ($\bar{x}$ = 2.38), and "Mathematics teachers invited professional to the class when appropriate" ($\bar{x}$ = 2.26) were unutilized sufficiently.

The fact that students need additional support is unquestionable. There are several support schemes teachers can use to support their students. For example, Ramesha and Narayanaswamy M. (2012) stated that tutorial strategy is generally considered to be one of the most valuable educational experiences. Lecture strategy is followed by tutorials because individual difficulties cannot be solved in lecture method. Tutorial aims at providing remedial help to the learner or to help individual difficulties of the learner. The cognitive and affective objectives of learning can also be achieved through the tutorial teaching strategy. Additionally, Tutorials help students to link together what they have heard in lectures and what students have read in textbooks, and to give them an opportunity to discuss these ideas. A good tutorial is highly interactive; promotes opportunity for discussion, debate and critical reflection; and engages students in the subject content by way of analysis of the material being studied. Tutorials give students the opportunity to make mistakes (and learn from them) in a collegial and supportive environment. This strategy helps students to review the material they have learned in lectures; develop their ideas and implement their learning though questions and problem-solving. This point was found to be implemented well in the teaching of applied mathematics, and students were given the opportunity to work in groups, which is helpful strategy to remedy individual differences and enhance active participation.

Active participation by students through establishing a high response rate to teacher's questioning and prompting is useful. Enforcing this the teacher may begin the lesson by presenting information using an explanatory or didactic approach, but then students are expected to enter into dialogue and contribute their own ideas, express their opinions, ask questions, and explain their thinking to others (Reynolds & Farrell, 1996). Within the activity learning approaches, the learner actively constructs his/her understanding of mathematical concepts. Albeit this, the components of the "teaching in the classroom" process are identified as "entities", teacher, student and contents, and "restrictions", place and time, which these two components together represent the "traditional teaching". This approach was found to be the most common practice ($\bar{x}$ = 3.89).

In fact, the "learner" is the "key-person" in activity learning strategy, that is, the mathematics teaching should be learner-centered. This means, the learner´s need to be active mentally, socially and physically in this education learning system. In this approach, the role of teachers is seen as that of a manager of the learning environment, and it also is notable that this process is open-ended learning. The learner and the teacher are two important actors in this environment.

It can be difficult to grasp a new concept or solve a problem when distracted by the views of others. For this reason, teachers should ensure that all students are given opportunities to think and work quietly by themselves, where they are not required to process the varied, sometimes conflicting perspectives of others. The individualized mathematics activities were given ($\bar{x}$ = 3.06) which is at moderate level. However, a lesson's group activities need to be interspersed with some quite think time during which students can engage in independent work. Engagement in independent work sessions requires a student to complete an assigned task without disturbing others also working on the task. Typically, student work individually, with the teacher available for help. Independent work sessions are essential to most teaching units. Although this seems to be valid, they need to be integrated with other types of learning activities, monitored, and guided such as collaborative teaching.

There are several advantages to collaborative teaching (Novicevic, Buckley, Harvey, & Keaton, 2003). First, this teaching approach can lead to learners' improved capability to evaluate problems critically, to argue substantively, and to apply effectively learned concepts to new situations or contexts. Second, the process augments the quality of teaching scholarship by transforming it into a participative activity with critical review and quality assurance. Third, collaborative teaching can be viewed as a means to achieve enhanced teaching outcomes because of its peer-reviewed and monitored nature. Additionally, it is structured to address multiple disciplinary perspectives. Fourth, collaborative teaching challenges traditional instructional delivery approaches. Its strength lies in the combined forces applied to address common goals or problems. If faculty goals vary in kind and nature, the outcome of the collaboration can be negative. In particular, if the goals and expected performance levels are not clearly defined at the beginning, team effectiveness can be affected.

Cooperative learning enhances opportunities for mathematical learning because students learn from each other's ideas (Good, Reys, Grouws, and Mulryan, 1989/90). In a similar way, cooperative learning supports critical thinking and higher level processing skills as students challenge each other while reaching a group decision (Rottier and Ogan, 1991). Students improve their communication and social skills and often gain self-esteem as they work toward a common goal (Good et al, 1989-90). In addition, cooperative learning allows students to move from concrete to abstract thinking and often makes it easier to learn difficult tasks (Rottier and Ogan, 1991). Cooperative learning also improves long-term retention (Whicker, Bol, and Nunnery, 1997). This was found to be implemented at ($\overline{x}$ = 3.08). From these one observes that both individual learning and collaborative learning are practiced moderately.

Another form of learning is use of mathematical modelling. According to the new Common Core State Standards in Mathematics (CCSSM), mathematical modelling is the ability to apply concepts learned in class to real world applications and to use the model to analyze a situation, draw conclusions, and make predictions. It is more than simply presenting the students with a word problem. It is a mathematical process that involves observing a situation, conjecturing relationships, applying mathematical analyses, obtaining mathematical results, and reinterpreting the model (Lingefjärd, 2006). It is an iterative process that requires students to fine tune the model until a reasonable prediction or result is obtained. The answer must be interpreted, and it may be necessary to repeat the cycle before getting a valid solution. Mooney & Swift (1999) stated that the model activities should serve as an opportunity for students to develop and change their understanding of mathematical concepts. The model should not be so narrow that students already know all of the mathematics that will be needed to solve the problem (Zbiek & Conner, 2006).

Mathematical modeling is used in understanding and resolving problems of reality, as a strategy for teaching and learning. It enabled us to use the chosen themes, knowing the problems that exist within it and try to solve them with the help of mathematics. As revealed by the data presented in Table 3, the mean score of teachers applying modeling approach was 3.38 with SD = 1.197 showing the variation. It seems that the effort to apply modeling was found to be better as compared to individual and collaborative learning strategies. Hence, this needs to be strengthened further.

Through the expansion of engineering and technology, one realizes the need for problem solving. This could be escalated when problem based learning is practiced. Problem Based Learning (PBL) is a student centered learning where it emphasis on the process of learning by which the students themselves will come up with the solution and the teacher will act as a facilitator. It works in small groups and deals with real life situations. It enables students to be a part of the learning process by which the students themselves organized their own learning. The PBL method was developed to stimulate the students, help the students to apply their knowledge to solve real life problems and also to motivate them to keep on learning (Barrows, 1986). The most important is how it helps students to think, create, analyze and apply their knowledge to solve the problem. The key element of PBL is the small group learning which has all the criteria for collaborative learning

(Dolmans and Schmidt, 2006). A research conducted by Webb (1996) using PBL on a Mathematics program called Interactive Mathematical Program (IMP) including topics like algebra, geometry, trigonometry, statistics and probability found that students participated in the inaugural IMP program performed better compared to their peers in the traditional high school Mathematics courses. The research also found that students showed great improvement in terms of problem solving skills and quantitative reasoning. According to Jaques (1992), teaching and learning in small groups is an important part of all rounded education for this purpose. In this endeavor, problem presented should be a real world situation. It should be meaningful to the lives of the students. Students work collaboratively in small groups and join their efforts to tackle the problem. Staff acts as facilitator and problem lead to the development of problem solving skills.

Although the background of learners might affect the effectiveness of problem based learning (PBL), the roles of the teacher in designing the problem-based scenarios remain the key to the successfulness of PBL. In mathematical study, teacher's instructional ability is critical to engage students in gathering information and apply their knowledge in their respective fields (Kyeong, 2003). Students, through mathematical PBL, have greater opportunity to learn mathematical processes associated with communication, presentation, modeling, and reasoning (Smith, 1998).

Problem solving has generally been accepted as a means for advancing thinking skills (e.g. Schoenfeld 1985). For example, in the NCTM Standards it is stated: "*Solving problems is not only a goal of learning mathematics but also a major means of doing so. ... In everyday life and in the workplace, being a good problem solver can lead to great advantages. ... Problem solving is an integral part of all mathematics learning."* (NCTM, 2000, 52)

The findings in this study revealed that mathematics teachers applied problem based learning approach ($\bar{x}$ = 3.55) and that of problem solving method ($\bar{x}$ = 3.72) both of which are promising, though there is a need to scale up such practices to a better level.

Albeit the aforementioned discussions, in the world-wide attempts to find a new teaching method that might meet the challenges set by constructivism, the so-called open approach was developed in the 1970's in Japan (e.g. Nohda 2000). Internationally it is accepted that open-ended problems form a useful tool in the development of mathematics teaching in schools, in a way that emphasizes understanding and creativity (e.g. Silver 1993, Stacey 1995). Nowadays different pieces of mathematical software are available for lecturers providing excellent services for graphical applications. From the practical point of view software such as MAPLE is an excellent tool for designing presentations containing pictures and animations, since one can find a lot of built-in tools planned for the educational applications. MatLab, in turn, is an effective tool for engineering students to carry out the calculation steps of particular methods in different mathematical models (Imre, 2007). Creating computer visualizations, especially animations, can help students to understand geometric objects (especially straight lines and curves), which are described by parametric equations, as point sets and to discover functional relationships and dynamic aspects. Because creating computer animations is very attractive for students it can help to motivate them to figure out features of parametric descriptions. To assemble straight lines or curves as point sets using parametric equations and to be able to create parameter-dependent animations, computer algebra systems (CAS, e. g. Mathematical, Maple and MuPAD) as well as 3D-graphics software, POV-Ray, among others, can be used (Andreas, 2012).

As mentioned earlier, as teachers, we all want to make the mathematics we teach more ‘alive’, more ‘realistic’ and more ‘accessible’. In this regard, mathematics is of practical value in many professions. It is not just the mathematical knowledge itself but the thinking processes acquired in genuine mathematical problem solving and investigation that can be applied to unfamiliar situations in other fields. Mathematical knowledge and processes are also useful outside the workplace in everyday life to understand and interpret certain events and news reports so as not to be deceived or swayed by others’ opinions without any reasonable basis, thus improving one’s own quality of life when one is able to lead a meaningful and responsible life. Teachers should impress upon their students the usefulness of mathematics in their daily life, and they should prepare their students for the future by focusing on the essential skills and processes that are required in the workplace (Joseph, 2010). Animation, or simulation visualization technique use computer or software during teaching-learning of applied mathematics in AAIT has mean score of 1.92 which is the least. This demands, thus a closer investigation.

Regarding quantitative experiments a lot of the aspects mentioned above can be touched. Measuring values are unknown objects representing an interval of numbers. They may change causing changes of other related measuring values. The relationship between measuring values is given by specific unknowns. They remain constant in the same situation and might change if settings or the environment change. Since “students’ conceptions of a mathematical concept is determined by the set of specific domains in which that concept has been introduced for the student” (Michelsen, 2006), experiments have a great potential to introduce the concept of variable. Using physical experiments to introduce mathematical concepts means putting emphasis on the mathematical aspects. That means some physical aspects should play a minor role. For example the way measuring instruments work, why an experiment is set up this way or another are not major concerns of mathematics. Major concern of mathematics is the reliability of the measuring values involved to do mathematics. Even then measurement errors occur, i.e. functional relationships between measuring values are ideal models and reflect reality only if one takes these errors in consideration. To minimize physical aspects which might trouble students, experiments should be easy to handle. Yet, the way we teach mathematics needs to take these into considerations. The response depicting ($\overline{x}$ = 2.53) which is below average.

Despite the approaches and methodological considerations, assessment and provision of feedback lies at the centre of teaching learning. Nicol & Draper (2008) suggests that there could be some class time set aside for decoding and discussion of feedback comments after assignments have been returned. One strategy that Nicol & Draper (2008) suggests here is to put students into small groups in tutorials and invite them to share and discuss feedback comments. Studies of the impact of feedback on student learning achievement also indicate that feedback has the potential to have a significant effect on student learning achievement (Hattie & Timperley, 2007). However, this potential is strongly related to the quality of the feedback and, unsurprisingly, Hattie and Timperley (2007) note that the most improvement in student learning takes place when students got “information feedback about a task and how to do it more effectively” and is clearly related to the learning goals. By contrast, the impact of feedback on learning achievement is low when feedback focussed on “praise, rewards and punishment” (Hattie & Timperley, 2007). Hattie and Timperley (2007) also note that feedback is more effective when it addresses achievable goals and when it does not carry “high threats to self-esteem”. At AAIT assessment was found to be performed to a better scale, each component described with mean score more than 3.00. But, the frequent forms of assessment were using quizzes/tests and exams (mean score $\bar{x}$ = 4.09). Even then the questions that appeared in exams represented proper concepts in the course ($\bar{x}$ = 3.91) and all contents in chapters are proportionally represented during quizzes/tests or assignments ($\bar{x}$ = 3.92). It can be concluded that mathematics teachers are providing representative assessment scheme, however, issues of self-assessment and peer assessment of students ($\bar{x}$ = 3.00), and the provision of class activities for assessing students learning ($\bar{x}$ = 3.09) demands possibility of implementation.

Cognizant of the aforementioned results, in an attempt to check whether there was difference in the responses of students with respect to sex and background qualifications, sex was not found to have any statistically significant difference while background qualification was found to be statistically significant. From the groups of students in terms of background qualification, there was statistically significant difference $F(3, 49) = 4.02$, $p = .012$ in the response of the students in regard to additional support given by the mathematics teachers and their teaching of applied mathematics $F(3, 49) = 1.668$, $p = .045$. This assessment revealed that students with preparatory background were found to have higher demand for additional support and the teaching of applied mathematics as compared with degree holder students. This delves that background of students need to be given due consideration during planning of instruction so that they can cope with the competitive learning environment in such a diverse groups.

Generally the perception of the students in the teaching of applied mathematics shown that there is promising effort undertaken by the teachers of applied mathematics, but also there are lots of components that need to be addressed as a consequence of which the delivery of the course applied mathematics could be enhanced and students benefit at large.

## CONCLUSION AND RECOMMENDATIONS

### CONCLUSION

The purpose of this study was to assess how applied mathematics was taught to engineering students as the AAIT of Addis Ababa University. That is to analyze the extent of implementation of each of the variables classroom instruction, additional support, methods and approaches, visualization techniques and assessment of students implemented in teaching of applied mathematics, and to check whether there were significant differences of these variables with respect to sex and background qualification. Based on the data gathered and analyzed, the following concluding remarks are forwarded:

- Assessment of students is relatively frequently used, while techniques in classroom instruction, additional support, different methods and approaches, and visualization techniques are sometimes applied in teaching mathematics.
- The strong part of the instructors in classroom instruction were the delivery of the course outline and showing the necessary and sufficient conditions when clarifying the concepts in applied mathematics, but there is a shortcoming in the coverage of the courses of applied mathematics, since the time allotment for the course is not enough and invitation of professionals in the appropriate places of the courses.
- Additional support given to the students were giving worksheet for each chapter and the questions helped in developing mathematical concepts, but the worksheet were not done collaboratively and discussing in groups in the tutorial class.

- Problem solving method and traditional method of teaching were mostly applied where definitions and formulas or rules are given and then theorems are proven and examples solved; less focus was given to independent and collaborative mathematics activities.
- Teachers implemented concept map visualization technique in most mathematics topics, but animation or simulation, experimentation and manipulative techniques in teaching mathematics were used rarely.
- Assessment of students' understanding by using class activities and self or peer assessment of students was least, but better assessment can be seen using quizzes, tests and exams.
- There is no significant difference in the teaching of applied mathematics and the components of teaching applied mathematics with respect to sex.
- There is no significant difference in the responses of students whose background is preparatory, TVET, diploma and degree in classroom instruction, method & approach and visualization techniques, but there was significant difference in the responses of additional support, assessment of students and teaching applied mathematics.
- There was no significant interaction effect between sex and background qualification on teaching applied mathematics, that is the effect of background qualification on teaching applied mathematics is the same for both sexes. males had larger mean than females for diploma background, but the difference between males and females was small for preparatory background and degree background.
- In general, there are some positive indications of perception of students towards teaching of applied mathematics. But, there are also several cases that need to be revisited to let the teaching-learning become effective.

## RECOMMENDATIONS

Based on the findings of the study, the following recommendations were forwarded:

- Training should be given to instructors in implementing different assessment techniques, additional students support, different methods and approaches, and visualization techniques in teaching mathematics.
- Enough time should be allotted for applied mathematics courses in the curriculum review.
- Encourage instructors to invite professionals in the appropriate places of the courses as a team teaching.
- Advise instructors to work on worksheet collaboratively and discussing in groups in the tutorial class.
- Instructors should give emphasis to independent and collaborative mathematics activities.
- Instructors should also focus on animation or simulation, experimentation and manipulative techniques in teaching mathematics.
- Instructors should also focus on assessment of students' understanding by using class activities and self or peer assessment of students.
- Instructors should provide feedback to students for each assessment.

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