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Research Article

Mathematics Competency Of Graduating Engineering Students Of Mountain Province State Polytechnic College

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Abstract

Mathematics is an integral part of the Engineering curriculum and Engineering licensure examinations which includes Algebra, Trigonometry, Analytic Geometry, Solid Geometry, Calculus, and Probability and Statistics. Little research has been conducted to explore engineering students' learning of mathematics, in particular with respect to what mathematical competencies are needed for Engineers. This study assessed the Mathematics competency of graduating Electrical, Civil, and Geodetic Engineering students of the Mountain Province State Polytechnic College (MPSPC) along the different subject areas. It also evaluated the level of competence of students along the 3 groups of learning outcomes (knowledge, problem analysis, and application to real world situations). The narrative descriptive survey was used. Weighted mean was used to determine the level of competence of the students and chi-square test for significant differences in their competence levels. Result showed that the level of competence of the students in Mathematics as a whole is unsatisfactory with satisfactory competence level in Probability and Statistics, unsatisfactory in both Algebra and Trigonometry, and poor in Calculus, Solid Geometry, and Analytic Geometry. There are significant differences in the students' level of competence along the different subject areas. The students' competency level in knowledge and application is poor, while unsatisfactory in analysis. With an unsatisfactory competence level in Mathematics, the graduating Engineering students lack the necessary mastery in Mathematics that warrants a better chance of passing the board.

Keywords: Engineering, Mathematics competency, MPSPC, Learning outcomes

1. Introduction

Background

Engineers are necessary for the design, development and maintenance of infrastructure and technology to sustainably satisfy society's needs and lifestyles. With Mathematics as an integral part of the Engineering Education, efforts to improve the mathematical and technical abilities of engineering students are being pushed by the Commission on Higher Education (CHED) through the Outcomes Based Education (OBE) System in higher education institutions offering engineering programs to meet the demands of global competitiveness. CMO no. 37 series of 2012[1] defines Outcomes Based Education (OBE) as "*focusing and establishing learning in an educational system based on what is vital for students to be able to perform successfully and effectively at the end of their learning engagements."* This CMO is now currently in effect among engineering schools as a means to establish an OBE system to prepare the concerned HEIs in meeting the accreditation criteria of the different accrediting bodies. The CMO require about 26 units of mathematics subjects in all engineering programs. MPSPC has been offering engineering courses ever since its start of operation in 1992 on an "open admission but selective retention basis." The programs being offered are Civil Geodetic, and Electrical Engineering.

Little research has been conducted to explore engineering students' learning of mathematics, in particular with respect to what mathematical competencies are needed for engineers, how engineering students' grasp and usage of mathematics can be attained and described [2], and how inquiry- based learning assist students to come to know and apply mathematical concepts [3].

Licensure examinations for engineering graduates are the ultimate yardstick of the engineering prowess of a graduate.

As seen from the 2012 Geodetic Engineering board exam [4] and is corroborated by the findings of Ferrer [5] on Civil Engineering and Electrical Engineering board exams, about 20-25% of the exam comprises of mathematics which includes Algebra, Plane and Spherical Trigonometry, Solid Geometry, Analytic Geometry, Differential and Integral Calculus. Feedbacks from the engineering licensure examinees of MPSPC revealed that the examinees performed poorly in the Mathematics area of the board examination.

Learning Outcomes are evidences of the knowledge, skills, and abilities a student possesses and can demonstrate upon completing a learning experience [6]. The learning outcomes in this study were grouped into 3, knowledge, analysis and application. Knowledge includes understanding and comprehension of Mathematics topics. Analysis encompasses the students' ability to solve problems related to a topic. Application includes problems that are found in real world situations.

Motivation

The purpose of this study is to appraise the mathematics achievement of the graduating students in Civil Engineering, Electrical Engineering and Geodetic Engineering such that the faculty members would know the level of competency of the graduating students and be able identify what to improve in their teaching approaches and what to focus on. Devitt and Goold [7] found out in their research that *"According to engineers, teachers are the principal influence on students' attitude with mathematics and the capability to communicate mathematics effectively and its importance is the principal attribute of a good mathematics instructor.*"

The level of competence of the graduating Engineering students in the different subject areas of Mathematics were assessed through an achievement test of 60 items. The level of competence of the students were assessed too along the three groups of learning outcomes. It is expected that after assessing their competency level, their learning capacity in Mathematics will be enhanced for a better chance of passing the board exam, likewise, there will also be reinforced and enriched Mathematics activities to be conducted by the instructors.

Objective

This study aimed to answer the following questions:

1. What is the level of competency of the engineering graduating students along the different subject areas?

   a. Trigonometry

   b. Algebra

   c. Analytic Geometry

   d. Solid Geometry

   e. Calculus

   f. Probability & Statistics

2. What is the overall competence level of the engineering graduating students?

3. Is there a significant difference on the level of competence of the students along the different subject areas?

4. What is the level of competence of the students along the three groups of learning outcomes in mathematics namely Knowledge/Comprehension, Analysis, and Application?

Hypothesis

There is no significant difference on the level of competence of the students along the different subject areas.

2. Statement Of Contribution/Method

Research Design

The narrative descriptive survey was used in conducting the study. The survey employed quantitative approach to obtain information about the mathematical competencies of the engineering graduating students in line with their competencies in each of the subject areas generally undertaken.

Subject Characteristics

The population of the study consisted of 23 engineering graduating students of Mountain Province State Polytechnic College. The students came from the three programs of the Engineering Department namely, Civil Engineering, Geodetic Engineering, and Electrical Engineering.

Data Collection Method

To determine the students' competency, a 60 – item multiple choice achievement test was used. The number of items in each subject area vary because the questionnaire was based on the percentages of questions per subject area from past engineering licensure examinations. 11 questions were asked in the field of Trigonometry, 14 in Algebra, 7 in Analytic Geometry, 7 in Solid Geometry, 16 in Calculus (Differential and Integral), and 5 in Probability and Statistics. The questionnaire was presented to the other members of the Engineering Department faculty for its reliability and all of them concurred with the researcher, it being an effective testing tool. As shown in Table 1, the questions were divided into 3 groups based on the three groups of learning outcomes, namely, knowledge, comprehension/analysis, and application. This is also emphasized in this study to determine which category the graduating students find difficulty in the three learning outcomes. The column on placement shows the location of the questions in each subject area in the questionnaire. Table 1 presents the distribution of test items.

Table 1. Distribution of Test Items in Mathematics

Subject Matter	Objectives			No. of Items	Placement	%
	Knowledge	Analysis	Application			
Trigono-metry	3	4	4	11	1,3,12,22,27,39,42,44,48,49,54	18.33%
Algebra	5	6	3	14	2,4-7,21,26,32,33,40,45-47,50	23.33%
Analytic Geome-try	2	2	3	7	8,11,24,25,36,37,41	11.66%
Solid Geome-try	3	2	2	7	15,18,19,28,43,51,52	11.66%
Calculus	5	4	7	16	13,14,16,17,20,29-31,38,52,55-60	26.66%
Probabi-lity & Statistics	2	1	2	5	9-10,23,34-35	8.33%
# of Items	20	20	20	60		
Percentage	33.33%	33.33%	33.33%			100%

Data Gathering Procedure

The achievement test was personally conducted by the researcher. The test was administered to the 23 students without letting them review. The answered questionnaires were later checked and tabulated. A scale was used to determine the students' level of competence, categorized as outstanding, very satisfactory, satisfactory, unsatisfactory, and poor.

Problem 1 which sought to determine the level of competence of the engineering graduating students along the different subject areas was analyzed using the weighted mean. For a graduating student to be competent, he should obtain a minimum of 50% correct response. The distribution of weights 1 – 5 was assigned to each category with the poor description getting the lowest weight of 1 and the outstanding description getting the highest weight of 5.

The interpretation of scores in all the subject areas is presented in table 2.

Table 2. Interpretation of Scores in all Subject Areas

Range of Scores	Percentage	Qualitative Description	Weight of Scores
10 – 11	91%	Outstanding	5
8 – 9	73%	Very Satisfactory	4
6 – 7	55%	Satisfactory	3
4 – 5	36%	Unsatisfactory	2
0 – 3	30%	Poor	1

Problem 2 which deals with the overall competency of the students in mathematics was analyzed using the weighted mean. The analysis of the overall competency of the students in Mathematics is based on the data in table 3.

Table 3. Overall Competency Level in Mathematics

Range of Scores	Percentage	Qualitative Description	Weight of Scores
51 - 60	85%	Outstanding	5
41 - 50	68%	Very Satisfactory	4
31 - 40	52%	Satisfactory	3
21 - 30	35%	Unsatisfactory	2
0 - 20	33%	Poor	1

Problem 3 determines whether there are significant differences on the level of competency along the different subject areas. The chi-square test was used at 0.05 level of confidence using the frequencies of responses.

The weighted mean of the scores in each subject area was computed and the average of the weighted means was also classified as outstanding, very satisfactory, satisfactory, unsatisfactory, and poor. Table 4 shows the qualitative description of the average weighted means of each subject area.

Table 4. Qualitative Description for the weighted mean

Weighted Mean	Qualitative Description
4.20 – 5.00	Outstanding Competence
3.40 – 4.19	Very Satisfactory Competence
2.60 – 3.39	Satisfactory Competence
1.80 – 2.59	Unsatisfactory Competence
1.00 – 1.79	Poor Competence

Problem 4 is focused on which of the three groups of learning outcomes in Mathematics (knowledge/comprehension, analysis, and application) the graduating students find difficulty. The problem was analyzed using the weighted mean. Table 5 presents the basis in analyzing the level of competence.

Table 5. Competency Level on Knowledge, Analysis, and Application

Range of Scores	Percentage	Qualitative Description	Weight of Scores
18 - 20	90%	Outstanding Competence	5
15-17	75%	Very Satisfactory Competence	4
12 – 14	60%	Satisfactory Competence	3
9 – 11	45%	Unsatisfactory Competence	2
0 – 8	40%	Poor Competence	1

3. Results, Discussions, and Conclusion

The focus of this study was on the level of competence of graduating Engineering students along the 6 subject areas namely, Trigonometry, Algebra, Analytic Geometry, Solid Geometry, Calculus, and is Probability/Statistics. It also determined the level of competence of such students along the three groups of learning outcomes in mathematics namely, Knowledge and Comprehension, Analysis, and Application. Knowledge is defined in this study as recalling of facts, terms, basic concepts and answers while Comprehension is understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating the main ideas. Analysis in this study means the ability to analyze problems similar to the examples given by the instructor while application refers to the ability to apply acquired knowledge, facts, techniques and rules in practical problems.

Competency along the 6 Subject Areas

The result of the test and the analysis and interpretation of the data is discussed.

Trigonometry

This subject is simultaneously offered with Algebra during the first semester of the first year in the Engineering Curricula of MPSPC. Table 6 displays the result of the correct responses of the students who took the examination in Trigonometry.

As seen from the table, the students encountered difficulty in Trigonometry. Only 4 students out of 23 were qualified as competent. With a weighted mean of 2.09 in Trigonometry, the competency level of the students in this subject was unsatisfactory. This level of competency could be attributed to the fact that Trigonometry is not offered in public high schools where most of the students of MPSPC come from.

Table 6. Distribution of Scores in Trigonometry

Score Range	Fre-quency	Weight	Percen-tage	Qualitative Description
10 - 11	0	5	0%	Outstanding
8 - 9	1	4	4.35%	Very Satisfactory
6 - 7	3	3	13.04%	Satisfactory
4 - 5	16	2	69.57%	Unsatisfactory
1 - 3	3	1	13.04%	Poor
Total	23		100%	
Weighted Mean		**2.09**		**Unsatisfac-tory**

Algebra

This subject is a stepping stone to higher Mathematics subjects. Table 7 reveals a satisfactory performance of 43.49%. The satisfactory and very satisfactory performance of the examinees can be attributed to the fact that the subject is also being taught in high school. This supports the *Law of Exercise* which states that in learning, the more frequently a stimulus and response are associated with each other, the more likely the particular response will follow the stimulus [6]. This, however, was not enough to lift the weighted mean of the performance of all the students to a satisfactory level.

Table 7. Distribution of Scores in Algebra

Score Range	F	Weight	%	Qualitative Description
13 - 14	0	5	0%	Outstanding
11 - 12	1	4	4.35%	Very Satisfactory
8 - 10	10	3	43.49%	Satisfactory
6 - 7	7	2	30.43%	Unsatisfactory
1 - 5	5	1	21.74%	Poor
Total	23		100%	
Weighted Mean		**2.30**		**Unsatisfactory**

Analytic Geometry

Analytic geometry is being offered in the Engineering Department of MPSPC during the second semester of the first year, after passing Algebra and Trigonometry. Table 8 displays the Mathematics competence of the examinees in Analytic Geometry. It is evident from this data that the students find it difficult to understand the Analytic Geometry subject as manifested by their poor competence level.

Table 8. Distribution of Scores in Analytic Geometry

Score Range	F	Weight	Percentage	Qualitative Description
6	1	4	4.35%	Very Satisfactory
4 – 5	2	3	11.5%	Satisfactory
3	5	2	21.74%	Unsatisfactory
1 - 2	15	1	65.22%	Poor
Total	23		100%	
Weighted Mean		**1.52**		**Poor**

Solid Geometry

This subject is offered during the second semester of the first year of the Engineering program. Table 9 provides us with the performance of the students in Solid Geometry. Majority of the students performed poorly in Solid Geometry with 74% of them being categorized as poor. The weighted mean of 1.35 in Solid Geometry manifests a difficulty in understanding and solving the problems on solids.

Table 9. Distribution of Scores in Solid Geometry

Score Range	F	Weight	%	Qualitative Description
4 – 5	2	3	8.70%	Satisfactory
3	4	2	17.39%	Unsatisfactory
1 – 2	17	1	73.91%	Poor
Total	23		100%	
Weighted Mean		**1.35**		**Poor**

Calculus

This subject is evolved from algebra, arithmetic, and geometry, such that Calculus is offered only if the students passed the pre requisite subjects mentioned. Table 10 shows that the students find difficulty in understanding calculus much more in solving the problems in Calculus. Only 4 students were qualified as competent in Calculus because of a satisfactory rating. The weighted mean scores of the students in Calculus is 1.61. The poor performance of students in calculus is an evidence of poor preparation for the subject. This finding was corroborated by Mina "unpublished" [8]. She found out that the inability of students to do well is traced from the fact that Calculus has not been taught in high school.

Table 10. Distribution of Scores in Calculus

Score Range	Frequency	Weight	Percentage	Qualitative Description
8 – 11	4	3	17.39%	Satisfactory
6 – 7	6	2	26.09%	Unsatisfactory
1 –5	13	1	56.52%	Poor
Total	23		100%	
Weighted Mean		**1.61**		**Poor**

Probability and Statistics

A different trend of correct responses in Probability and Statistics is shown in table 11. It is significant to note that 22% of the examinees were categorized as very satisfactory and 4% of them got an outstanding rating. With mean weight of 2.61, the performance of all the examinees in Probability and Statistics was satisfactory which implies that the students' knowledge and understanding of the topics on probability and statistics were retained. This may be true because the subject is being offered during the third year of the course. This supports the principle behind the *Law of Recency* which states that things most recently learned are best remembered [9].

Table 11. Distribution of Scores in Probability and Statistics

Score Range	F	Weight	%	Qualitative Description
5	1	5	4.35%	Outstanding
4	6	4	21.74%	Very Satisfactory
3	4	3	17.39%	Satisfactory
2	7	2	34.78%	Unsatisfactory
1	5	1	21.74%	Poor
Total	23		100%	
Weighted Mean		**2.61**		**Satisfactory**

Comparison of the Competency Levels in the Different Subject Areas

The competency level of the students in the different subject areas vary. The basis of the competency level per subject area is the weighted mean. Figure 1 compares the weighted mean of the competencies of the students in the different subject areas.

Figure 1 shows that the graduating engineering students are competent in Probability and Statistics and a few points behind in Algebra and Trigonometry. They performed poorly in Calculus which is expected because generally, students get difficulty in understanding Calculus. What is unexpected is the low turnout of scores in Analytic Geometry and Solid Geometry which are requisite subjects of Calculus. These poor performances in Analytic Geometry and Solid Geometry could be attributed to the fact that these subjects are not fully offered in High School.

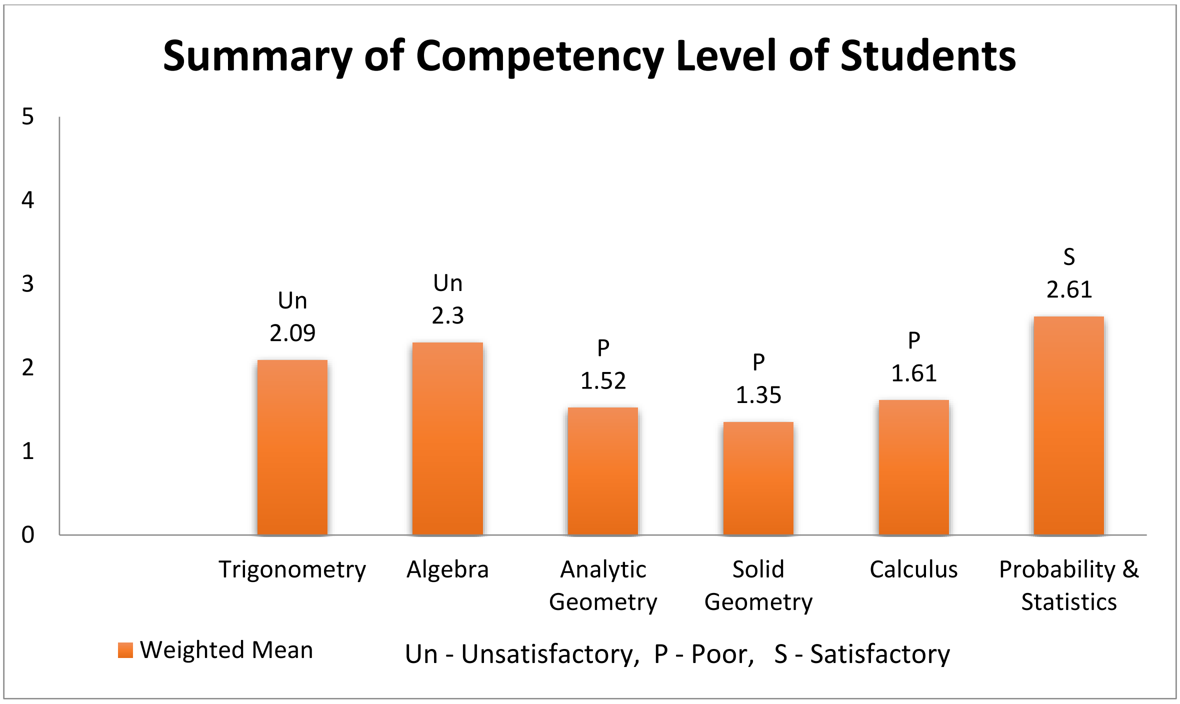

Figure 1. Summary of the Competency Level of the Examinees

Overall Competency in Mathematics

The overall performance of the graduating engineering students was measured to come up with a general impression of graduating engineering students of MPSPC as regards their Mathematical proficiency.

The overall competency level of graduating engineering students was unsatisfactory as shown in table 12. Only 17.39% of the examinees were considered competent in Mathematics. This corroborates the claim of the Engineering graduates who took the board exams that they lack the necessary proficiency in Mathematics to pass the board exam mainly because their foundation in mathematics is poor.

Table 12. Overall Competency in Mathematics

Range of Scores	Frequency	Percentage	Qualitative Description
51 - 60	0	0	Outstanding
41 - 50	0	0	Very Satisfactory
31 - 40	4	17.39%	Satisfactory
21 - 30	15	65.22%	Unsatisfactory
1 - 20	4	17.39%	Poor

Significance of Differences in the Levels of Competency along the Subject Areas

The chi-square test was used to determine if there are significant differences in the level of competency along the different subject areas.

The computed value of the chi-square (79.24) is greater than the tabulated value (31.41), therefore, the null hypothesis was rejected. There are significant differences in the level of competency of the graduating Engineering students of MPSPC in the different subject areas.

Competency Level of Students along Knowledge/Comprehension, Analysis, and Application

Some faculty members of the Engineering Department of MPSPC have been observing that sometimes students tend to forget the definition of terms used in mathematics but are still able to solve problems relative to such terms. Some faculty members also observe that though students are able to understand the examples given by the instructors because they are able to answer the exercises correctly, they are not able to do so with the application of theories to real world problems. This part of the research tries to corroborate or disprove the observations. Tables 13, 14, and 15, shows the competency level of the students along knowledge, Analysis, and Application. A 20-item test was assigned on learning outcome.

Table 13 presents a fact that if students are given surprise exams, they are not able to depend on their stocked knowledge about mathematics concepts. With a mean weight of 1.65, the competency level of the examinees on knowledge/comprehension was poor which is indicative of poor memory on mathematical terms.

Table 14 exhibits the result of the performance of students on problem solving activities and it is evident that they performed better than under the knowledge category. The result supports the observation of the Engineering faculty members that the students are better in the analysis of problems than in identification or definition of terms. With a weighted mean of 2.30, the competency level of the students was still unsatisfactory but at least 7 out of 23 got satisfactory ratings and 4 were categorized as very satisfactory.

The result in table 15 of the competency level of the examinees on application is poor. This study implies that though, the students take it hard to remember the definition of mathematical terms, they are able to solve Mathematics problems. The students, though have difficulty in connecting these problems to real world situations. This result emphasizes the difficulty of the students to define the problem clearly before they start working on the solution. Clement and Rosnick[10] found that even though students could learn to generate equations correctly, they often lacked conceptual understanding of their equations.

Table 13. Competency Level along Knowledge/ Comprehension

Score Range	**Fre-quency**	**Weight**	**Percentage**	**Qualitative Description**
18- 20	0	5	0	Outstanding
15- 17	0	4	0	Very Satisfactory
12- 14	2	3	8.70%	Satisfactory
9 - 11	11	2	47.83%	Unsatisfac-tory
0 - 8	10	1	43.48%	Poor
Total	23		100%	
Weighted Mean		**1.65**		**Poor**

Table 14. Competency Level along Analysis

Score Range	**Frequency N = 23**	**Weight of Score**	**%**	**Qualitative Description**
18 - 20	0	5		Outstanding
15- 17	3	4		Very Satisfactory
12 - 14	7	3		Satisfactory
9 - 11	7	2		Unsatisfactory
0 - 8	6	1		Poor
Total	23		100%	
Weighted Mean		**2.30**		**Unsatisfactory**

Table 15. Competency Level on Application

Score Range	**Frequency N = 23**	**Weight of Score**	**%**	**Qualitative Description**
18 - 20	0	5	0	Outstanding
15- 17	0	4	0	Very Satisfactory
12 - 14	0	3	0	Satisfactory

9 - 11	2	2	8.70%	Unsatisfactory
0 - 8	21	1	91.30%	Poor
Total	23		100%	
Weighted Mean		**1.09**		**Poor**

4. Conclusion

The subject areas that were taught in high school and were reinforced in college show retention on the students as shown in the result of their exam in Algebra, Trigonometry, and Statistics. They performed satisfactorily in Probability and Statistics because it is also offered in high school and is offered on the third year of the engineering course which proves that the more recent a topic is, the more it is retained in the minds of students.

The unsatisfactory performance of graduating engineering students in mathematics implies that their foundation in mathematics is not good enough to warrant a passing score in the Mathematics area of the licensure exam and be able to solve work related problems

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