TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 10148 - 10158

Entry Competencies and Performance in Mathematics of First Year Engineering Students in State Universities in Region 3

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Article Info
Volume 83
Page Number: 10148 - 10158
Publication Issue:
May - June 2020

Article History
***Article Received**: 19 November 2019*
***Revised**: 27 January 2020*
***Accepted**: 24 February 2020*
***Publication**: 18 May 2020*

Abstract:
This study was conducted to explore the entry competencies and performance in Mathematics of first-year engineering students in state technological universities in Region 3 in the Philippines. It utilized descriptive-correlational research design using researcher-made-tests as instruments of the study. The respondents scored average in the test in General Mathematics and below average in Probability and Statistics, Pre-Calculus and Basic Calculus. Overall, the entry competency in Mathematics of first-year engineering students is low. As to the respondents' performance in Engineering Mathematics, they are at an average level. Additionally, those students with high entry competencies in mathematics performed better in their engineering math. Based on the findings and conclusions the following are recommended and offered by the researcher: senior high school mathematics teachers may teach Probability and Statistics, Pre-Calculus and Basic Calculus the way it may be easily learned and understood by their students. They may consider applying effective strategies for each subject that will make the students engaged in the teaching and learning process. Likewise, Engineering Mathematics Test (EMT) developed by the researchers may be adopted by the deans of the College of Engineering to be their instrument in choosing students who want to enroll in the said course.
***Keywords**: Calculus, Civil Engineering, Electrical Engineering, Mathematics, Mechanical. Engineering, Probability and Statistics*

INTRODUCTION

The performance of the country's public high school students in the National Achievement Test (NAT) had been on the decline and was significantly lower than the passing mean percentage score (MPS) of 75%. The Department of Education (DepEd) data showed that the average NAT performance of public high school students from School Year 2007-2008 to School Year 2011-2012 was significantly lower at 50% [1], implying that Filipino students were very poor and had very low competencies, especially in science and mathematics. The said figures showed that something might be wrong in the Philippine educational system that required a change in curricula and restructuring of the basic education curriculum. President Benigno Aquino III responded to the change when in a historic moment for advocates of educational standards, he signed into law Republic Act (RA) 10533, most popularly known as the K to 12 program on May 15, 2013. With the said curricular reform, the current educational system aims to provide mastery of skills for lifelong learners and prepare them for career opportunities. Furthermore, in implementing 13 years of basic education, the Philippines will measure up to the global standards for students and

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professionals [2]. Concepts are best learned and skills are best mastered within a 13-year program than in a ten-year program. According to [3], “the K to 12 education plan will be beneficial for the Philippines since students will have sufficient instructional time for subject-related tasks, making them more prepared in every subject area”. With the old system, Filipino students’ performances in international tests, especially in mathematics, were consistently behind on achievement scores compared to other countries. Furthe rmore, it is believed that the K to 12 program will improve the competency of the Filipino students in mathematics because the design of the curriculum under the program is spiral where concepts and skills are taught in increasing complexity and sophistication for better mastery [2]. The spiral progression approach is applicable to all subjects including mathematics. From the five contents areas in Mathematics of Grades 7-10 such as Numbers and Number Sense, Measurement, Geometry, Patterns and Algebra and Probability and Statistics, the Grade 10 completers will be promoted to senior high school (Grades 11 and 12) and will be taught of General Mathematics, Advanced Probability and Statistics, Pre-Calculus and Basic Calculus to improve the competency in mathematics of the students. Competency in mathematics as claimed by [4] is characterized both in terms of content and process and this means the ability of the students to understand, judge, do and use mathematics in a variety of intra-extra-mathematical contexts and situations.In the study of the authors in [5], "they found out that competence in mathematics of first-year engineering students on an extended program at the University of Pretoria needed to be improved and can be enhanced through academic support which can be provided by teachers training the students to engage in higher-order thinking skills (HOTS).Cognizant of the need to ensure a better mathematics performance by the students under the K to 12 program, and eager to find out somehow how do said students perform after receiving instruction under the program, the researchers aimed to determine, with the use of a test instrument they developed , the entry competencies in mathematics of the first batch of senior high school graduates who were enrolled in the engineering courses of state universities in Region III. The findings of the study will show how prepared and how competent are the graduates of the K to 12 program in tertiary mathematics. Additionally, the tests created for this study may be utilized by other state universities and colleges as an alternative tool either for entrance examination or for a qualifying test to select first-year engineering students. Moreover, the developed instruments can also be utilized by the Department of Education as an achievement test to determine the readiness of their STEM graduates for college engineering mathematics. Hence, this study finds meaning and substance.

Statement of the Problem

This study aimed at assessing the entry competencies in the mathematics of first-year engineering students enrolled in State Universities in Region III. Specifically, it aimed to

1.Assess the students’ level of entry competencies in following senior high school mathematics:

- 1.1. General Mathematics
- 1.2. Probability and Statistics
- 1.3. Pre-Calculus
- 1.4. Basic Calculus

2. Describe the performance of first-year students in Engineering Mathematics.

3. Relate the entry competencies in senior high school mathematics of the first-year engineering students with their performance in Engineering Mathematics.

Hypotheses

The following null hypotheses were tested in this study:

1. Entry competencies in senior high school mathematics of the first-year engineering students do not relate to their performance in Engineering Mathematics.

Research Design

This study employed a descriptive-correlational research design. Descriptive research is a fact-finding study with adequate and accurate interpretation of data. It describes with emphasis what actually exist such as the current condition of the phenomenon [6]. Descriptive research in this study was utilized to describe the entry competencies in senior high school mathematics of the first-year engineering students among three state universities in Region 3 using the Mathematics Entrance Test (MET) as one of the instruments used in this study. Also, the performance in Engineering Mathematics of first-year engineering students was also described with the use of Engineering Mathematics Test (EMT). While according to [7], as cited by the authors in [8] & [9], "Correlational research is employed to test the degree of relationship between two variables". In this study, the relationship between entry competencies and performance in engineering mathematics was tested.

Samples and Sampling Procedure

The samples of the study were selected engineering freshmen enrolled in Electrical Engineering, Mechanical Engineering and Civil Engineering courses of the three state technological Universities. The common engineering courses offered in these institutions were the criterion in selecting them. Purposive sampling technique was employed in selecting the 364 samples of the study.

Respondents of the Study

Table 1 shows the distribution of respondents by the program from the three State Universities.

Table 1.Distribution of the Respondents by Program and by University

University	Civil Engineering	Electrical Engineering	Mechanical Engineering	Total
UNIV A	41	36	40	117
UNIV B	38	41	37	116
UNIV C	43	41	47	131
Total	122	118	124	364

Research Instruments

Two data gathering instruments were utilized in this study The Mathematics Entrance Test (MET) was designed to assess the entry competencies of the respondents. The MET was a multiple choice-test composed of topics taken in Senior High School mathematics subjects namely: General Mathematics, Probability and Statistics, Pre-Calculus and Basic Calculus. The competencies in senior high school mathematics prescribed by the Department of Education (Dep.Ed.) were considered in constructing the test items. The contents of the test were checked by the adviser and in consultation with other mathematics teachers. The internal consistency method of establishing test reliability was employed using Cronbach's alpha formula. The computed reliability coefficients of the tests were 0.891 for General Mathematics, 0.836 for Probability and Statistics, 0.843 for Pre-Calculus and 0.821 for Basic Calculus. The second instrument used in the study is the Engineering Mathematics Test (EMT). The Engineering Mathematics subject common among the three respondent schools during the first semester of the school year 2018-2019 is Differential Calculus. Based on the syllabus in Engineering Math taken from each University, the common topics included in EMT are relations and functions, graphs, limits and continuity, derivatives and application of derivatives. EMT was also tried out, item analyzed and subjected to the evaluation of experts in Mathematics. The test was found reliable with a reliability coefficient of 0.875.

Data Analysis Technique

The following statistical tools were utilized in this study:

1. To describe the level of entry competencies in Mathematics of first-year engineering students in General Mathematics, Probability and Statistics, Pre-Calculus and Basic Calculus, frequency of scores, percentage and mean were used. The following scale was used to describe the level of entry competencies of the students in Mathematics.

Range of Scores	Descriptors
13 to 15	Very High
10 to 12	High
7 to 9	Average
4 to 6	Below Average
0 to 3	Poor

2. The following scale was used to describe the performance of the students in Engineering Mathematics.

Range of Scores	Descriptors
40 to 50	Very High
30 to 39	High
20 to 29	Average
10 to 19	Below Average
0 to 9	Poor

3. To show the significant relationship between the entry competencies in senior high school mathematics of the students and their performance in Engineering Mathematics, Pearson Product Moment of Correlation (Pearson's r) was employed.

RESULTS AND DISCUSSIONS

1. Level of First-Year Engineering Students' Entry Competencies in Senior High School Mathematics

The level of first-year Engineering students' entry competencies in mathematics are discussed separately and in the order, they were presented in the objectives of the study.

1.1. General Mathematics

It could be gleaned from Table 2 thateight (8) students (2.20%) obtained scores that range from 13 to 15, manifesting that their entry competency in the subject is very high. Nine students (2.47%) got low scores of 0 to 3, while 133 of them (36.54%) acquired scores from 4 to 6, indicating a below-average competency level.The majority of them, 172 (47.25%) had average test results; while 42 (11.54%) had high competency as they obtained MET scores within the range of 10 to 12.As a whole, however, the students were found to have average competency in General Mathematics having obtained an overall mean score of 7.2. It is evidently shown in the table that the majority of scores obtained by the respondents tend to fall from the average level down to the poor level.

Table 2. Level of Entry Competencies in General Mathematics

Range of Scores	Frequency	Percentage	Descriptors
13 to 15	8	2.20	Very High

10 to 12	42	11.54	High
7 to 9	172	47.25	Average
4 to 6	133	36.54	Below Average
0 to 3	9	2.47	Poor
Total	**364**	100.00	
Mean Score		**7.23**	**Average**

Among the four subjects under the Mathematics Entrance Test (MET), General Mathematics was the only subject where the respondents obtained passing scores. This finding affirmed the finding of [10], that the mathematics competency of students in Numbers, Number Sense and General Mathematics is better compared to their competency in Algebra and Geometry. When one respondent was asked about which among the tests was easy for him, he narrated "among the four subjects, I think general mathematics is easy since most of the topics were discussed repeatedly in my junior high school and therefore I have a strong background on it". Another respondent said, "general mathematics is easier since it is more basic than calculus and that is the only math subject I find easy especially in my senior high school".The finding of the study in terms of the respondents' competency in General Mathematics does not only imply that majority of the students hardly met the prescribed requirement for passing the test; but also mean that they would tend to find difficulty in their higher mathematics subjects, because these higher mathematics subjects are founded on the general mathematics subjects the student respondents were supposed to have mastered in their senior high school years. It further implies that teachers teaching mathematics for first-year engineering students will have to make an adjustment so as to cater to the learning gaps among their students.

1.2. Probability and Statistics

Table 3 shows that no student exhibited very high competency in Probability and Statistics as none of them obtained scores from 13 to 15.

Table 3. Level of Entry Competencies in Probability and Statistics

Range of Scores	Frequency	Percentage	Descriptors
13 to 15	0	0.00	Very High
10 to 12	15	4.12	High
7 to 9	122	33.52	Average
4 to 6	195	53.57	Below Average
0 to 3	32	8.79	Poor
Total	**364**	**100**	
Mean Score		**5.98**	**Below Average**

Although no student obtained a very high score, it could be gleaned from the table that there were at least 15 (4.12%) of them who displayed high competency for having obtained scores from 10 to 12. Among the 364 respondents, 122 (33.52%) obtained scores that range from 7 to 9, described as having average competency; while more than half of them are in the below average and poor competency level, implying that they hardly met the minimum passing requirement for the test in Probability and

Statistics. When viewed as a whole, the mean score of the students was below average, which was a clear indication that the students' competency in probability and statistics was low and poor. The finding was similar to the finding of the study of [11] where respondents were found to have low competence in mathematics topics that include permutation, combination and probability.

According to some student respondents: "*Although the formulas we have memorized in probability and statistics are not that difficult to remember compared to other math subjects, we are having a hard time when are we going to apply the formulas especially in combination and permutation. We do not know what the difference between the two is.*" This indicates that confusion about concepts and formula in the subject, especially those that involve permutations and combinations could be the reason behind the students' poor performance in MET probability and statistics content. In general, the finding implies that the students were not able to master Probability and Statistics in senior high school, and this may make it difficult for them to survive Engineering mathematics unless intervention was made to facilitate their academic adjustment in the engineering program.

1.3. Pre-Calculus

In this subject, the mean competency score obtained by the students was 6.45, which like in probability and statistics, was described as below average. Table 8 shows that unlike in probability and statistics content of the MET, there were nine (9) or 2.47% of the respondents who scored from 13 to 15 and attained a very high competency level, which means that they have very high competency in Pre-Calculus. Thirty students had high competency for having obtained scores ranging from 10 to 12. One hundred thirty-seven (37.64%) students were average, 159 (43.68%) were below average and all others have poor competency. Again, it was very evident that the majority of the respondents scored from the average down to the poor level of competency, with the mode being below average.

Table 4. Level of Entry Competencies in Pre-Calculus

Range of Scores	Frequency	Percentage	Descriptors
13 to 15	9	2.47	Very High
10 to 12	30	8.24	High
7 to 9	137	37.64	Average
4 to 6	159	43.68	Below Average
0 to 3	29	7.97	Poor
Total	**364**	100.00	
Mean Score	**6.45**		**Below Average**

According to [12], pre-calculus is difficult for high school students since it is a more tedious version of Algebra where students deal with difficult fractions and decimals, do more complex factoring and learn new but more complicated topics, like trigonometry, long division of polynomials, remainder theorem, etc. that are too technical for most students to be liked. With the below-average competency level of the respondents in pre-calculus, it could be deduced that the first graduates of the Senior High School under the K to 12 program did not meet the outcomes expected of pre-calculus in the senior high school; and because of this, the students might

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encounter difficulty in dealing with the mathematics subjects required in the engineering program; unless some intervention was done early on to alter the situation and facilitate the students' academic adjustment while pursuing Engineering as a course.

1.4. Basic Calculus

Only one student obtained a score in the range of 13 to 15, which was a manifestation of exemplary competency indicating that his entry competency in Basic Calculus is very high. However, 39 or 10.71 % of the students got low scores ranging from 0 to 3. It is also worth noting that 157 (43.13%) acquired scores from 4 to 6 described as below average; while 162 (44.51%) obtained scores in the range of 7 to 9, described as average. Five (5) or 1.37 % had high competency in the Mathematics Entrance Test (MET) as they obtained scores within the range of 10 to 12. These scores are indicative of their very good competency implying that they are highly competent.

Table 5. Level of Entry Competencies in Basic Calculus

Range of Scores	Frequency	Percentage	Descriptors
13 to 15	1	0.27	Very High
10 to 12	5	1.37	High
7 to 9	162	44.51	Average
4 to 6	157	43.13	Below Average
0 to 3	39	10.71	Poor
Total	**364**	100.00	
Mean Score		**6.12**	**Below Average**

The mean score obtained by the respondents in basic calculus was 6.12. This was low, indicating poor competency level in basic calculus. Furthermore, a majority of the students' competency in the subject was within the average down to poor level, it could be deduced that only a few of them could survive the academic challenges of Engineering as a course. Some reasons given by the respondents for not performing well in basic calculus were as follows:1)“Calculus is a very difficult subject for me and most if not all of the problems in the test were not taught to us by our teachers in senior high school”; 2)"It is difficult because we did not tackle calculus in our senior high school. But now we are looking forward to learn more on this subject because we need it in our program and this subject will help us a lot to be engineers"; 3) "Our teachers in calculus in our senior high school were very strict and they did not like to entertain questions that were why we were not motivated to study the subject. Anyway, they would not give us failing grades even when we got zero from the test because we heard from them

that if they would fail us, they would be asked to give remediation for us to be able to pass in the subject. And that would be another effort for them, hehe”.The abovementioned causes of low achievement in mathematics cited by the respondents during the interview were similar to the result of the investigation conducted by [13] who researched on the underlying causes of students’ low achievement in mathematics by covering the perception of teachers, parents and students. They found out that “the students perceived teachers' strictness while teaching mathematics was the culprit. On one hand, the teachers perceived that it was due to a lack of mathematics exercises. Parents, on the other hand, blamed students' lack of attention as the major cause of low achievement in the subject”.The summary of the entry competency level of the respondents in all the senior high school

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mathematics can be viewed in Table 6, which shows that the entry competencies of the first-year engineering students in general mathematics range from average to below average in probability and statistics, pre-calculus and basic calculus. Overall, the achievement in MET of the respondents is below average. The result implies that they lack the basic concepts and skills in mathematics taken in senior high school and may also mean that they will tend to find difficulty dealing with higher mathematics in college.

Table 6. Summary Table on the Level of Entry Competencies of the Students in Senior High Mathematics

Subject	Mean	Descriptors
General Mathematics	7.23	Average
Probability and Statistics	5.98	Below Average
Pre-Calculus	6.45	Below Average
Basic Calculus	6.12	Below Average
Overall Mean	6.44	**Below Average**

This finding does not agree with the claim of the proponents of the K to12 program that presupposed the competency of the Filipino students in mathematics will improve because of the spiral design of the curriculum where concepts and skills are taught in increasing complexity and sophistication for better mastery. It seems that graduates of senior high school did not attain the mastery needed to prepare them for tertiary mathematics.The outcome of this study affirmed the finding of the research done by the researchers in [14] concerning the mathematics competency of Grade 8 students in the K to 12 curriculum. They found out that most of the student respondents were in the beginning level of achievement only. Moreover, half of the tested contents were least mastered. Incorrectly applying the formulas, properties, theorems, and/or laws and incompletely solving the problem despite correctly doing the initial procedure are their common difficulties.

2. Description of First-Year Engineering Students' Performance in Engineering Mathematics

Table 7 illustrates the scores obtained by the first-year engineering students in their engineering mathematics. It can be seen from the table that 20 students performed poorly, obtaining scores from 0 to 9 (poor); 37 performed below average with their scores that ranged from 10 to 19; while 190 performed averagely with their scores that ranged from20 to 29. On the other hand, there were also 110 whose performance was high as they obtained scores that ranged from 30 to 39.

Table 7. Performance in Engineering Mathematics of the Respondents

Range of Scores	Frequency	Percentage	Descriptors
40 to 50	7	1.92	Very High
30 to 39	110	30.22	High
20 to 29	190	52.20	Average
10 to 19	37	10.16	Below Average
0 to 9	20	5.49	Poor

Total	**364**	100.00	
Mean Score		**26.29**	**Average**

The overall performance in the Engineering Mathematics Test (EMT) of the students was 26.29, interpreted as average. This means that the first-year engineering students met the minimum standard of expectation to pass in the subject, implying that there was so much room for them to improve or else they would tend to experience difficulty in hurdling higher-level engineering mathematics. Students should work hard to improve their higher-order thinking skills in order to succeed in higher-level Engineering mathematics because this would require mastery and competence, such as that being aimed at by the K to 12 Senior High School.It is particularly important that students take mathematics courses seriously in their senior year of high school. Experience has shown that students who take a break from studying mathematics in high school are very often unprepared for courses of a quantitative nature in college and are unable to continue in these courses without remediation in mathematics [15].In the study conducted by [16], "diagnostic testing proved to be useful in assessing learners' mathematical preparedness by identifying their mathematical areas of weakness, which hindered their mathematics learning and performance. Taking the results of a diagnostic test into consideration could help teachers cater to their learners who need remediation classes as early as possible before extending the mathematics curriculum".According to [17], Filipino students found it difficult to accurately calculate the value of simple expressions with or without calculator, to calculate the area of a simple shape, to estimate results, to translate a simple real-life problem into mathematical language and to assess the reality of any results, to differentiate between solving equations and simplifying expressions leading to grossly wrong answers to simple problems, to understand the meaning of a simple graph or determine the value of a function either analytically from the function or visually from its graph. It should be noted that these skills are basic practical skills necessary for any profession-not just for the technical profession. It should also be emphasized that this is not a problem of a few incoming students, but of the majority of students-even among those taking up technical sciences. This usually results in unusually long first study cycles and high dropout rates.

3. Relationship of the First-Year Engineering Students Entry Competencies in Mathematics and their Performance in Engineering Mathematics

Table 8 shows that competencies in general mathematics ($r=.122^*$, $p<0.05$); pre-calculus ($r=.247^{**}$, $p<0.01$) and basic calculus ($r=.367^{**}$, $p<0.01$) of the first-year engineering students were significantly related to their performance in engineering mathematics. This means that the higher the scores of the respondents in the three (3) subjects, the higher are their scores in engineering mathematics and vice versa. This signifies that a student with high entry competency in General Mathematics, Pre and Basic Calculus had high performance in Engineering Mathematics. Similarly, a student who had poor competency in the 3 subjects had poor performance in Engineering Mathematics.

Table 8. Relationship Between Entry Competencies in Mathematics and Engineering Mathematics Scores

Pearson's r Correlational Analysis	**Engineering Mathematics (EMT)**		
MET	**r-value**	**p-value**	**Interpretation**
General Mathematics	.122*	.023	Significant relationship

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Probability and Statistics	.070	.192	No significant relationship
Pre-Calculus	.247**	.000	Significant relationship
Basic Calculus	.367**	.000	Significant relationship

correlation is significant @ 0.05 level; **correlation is significant @ 0.01 level

The finding conveys that topics in General Mathematics, Pre-Calculus and Basic Calculus such as functions, relations, graphs, equations, logarithms, conics, limits and basic derivatives were connected to the first-year engineering students learning of Engineering Mathematics which is composed of advanced topics in differential calculus such as applied differentiation using algebraic, trigonometric and logarithmic functions.Further, the finding indicated that higher mathematics subject of the respondents was dependent on the skills developed among them in their senior high school mathematics. This finding can be explained by the connectionism theory of Thorndike which was written in his book "The Psychology of Arithmetic". He emphasized two principles related to mathematics regarding the transfer of learning and intelligence. According to him, transfer of learning occurs because of previously encountered situations; and that intelligence is a function of the number of connections learned [18].

Conclusions and Recommendations

The entry competencies in senior high school mathematics of first-year engineering students are low. Their performance in Engineering Mathematics is at the average level and their entry competencies in mathematics are connected with their Engineering Mathematics performance.Based on the findings and conclusions the following are recommended and offered by the researcher: Senior high school mathematics teachers may teach Probability and Statistics, Pre-Calculus and Basic Calculus the way it may be easily learned and understood by their students. They may consider applying effective strategies for each subject that will make the students engaged in the teaching and learning process. Mathematics Entrance Test (MET) may be utilized by school principals and supervisors to determine the readiness of their graduates in tertiary mathematics. Likewise, Engineering Mathematics Test (EMT) developed by the researcher may be adopted by the deans of the College of Engineering to be their instrument in choosing students who want to enroll in the said course. Lastly, studies related to the mathematics skills and abilities of senior high school graduates who will take engineering courses with larger samples may be undertaken by future researchers to further strengthen the findings of this study.

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