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A Pilot Study: Introduction of Audit Course to Support Learning Engineering Mathematics

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Abstract: A first- year introductory course on mathematics has been the norm in engineering education. These courses create a solid mathematical background for learning engineering courses.

The students who are admitted as a lateral entry in the second year as per norms are deprived of learning these fundamental courses.

Instructing mathematics to these students is a challenge because of their limited knowledge of prerequisite mathematical concepts. Hence, a new approach has been considered in the curriculum of an autonomous self-financed college in the University of Mumbai. An audit course is designed, in addition to regular mathematics classes in semester III, which makes the students familiar with the concepts required to achieve mathematical competencies in the Second year. This audit course is compulsory for the Direct Second Year (DSE) students. The author presents some observations concerning the performance of DSE students in Mathematics course before and after the introduction of the audit course.

Keywords: audit course, mathematical competencies, curriculum design

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1. Introduction and Motivation

"The study of technology and engineering is not possible without the study of the natural sciences. These in turn cannot be understood in depth without a fundamental understanding of mathematics because as Feynman has pointed out in his book, The Character of Physical Law, "Mathematics is not just another language. Mathematics is a language plus reasoning; it is a language plus logic. Mathematics is a tool for reasoning."[1]. Nobody can deny the importance of mathematics in any field of technical education, but in engineering education mathematics is the solid foundation on which all other subjects rely and flourish.

The first graduate attribute defined by ABET and NBA is 'an ability to apply knowledge of mathematics, science and engineering'. The parameters adopted by NBA for accreditation of programmes are based on initial capabilities, competence, skills, etc. keeping in mind the outcomes desired by the profession concerned. Complete knowledge of mathematical concepts and their various applications is the most important and desirable skill in an engineering graduate. Also according to NBA accreditation criteria curriculum of a programme should be designed in such a way that it provides an education which is a balance between high academic quality and professional relevance. So to fulfill the condition of first graduate attribute, it is necessary that all the students should receive training in all relevant concepts of mathematics.

But unfortunately there is a common misconception among students regarding the usefulness of the mathematics course in engineering education. "In an engineering college, where students look for exciting "engineering" experiences, acquiring mathematical skills is instinctively pushed to the background. The zeal to excel in hard-core engineering subjects lead to a view that mathematics is an unnecessary evil. Nothing tangible has been done or is being done, to remove this mental blockade." [2]

This type of attitude is very common in engineering students and the situation is even worse in case of polytechnic students. As a result the students who get admitted to direct second year of engineering, after completing their diploma course, lack the understanding of basic concepts of higher mathematics and have a fear of the subject. There is a fundamental mismatch between what is expected of some students and what they can realistically achieve due to their prior education. The hierarchical nature of mathematics is such that omission of important foundations causes problems later. This unpreparedness of the students reflected in their performance in mathematics course during their second year of engineering. Many of these students failed to perform fairly in mathematics course which in turn affected their overall performance. This problem was evident to all the mathematics teachers as well as the policy makers in the institute. But being a part of the university system nothing much could be done to help these students.

As per government norms and admission process, these students get admitted to the institute nearly after a month of the start of the academic term of semester - III. As a result these students miss some concepts of semester - III mathematics course as well. Mathematics teachers had a practice of conducting extra lectures for these students. These extra lectures were conducted with the intension of making the DSE students familiar with the topics of mathematics course of semester - III which the students have missed due to their late admission. But this practice did not fill the gap which was created due to their limited exposure to the mathematics course during their diploma years.

So as soon as the institute was granted academic autonomy, the mathematics teachers and policy makers of the college thought of dealing with this situation and providing assistance to DSE students in acquiring knowledge of basic concepts of engineering mathematics.

2. Methodology

As a part of autonomy syllabus every student was required to register for one audit course in every semester from second year onwards. There were various types of audit courses offered to students ranging from finance to core technical subjects of other engineering branches. It was thought that an audit course based on the syllabus of mathematics of first year of engineering could be introduced for DSE students. The syllabus of this audit course was designed to cover almost all the topics which other students learn in first year. The course was designed to ensure that the most able students have sufficiently developed analytical reasoning skills to match with other students in the class and elsewhere and at the same time ensure that the less able have rewarding and relevant educational experiences at an appropriate level.

A first year common engineering course often employs a problem-based curriculum to ensure that students find relevance in the Physics and Mathematics courses being taken in the first two years of engineering.[3]

In accordance with such tradition the syllabus of the audit course was designed to compensate for the loss of learning of first year of engineering mathematics course.

The syllabus of the audit course consisted of

1. Complex Numbers: De-Moivre's Theorem, Roots of complex numbers, Hyperbolic Functions, Logarithmic functions

2. Partial Differentiation: Partial Differentiation of first and Higher order, Composite functions and chain rule

3. Homogeneous Function: Euler's Theorem of homogeneous functions, Maxima and minima of 2 variable functions

4. Integration: Definite integral and properties, Beta and Gamma functions

5. Double Integration: Evaluation of Double integral, Change of order of integration, Evaluation by changing to polar coordinate

   Triple Integration: Evaluation of Triple integral,

application of multiple integral to compute area and volume.

This syllabus covered all the important topics of first year mathematics course which are essential for the understanding of second year mathematics course.

In accordance with the concept of Outcome Based Education, the audit course also had following well defined course outcomes.

At the end of successful completion of the audit course a student will be able to Solve Problems involving complex numbers making use of different forms and properties of Complex numbers, hyperbolic functions and logarithms of complex numbers.

Find Partial derivatives of first and higher order, total derivative of a function of 2 and 3 variables. Find maxima and minima of functions of two variables.

Apply basic rules and concepts of Beta - Gamma Functions to solve integration problems.

Solve problems on double and triple integrals and use of multiple integral to compute Area and Volume.

The methodology used in this audit course was "Learning by Doing". The contact hours were 2 hours per week resulting in 18 to 20 contact hours in the whole semester. During these lectures the instructor explained the basic concepts and elaborated it with the help of suitable examples.

The evaluation process consisted of 4 home assignments based on the above mentioned topics in the syllabus and each assignment corresponding to one of the course outcomes. The students were expected to complete these assignments which involved problems based on conceptual understanding as well as problems which were application oriented. Students were motivated to refer several books and come up with solutions of these problems. These assignments reinforced the learning process of students and increased their competencies before each assessment test. After the completion and submission of each assignment the students were given grades according to their performance. The criteria used for grading the students involved factors like timely submission of assignments, completeness of the work assigned and attendance of the students in the lectures of the audit course.

The course being an audit course, these grades were not reflected in the final grade sheet of the student but the grades were required to declare the successful completion of the audit course.

In the academic year 2015-16, all the students completed this audit course successfully. Although there is no direct method to calculate the attainment of the course outcomes of the audit course, the eventual performance of the DSE students in their Semester - III mathematics course can be taken as an indirect method to understand the attainment of course outcomes of the audit course.

3. Implementation and Data Gathered

The study in this paper is made on the basis of performance of DSE students in academic year 2014-15 (before the introduction of audit course) and academic year 2015-16 (after the introduction of audit course).

The study is conducted on 131 DSE students of academic year 2014-15 and 143 DSE students of academic year 2015-16.

The performance of students in Applied Mathematics course in End Semester Exam (ESE) is compared with respect to the following criteria.

1. Percentage of DSE students passing in ESE
2. Percentage of DSE students securing 60% or more marks in ESE
3. Mean of marks scored by DSE students in ESE
4. Standard Deviation of Marks scored by DSE students in ESE

Further, with the help of Large Sample test, the mean of both the populations is compared to test whether the performance of DSE students is improved due to the introduction of audit course.

4. Observations

Following tables represent the observations made on performance of DSE students.

Table 1 represents the data related to result of DSE students in ESE of semester - III in the subject of Applied Mathematics -III for the academic years

2014-15 and 2015-16.

Table 2 represents the data related to result of DSE students in ESE of semester - IV in the subject of Applied Mathematics -IV for the academic years 2014-15 and 2015-16.

Table 1: Performance of all DSE students in SEM-III

SEM-III		
Academic Year	Before Audit Course	After Audit Course
	2014-15	2015-16
Total number of Students	131	143
Number of Students who have passed in ESE	105	123
% of students who have passed in ESE	80%	86%
Number of students who secured 60% or more in ESE	27	62
% of students who secured 60% or more in ESE	21%	43%
Mean of Marks scored by all DSE students in ESE	43.6	53.66
Standard Deviation of marks	18.11	23.13

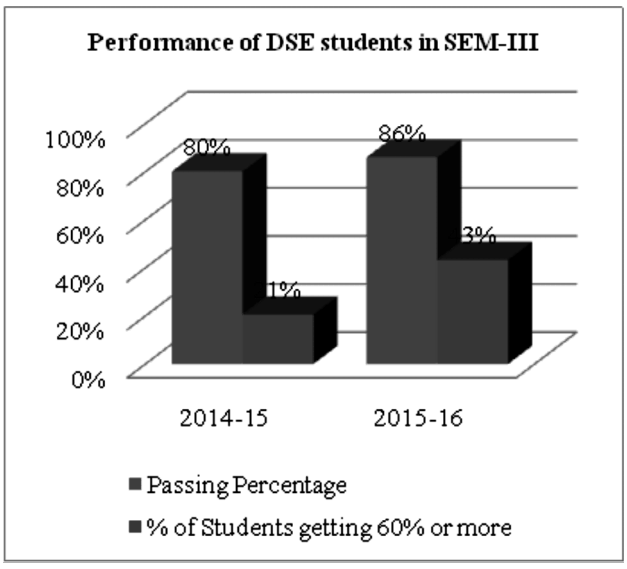

Fig. 1: Performance of all DSE students in SEM-III

From Table 1, it is quite evident that there is a significant increase in the passing percentage and in the percentage of students securing 60% or more in the ESE of semester-III after the introduction of audit course. Also the mean of the marks scored by all DSE Students has increased from 43.6 to 53.66. That shows that there is an increase of 10 marks on an average in the total marks of DSE students who have attended audit course of mathematics.

Table 2: Performance of all DSE students in SEM-IV

SEM-IV		
Academic Year	Before Audit Course	After Audit Course
	2014-15	2015-16
Total number of Students	131	143
Number of Students who have passed in ESE	126	134
% of students who have passed in ESE	96%	94%
Number of students who secured 60% or more in ESE	57	68
% of students who secured 60% or more in ESE	44%	48%
Mean of Marks scored by all DSE students in ESE	56.78	57.57
Standard deviation of marks	16.47	19.41

Fig. 2: Performance of all DSE students in SEM-IV

From Table 2, we can observe that there is a slight increase in the passing percentage and percentage of students securing 60% or more in the End Semester Exam of semester-IV after the introduction of audit course. This is because the syllabus of semester - IV mathematics majorly comprises of topics from statistics. As the audit course syllabus deals with basics of mathematics, it does not affect the performance of DSE students in semester- IV.

Now to test the hypothesis that "the performance of DSE students in ESE of semester -III has become better after attending the audit course", Large Sample test can be applied.

This test is performed under assumption that both

these samples come from different populations whose standard deviations are unknown and unequal. The marks scored by DSE students of academic year 2014-15 in ESE are considered as sample 1 and the marks scored by DSE students of academic year 2015-16 as sample 2.

The test statistics used is given by the formula

$$z = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{{s_1}^2}{n_1} + \frac{{s_2}^2}{n_2}}}$$

Where $\overline{X_1}$ = Mean of Sample 1
$\overline{X_2}$ = Mean of Sample 2
n_1= Size of Sample 1
n_2= Size of Sample 2
s_1= Standard Deviation of Sample 1
s_2= Standard Deviation of Sample 2

Also μ_1 represents mean of first population and μ_2 represents the mean of second population.
The hypothesis statements are defined as follows:
Null Hypothesis H_0: $\mu_1 = \mu_2$

(This means that there is no effect of audit course on the performance of DSE students in ESE)
Alternate Hypothesis H_α: $\mu_1 < \mu_2$
(This means that the audit course resulted in betterment of DSE student's performance in ESE.

Calculation of Test Statistic:

$$z = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{{s_1}^2}{n_1} + \frac{{s_2}^2}{n_2}}}$$

Substituting values from Table 1,

$\overline{X_1}$ = 43.6,
$\overline{X_2}$ = 53.66,
n_1= 131,
n_2= 143,
s_1= 18.11,
s_2= 23.13

Value of test statistic $\boldsymbol{z}$ can be calculated as $z = -4.0257$

Applying left tailed test, at 1% level of significance (i.e. 99% region of acceptance), the critical valu e of $\boldsymbol{z}$ from the standard normal distribution table is $z_\alpha = -2.33$

As the calculated value of z is less than the critical value z_α, the calculated value of z falls in the rejection area.
As a result it can be concluded that the null hypothesis is rejected.

Hence the alternate hypothesis is accepted.

That indicates that there is an improvement in the performance of DSE students after attending audit course.

4. Conclusion

This paper makes an effort to show the effect of the audit course on DSE students. The author understands that the data comprises of only one year before and after the introduction of the audit course. The data may be insufficient to provide solid ground to draw any convincing conclusion to the theory of usefulness of such audit course on the performance of DSE students. Also there is a possibility of other factors affecting such observation.

However with the help of available data, it is very essential to understand the contribution of the audit course in the improvement of performance of DSE students in mathematics course. Mathematics being such an important part of engineering curriculum, such innovations are required to help students gain knowledge and expertise in the subject.

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