Critical Analysis of the Recent Poor Performance of Engineering Students in Engineering Mathematics: A Case of Nnamdi Azikiwe University, Awka, Nigeria.

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Abstract

The ever-increasing rate of failure of engineering students in engineering mathematics is one which the school management and entire stakeholders need not wink at any longer. Engineering mathematics is a prerequisite for all engineering discipline. It equips the student with problem-solving skills and cognitive ability needed for higher thinking. The research was conducted to investigate and critically analyze the causes of the recent poor performance of engineering students in the past four academic sessions. Descriptive and Correlation research design were used. The study was designed to capture the entire population of students and some lecturers using questionnaires, interviews, work study, work sampling, and analysis of past results using correlation and regression analysis, chi-square and ANOVA. The findings revealed that students have positive attitude towards engineering mathematics. Nevertheless, poor learning environment and present coordination are major factors contributing to poor performance of students in engineering mathematics. Splitting the lecture schedule into two or more groups, and fair assessment and marking of examination scripts are highly recommended.

Keywords: Engineering Mathematics, Poor Performance, Coordination, Chi-square

INTRODUCTION

Engineering and technology drive the world. The quality and quantity of engineers in any nation directly affect its growth and development. The tertiary institutions are where potential engineers are trained. Performance of students in engineering mathematics is a measure of their cognitive and intuitive abilities, problem identification and solving abilities, abilities of students in carrying out engineering analysis, and abilities to make justifiable decisions.

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

In recent years, performance of engineering students in engineering mathematics has never been impressive. The recent poor performance of students in engineering mathematics in Nnamdi Azikiwe University, Awka Nigeria is not the first of its kind. Poor performance of students in mathematics has been a global issue among stakeholders in engineering mathematics learning. A lot of researches have attributed this poor performance to some factors. Such factors include: lack of lecture hall, capacity and conduciveness of lecture halls, lack of teaching aids like public address system, poor attendance of students to lectures, poor background in mathematics, anxiety, off-campus settlement, lack of cognitive and computational skills, bastardized admission process (Bell, 1993; Canobi, 2005; Cardella, 2008; Vasudha, 2012; Ernest, 2004, Ainley et al., 2005; Townsend & Wilton, 2003). Aremu and Sokan (2003) submitted that the search for the causes of poor academic achievement in Mathematics is unending. Mason and Spence (1999), Canobi (2005) showed that students' conceptions of understanding mathematics are important in their success in mathematics learning. Baloglu and Kocak (2006) stated that the causes of mathematics anxiety fall within three major factors: dispositional, situational, and environmental. The dispositional factors deal with psychological and emotional features such as attitudes towards mathematics, self-concept, and learning styles.

In 2011/2012 academic session in the Faculty of Engineering of Nnamdi Azikiwe University, Awka Nigeria there was a restructure in the coordination of engineering mathematics courses because of the pervasive complaints that post graduate students lack the knowledge of basic engineering mathematic tools and techniques. The originally decentralized coordination was centralized for more control and supervision. More lecturers were involved to lecture various topics of expertise. Hence, the course content was diversified to equip the students with computational and analytical tools. Contrary to expectation, the performance of students soared tremendously, with far much higher failure rates when compared with previous sessions. A careful study of **2011/2012** session results revealed that in the department of Mechanical Engineering **95%** of the students scored below average, and **68%** failed FEG 404; in the department of Industrial/Production Engineering, about **91%** of the students scored below average and **28%** failed FEG 303. Results obtained from other departments do not significantly portray otherwise, as no department produced more than two students who made distinctions.

Even though the effect of teaching method employed in teaching engineering students on their performance in mathematics have long been established, the effect of a change in coordination has not been fully investigated. Hence, it is pertinent that methodologies employed in coordinating engineering mathematics should be properly analyzed so as to achieve continuous improvement and higher productivity. Moreover, analysis of students' performance in engineering mathematics is a novel research whose crucial importance has been relegated to the background in the faculty of engineering, Nnamdi Azikiwe University, Awka. Apt research studies are never conducted to criticize existing academic structure in order to effect positive improvement.

This study employs interviews, work study, questionnaires, and interactive sessions with students, lecturers, and various stakeholders in engineering mathematics learning to establish the root causes of students' poor performance in engineering mathematics. Employing an informal approach will facilitate the revelation of the hidden things associated with students' performances. This is effective, especially with respect to engineering students, and will ensure that all possible factors are identified for detailed analysis. The correlation and regression analysis, control chart, performance chart, chi-square and ANOVA are utilized in the analysis of data collected.

The results obtained in this study will help Nnamdi Azikiwe University, Awka and other Universities in understanding the effect of coordination and other factors on students' performances, hence improving the performances of students in engineering mathematics.

RESEARCH METHODOLOGY

Methods of Data Collection

The research survey covered the entire population of engineering students, some lecturers and the coordinators of FEG courses in the faculty. Four years past results (2008-2012) from selected courses were collected from all the departments in the faculty of engineering. Other information was gathered from engineering students, some lecturers and the Coordinators of FEG courses using: interviews, well constructed questionnaire and work study.

Work studies were carried out to evaluate the efficiency of the learning process adopted in engineering mathematics, identify more factors that could be responsible for the poor performance as well as to investigate and rate the utilization of the learning resources. The following were critically examined; the learning environment, seating arrangement and capacity, lecture period (total credit hours, conduciveness of the lecture time), Students and lecturers attendance to lectures, lecture method, and course content.

The questionnaire was structured to capture the level of agreement of the students to the identified factors affecting performance. The questionnaire covered student information (Dept, sex, age, high school); attitude towards mathematics, mathematics anxiety, seating position lecture methods, availability of lecture materials, nature of examination questions; and school related factors (availability of library resources and adequacy lecture halls).

Methods of Data Analysis

Descriptive Statistics: Descriptive statistics was used for organizing, summarizing and classifying the performance scores of students in engineering mathematics. The mean and standard deviation were used as the measures of central tendency and variability respectively.

Correlation and Regression analysis: The correlation coefficient was used to determine the strength of such relationship; whereas, the regression analysis was used to predict the future outcomes.

Control Chart: The proportion control chart was used to monitor the variation of the failure percentages of students in various engineering mathematics courses for the four sessions. This tool was used to determine if the performance of students were out of the anticipated performance range (control limit). Consequently, predictions could be made on the process capability of the system.

Performance Chart: This gives a bird-eye view of the performance achievements of engineering students in engineering mathematics. The point average method was used to weigh the grades scored by students.

Progress Chart: The Progress chart was used to monitor the average performance of final year students who have completed all courses in engineering mathematics. Identification of the variation of the students' performance can be done, and inferences can be made on possible factors affecting such variations.

One Way Analysis Of Variance (ANOVA): ANOVA was used to test the existence of a significant difference in the grade distribution of the 500 level students across the various engineering mathematics courses.

Chi-Square Analysis: The Chi-square, χ^2 was used in testing the hypothesis concerning the existence of a significant difference between the number of passes and failures in engineering mathematics against expected or theoretical frequencies.

RESULTS AND DISCUSSION OF FINDINGS

Descriptive Statistics

Table 1: Mean and standard deviation of scores of Industrial & Production engineering students.

DESCRIPTIVE STATISTICS								
	2008/2009		**2009/2010**		**2010/2011**		**2011/2012**	
COURSE	MEAN	S.D	MEAN	S.D	MEAN	S.D	MEAN	S.D
FEG 101	**49.5**	19.4894	50.5918	17.3428	38.8472	15.8497	52.5556	17.7992
FEG 102	**48.6732**	10.5789	52.3	12.5988	43.7143	14.5152	47.2064	10.2495
FEG 303	50.8367	9.28538	50.6415	11.6183	**56.0732**	10.7871	37.0465	12.3796
FEG 404	47.3571	14.5059	55.66	9.62624	51.2069	10.9714	**36.8864**	14.1425

Table 1 shows the mean and standard deviation of the performance of Industrial and Production engineering students. The mean score in FEG 404 and FEG 303 2011/2012 session were significantly low. The mean scores in bold format shows the average score rating of students admitted in 2008/2009 session. Following the mean score improvement in FEG 303 (56.0732), there was a performance drop in FEG 404 (36.8864); of which change in coordination was the only significant event that took place between the courses.

Correlation and Regression analysis

The performance of Mechanical, and Industrial/Production engineering students in FEG 102 was correlated with their performance in MEC 372 and FEG 103. At 0.95 confidence level, there was a significant linear relationship between the performance of students in FEG 102 and their performance in FEG 103. There was no conclusive linear relation between the performance of students in FEG 303, and their performance in MEC 372.

Table 2: linear correlation coefficient of the performance of students in FEG 303 and MEC 372

	Correlation Coefficient			
	2008/2009	**2009/2010**	**2010/2011**	**2011/2012**
	FEG 303	FEG 303	FEG 303	FEG 303
MEC 372	0.106	0.291	0.311	0.151
No of Students	45	49	67	67

Table3: linear correlation coefficient of students' performance in FEG 101, FEG 102 and FEG 103

	Correlation Coefficient					
	2009/2010		**2010/2011**		**2011/2012**	
	FEG 101	FEG 102	FEG 101	FEG 102	FEG 101	FEG 102
FEG 103	0.172929	0.585235	0.369446	0.483298	0.462193	0.564533
No of Students	43	43	56	52	40	40

Control Chart

The P-bar chart was used to monitor the performance of engineering students in engineering mathematics. The failure percentages in each session were plotted as samples while the grand mean was plotted as the centre line. From the chart, it was observed that the process is out of statistical control. While the performance of students in FEG 101 and FEG 102 were adversely affected in 2010/2011, the performance in FEG 303 and FEG 404 soared in 2011/2012. It became evident that there is a need to critically investigate the assignable causes that resulted in the performance drop of engineering students.

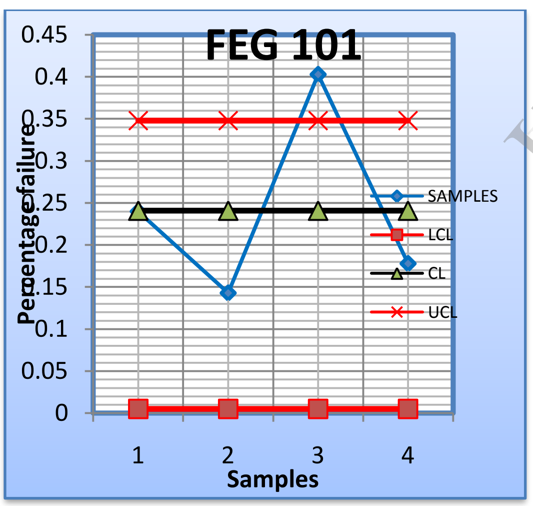

Fig. 1: P-chart showing mean percentage failure in FEG 101

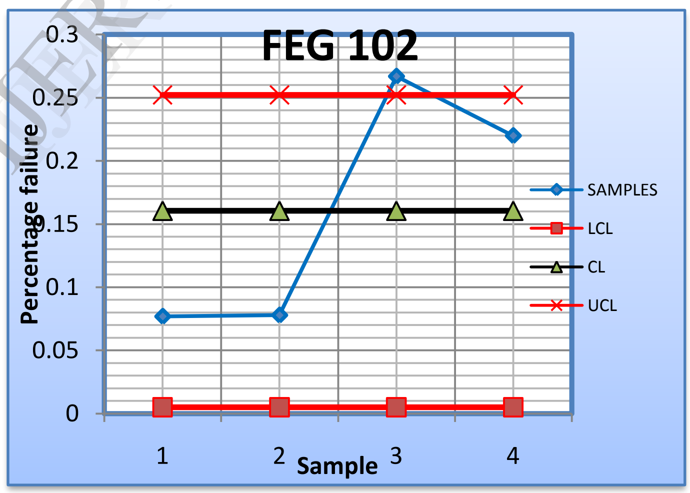

Fig. 2: P-chart showing mean percentage failure in FEG 102

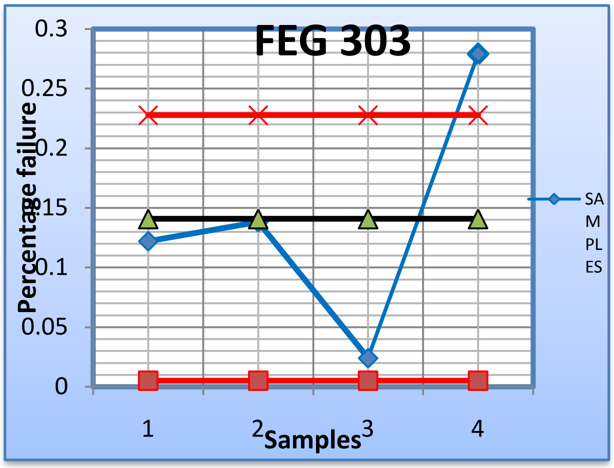

Fig. 3: P-chart showing mean percentage failure in FEG 103

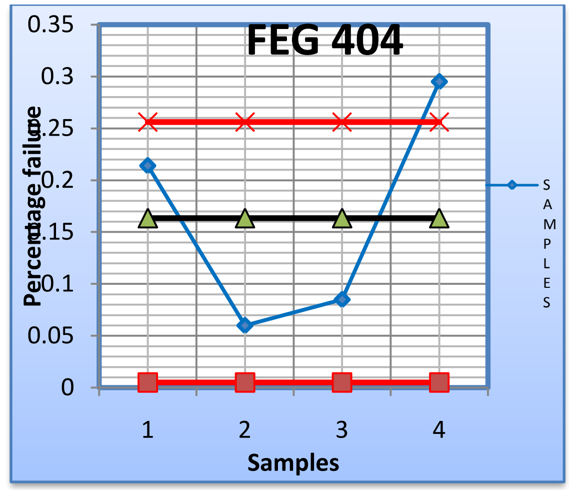

Fig. 4: P-chart showing mean percentage failure in FEG 104

Performance Chart

The Point average of the grades scored by students in various engineering mathematics courses in the past four sessions were plotted using excel spreadsheet. The performances are summarized in Figures 5 and 6.

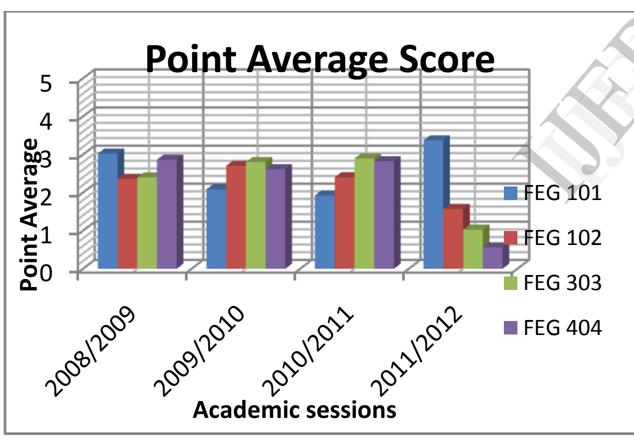

Fig. 5a: Point Average Score of Mechanical Engineering Mathematics

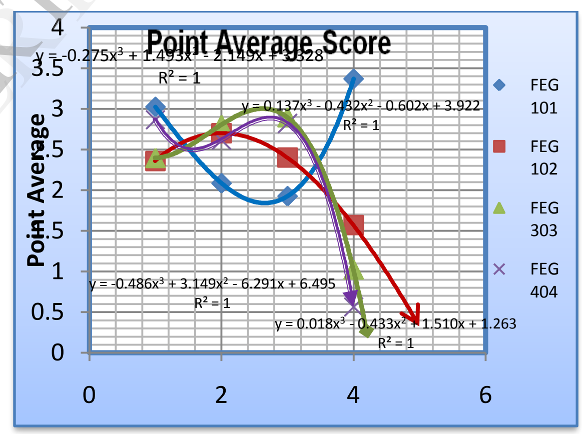

Fig. 5b: Point Average Score of Mechanical Engineering Mathematics

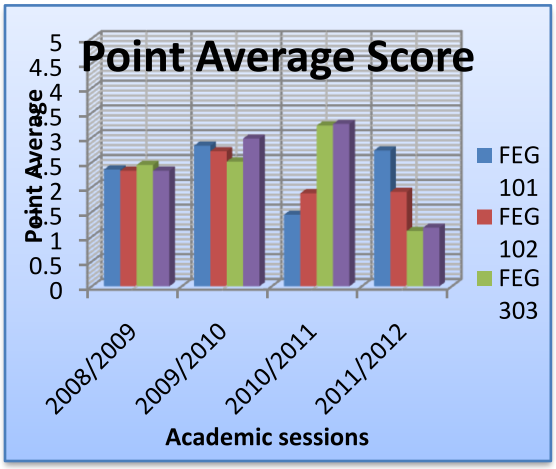

Fig. 6a: Point Ave Score of Industrial & Production Engineering Students in Engineering Mathematics

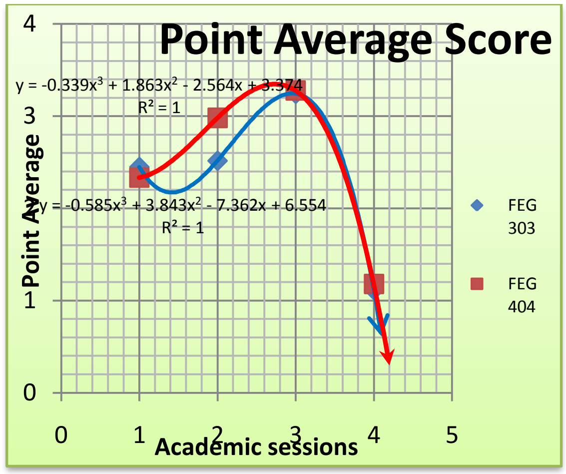

Fig. 6b: Point Average Score of Industrial & Production Engineering Students in Engineering Mathematics

Progress Chart

The Point Average rating of the performance of the final year students was plotted to ascertain the students' progress across the various engineering mathematics courses. Fig. 7 shows that there is a significant drop in the students' performance in 2011/2012. The most significant factor that contributed to the omen was the change in coordination and academic restructuring which took place in 2011/2012 session.

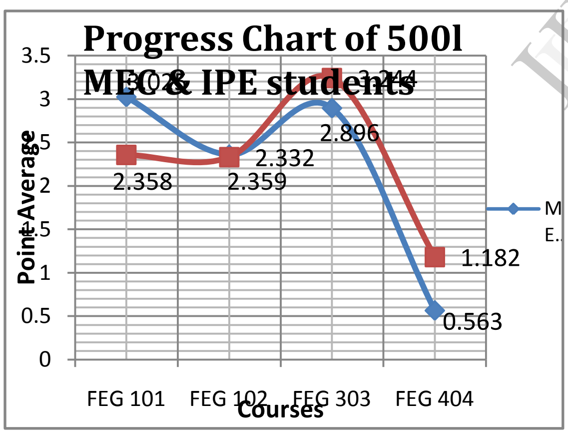

Fig. 7: Progress Chart of 500L Students of Mechanical and Industrial/Prod Engineering

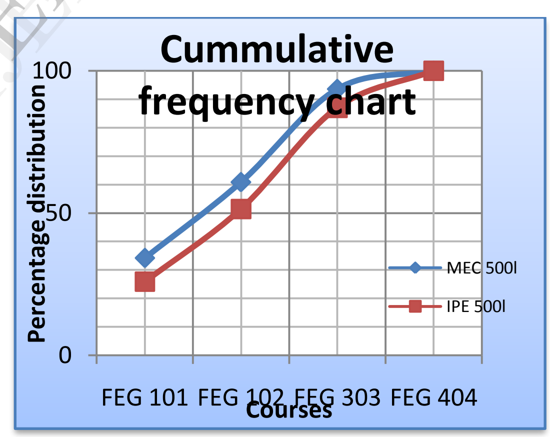

Fig. 8: Cumulative frequency distribution of the progress chart of MEC and IPE students

One Way Analysis Of Variance

ANOVA was used to test the existence of a significant difference in the grade distribution of the 500 level students across the various engineering mathematics courses.

Table 4: Grade distribution of 500L IPE students' performance in engineering mathematics

GRADE DISTRIBUTION				
	FEG 101	**FEG 102**	**FEG 303**	**FEG 404**
A	14	2	7	1
B	9	7	12	1
C	11	14	12	5
D	2	11	5	5
E	15	14	4	18
F	16	4	1	14
Total	67	52	41	44

Table5: ANOVA Computation Table

	Sum of Squares	degree of freedom	Mean Square	F- ratio
Between Group	91.51	3	30.5	**13.24**
within group	460.74	200	2.3037	
Total	552.25	203		

$$\mathbf{F_{0.95,3,200} = 2.60}$$

Since $\mathbf{F^*_{0.95,\ 3,200} = 13.24 > 2.60,}$ we reject the null hypothesis of equal treatment of means, and conclude that on the average, the grade distribution in the four sessions is significantly different.

Comparing the grade distribution in FEG 303 with that of FEG 404, at 0.95 confidence level, the confidence interval obtained using the t-score analysis was $\mathbf{1.3186 \leq \mu_2 - \mu_3 \leq 2.8074}$.Since this interval does not include zero, it can be concluded that the performance in FEG 303 has a grade distribution that is significantly different with that of FEG 404.

Further investigation was carried out using **Scheffe multiple comparison**. The grade distribution of the students in FEG 101, FEG 102 and FEG 303 were compared with that of FEG 404. Applying Scheffe Critical Value (S) at 0.95 confidence level, the confidence interval obtained was $\mathbf{0.7379 \leq L \leq 2.1873}$**.** The confidence interval does not include zero, we can conclude that the performance in FEG 101, FEG 102 and FEG 303 have a grade distribution that is significantly different from that of FEG 404.

Chi-Square Analysis

Chi-square was used to investigate if there was a significant difference in the number of passes and failures recorded in FEG 101, FEG 303, and FEG 404. The analysis carried out is summarized below;

Null Hypothesis H_{01}: There is no significant difference in the performance of students in FEG 101 across the various academic sessions.

Table 6: FEG 101 Chi-square result for 2008/2009 to 2011/2012 Academic sessions

Performance	2008/2009	2009/2010	2010/2011	2011/2012	Total
Pass	51 (50.3)	42 (36.8)	43 (54.1)	60 (54.8)	196
Failure	16 (16.7)	07 (12.2)	29 (17.9)	13 (18.2)	65
Total	67	49	72	73	261
$\chi^2 = 14.13$					
$\chi^2_{0.95,3} = 7.815$					

Since χ^2 **= 14.13 > 7.815,** we reject the null hypothesis, and conclude that there is a significant difference in the performance of students in FEG 101 across the various academic sessions.

Table 7: Result obtained when 2010/2011session which has the greatest contribution to Chi-square value was omitted.

Performance	2008/2009	2009/2010	2011/2012	Total
Pass	51 (54.2)	42 (36.7)	60 (59.1)	153
Failure	16 (12.8)	07 (9.3)	13 (13.9)	36
Total	67	49	73	189
$\chi^2 = 2.39517$ $\chi^2_{0.95,2} = 5.991$				

Since χ^2 **= 2.39517 < 5.991,** we accept the null hypothesis, and conclude that there is no significant difference in the performance of students in FEG 101 across the various academic sessions.

Table 8: Comparing the performance in 2010/2011 sessions with that of other sessions

Performance	2010/2011	Others	Total
Pass	43 (54.1)	153 (141.9)	196
Failure	29 (17.9)	36 (47.1)	65
Total	72	189	261
$\chi^2 = 12.6449$ $\chi^2_{0.95,1} = 3.841$			

Since χ^2 **= 12.6449 > 3.841,** we reject the null hypothesis, and conclude that there is a significant difference in the performance of students in FEG 101 across the various academic sessions.
Ipso facto, we conclude that the difference in the performance of students in FEG 101 in the four sessions is primarily due to the relatively poor performance in 2010/2011 session.

Null Hypothesis H_{02}: There is no significant difference in the performance of students in FEG 303 across the various academic sessions.

Table 9: FEG 303 Chi-square result for 2008/2009 to 2011/2012 Academic Sessions

Performance	2008/2009	2009/2010	2010/2011	2011/2012	Total
Pass	43 (42.1)	50 (35.2)	40 (35.2)	31 (36.9)	164
Failure	06 (6.9)	08 (8.2)	01 (5.8)	12 (6.1)	27
Total	49	58	41	43	191
$\chi^2 = 11.41918$					
$\chi^2_{0.95,3} = 7.815$					

Since χ^2 **= 11.4192 > 7.815,** we reject the null hypothesis, and conclude that there is a significant difference in the performance of students in FEG 303 across the various academic sessions.

Table 10: Result obtained when 2011/2012 session which has the greatest contribution to Chi-square value was omitted.

Performance	2008/2009	2009/2010	2010/2011	Total
Pass	43(44)	50(52.1)	40(36.8)	133
Failure	06(5.0)	08(5.9)	01(4.2)	15
Total	49	58	41	148
$\chi^2 = 3.77119$				
$\chi^2_{0.95,2} = 5.991$				

Since χ^2 **= 3.377119 < 5.991,** we accept the null hypothesis, and conclude that there is no significant difference in the performance of students in FEG 303 across the various academic sessions.

Table 11: Comparing the performance in 2011/2012 sessions with that of other sessions

Performance	2011/2012	Others	Total
Pass	31 (36.9)	133 (127.1)	164
Failure	12 (6.1)	15 (20.9)	27
Total	43	148	191
$\chi^2 = 8.58935$			
$\chi^2_{0.95,1} = 3.841$			

Since χ^2 **= 8.58935 > 3.841,** we reject the null hypothesis, and conclude that there is a significant difference in the performance of students in FEG 303 across the various academic sessions.
Ipso facto, we conclude that the difference in the performance of students in FEG 303 in the four sessions is primarily due to the relatively poor performance in 2011/2012 session.

Null Hypothesis H_{03}: There is no significant difference in the performance of students in FEG 404 across the various academic sessions.

Table 12: FEG 404 Chi-square Result for 2008/2009 to 2011/2012

Performance	2008/2009	2009/2010	2010/2011	2011/2012	Total
Pass	33 (35.5)	47 (42.3)	54 (49.9)	31 (37.2)	165
Failure	09 (6.5)	03 (7.7)	05 (9.1)	13 (6.8)	30
Total	42	50	59	44	195
$\chi^2 = 13.39904$					
$\chi^2_{0.95,3} = 7.815$					

Since χ^2 **= 13.39904 > 7.815,** we reject the null hypothesis, and conclude that there is a significant difference in the performance of students in FEG 404 across the various academic sessions.

Table 13: Result obtained when 2011/2012 session which has the greatest contribution to Chi-square value was omitted.

Performance	2008/2009	2009/2010	2010/2011	Total
Pass	33(37.3)	47 (44.4)	54 (52.4)	134
Failure	09 (4.7)	03 (5.6)	05 (6.4)	17
Total	42	50	59	151
$\chi^2 = 5.59744$				
$\chi^2_{0.95,2} = 5.991$				

Since χ^2 **= 5.59744 < 5.991,** we accept the null hypothesis, and conclude that there is no significant difference in the performance of students in FEG 404 across the various academic sessions.

Table 14: Comparing the performance in 2011/2012 sessions with that of other sessions

Performance	2011/2012	Others	Total
Pass	31 (37.2)	134 (127.8)	165
Failure	13 (6.8)	17 (23.2)	30
Total	44	151	195
$\chi^2 = 8.64595$			
$\chi^2_{0.95,1} = 3.841$			

Since χ^2 **= 8.64595 > 3.841,** we reject the null hypothesis, and conclude that there is a significant difference in the performance of students in FEG 404 across the various academic sessions.

Ipso facto, we conclude that the difference in the performance of students in FEG 404 in the four sessions is primarily due to the relatively poor performance in 2011/2012 session.

Questionnaire

The response of students on the rating of the various factors affecting engineering mathematics learning and students performance is shown in fig. 9. The higher the point score, the better the contribution to the overall performance in engineering mathematics. The figure shows that factors such as Interest and Perception have relatively higher point rating. This implies that engineering students generally have positive attitude towards engineering mathematics. However, factors such as learning environment and Coordination have lower point rating. It is vivid that the learning environment is not conducive for engineering mathematics learning. Noise and seating capacity are the major area of concern. Also, the students opinion suggest a review in the coordination of the courses in aspects of timing of the lecture, and fair and standard marking of examination scripts. The important discoveries in the questionnaire responses are given thus;

- There was a non-negative response on lecturer attendance and class participation. Audibility and solving ample examples during lectures were critical areas for possible improvements
- There were negative responses towards the timing of lectures and the marking of script.
- Most engineering students like studying engineering mathematics (A=50%, SA=16%)
- Current seating capacity is not adequate, and learning environment not conducive (A=33%, SA=48%)
- Lecturers attend lectures (A=67.4%, SA=7%)
- Engineering mathematics is important and related to other engineering courses (A=50%, SA-30%)
- Conduciveness of the Lecture halls (Fair = 39%, Poor = 41%)
- Only 17% of respondents agreed that the marking of examination scripts is fair and standard.
- Only 20% of respondents disagreed that the examination questions are more difficult than expected.

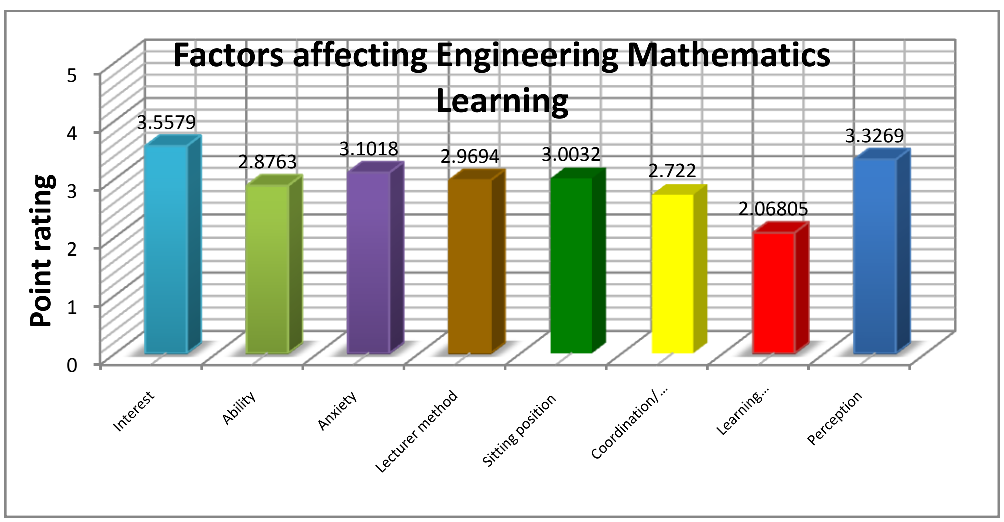

Fig. 9: Factors affecting Engineering mathematics learning

CONCLUSION

From the findings, there is a significant relationship between the performances of students in engineering mathematics with their performance in other related courses. It is obvious that the effect of the recent poor performance in engineering mathematics is grave, and cannot be neglected. Hence, there is need for diligence in handling engineering mathematics courses. It is highly recommended that a timely intervention should be made on improving the learning environment. There is no gain-saying that the high Student-Lecturer ratio is an important factor affecting learning and performance. Moreover, the seating capacity is far from being adequate for all engineering students offering engineering mathematics. Therefore, it is recommended that the students should be split, according to their departments into two or three classes to enhance learning. A careful review should be made on setting and marking examination scripts, so that unwarranted disparity in the performance of students across various departments can be minimized. From the control chart, if the recent performance trend continues, there could be 94.2% failure in engineering mathematics by 2014/2015 academic session. A further research should be conducted to investigate the effects of some demographic factors such as; mode of entry, sex, age, type of high school attended, achievement scores in SSCE and UTME, and place of residence on students' performance in engineering mathematics.

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