International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 1, November-December 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Errors Committed in Integral Calculus: Basis for a Review Guide

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ABSTRACT

This study determined the errors of engineering students in Integral Calculus in the University of Eastern Philippines (UEP), Catarman, Northern Samar as basis in developing a review guide. It adopted a developmental research design. A total of 162 second year Engineering students taking up Integral Calculus, who were enrolled on the Second Semester of School Year 2016-2017,were the respondents of this study.

The findings of this study show that majority of the students in Integral Calculus got "fair" to "passing" grades in their pre-requisite subjects and that most of the students taking up Integral Calculus are first time takers.

As shown in the results, the students had hard time understanding Integral Calculus concepts which comprises the majority of the total errors committed. The other errors committed were concepts in Algebra, Analytic Geometry, Basic Mathematics, Differential Calculus and Plane Trigonometry and due to carelessness in their solutions.

These findings indicate that for the preliminary topics in Integral Calculus, the pre-requisite subject where most of the students committed errors is Algebra. This can be attributed to some difficulty they are experiencing in recalling the concepts learned in this subject.

The findings also show that for the higher integration techniques topics in Integral Calculus, most students are having hard time understanding these integration concepts. And in application of integration concepts in finding plane areas under and between curves and volumes of revolutions, the students lack the skills in sketching the graph.

The development of a review guide for remedial instruction prior to and at the early part of the subject Integral Calculus, generally, aims to help the students, taking up Integral Calculus, in recollecting the concepts in its pre-requisite subjects. The topics included are the identified concepts in pre-Integral Calculus subjects where the engineering students commonly commit errors.

Keywords: *Integral Calculus, Review Guide, UEP, Pre-Calculus, Errors Committed*

How to cite this paper: Kissa P. Banawis | Benjamin D. Varela "Errors Committed in Integral Calculus: Basis for a Review Guide" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-1, December 2020, pp.299-304, URL: www.ijtsrd.com/papers/ijtsrd37934.pdf

IJTSRD37934

INTRODUCTION

The University of Eastern Philippines, being supervised by the Commission on Higher Education (CHED), trails to support its whole stud entry and faculty members towards attaining a just and appropriate contribution to the institution and the community. The school revises and adopts curricula which are suitable to the present needs of the society and will suffice the existing requirements in seeking future professionalism.

The College of Engineering's existing curricula offers thirty (30) units of Mathematics subjects covering nine (9) subjects from basic algebra and trigonometry to advance engineering mathematics during the first three years. Thus, it is expected that students who enroll in the courses the college offers are those who are mathematically inclined.

Integral Calculus is one of these mathematics subjects. It is a 5-unit subject that is offered in the second semester of the second year level. It is the next Calculus subject taken by an engineering student after Differential Calculus. It is the prerequisite subject of Differential Equations and Advanced Engineering Math and Numerical Methods.

Integral Calculus is an essential subject in engineering courses. It is considered as a critical screen among sophomore students. Success in this subject means elevating to the next level, but failure means repeating it and not being able to finish the course on required time/schedule.

The highest percentage of failure, reaching to about 72%, was recorded in the second semester of school year 2015-2016 in the subject Integral Calculus based on data from the registrar's office of the University of Eastern Philippines. This failure rate is quite alarming and no longer normal. This is why the College of Engineering is always urged to offer this failed subjects during the next semester or during

summer. Every year, additional students fail and decide to shift to other courses, drop the subject or stop schooling completely.

A variety of reasons are given for the unsuccessful attempts of the students to pass Integral Calculus. These causes can be the student factors, teacher factors or the environment factors. Since this is the problem of most of the educators, different researchers all over the globe have sought to understand the problematic situation in their own milieu.

EngKiat(2005) found out that technical errors accounted for the largest number of errors made in the test he conducted. This was largely due to the students' lack of mathematical content knowledge in other topics. Possible reasons to this are the inability to have in-depth understanding of the basic mathematical concepts and they may have failed to recall the concepts needed.

The research of Campbell (2009) which made use of data collected from both written student work and clinical interviews also indicated that students face a variety of difficulties as they attempt to solve calculus problems. Many of these difficulties relate to pre-requisite mathematics knowledge of function, geometry, and algebra. Findings also indicate that students often do not use the techniques of calculus, even when they have demonstrated competency in applying that knowledge in analogous problems in non-applied contexts.

Mathematics needs an approach of teaching that can deepen understanding of the concepts underlying in each topic. Deep cognitive understanding can be obtained through a carefully designed teaching that allows students to flexibly cater their pre-knowledge deficiencies and also allows them to do reflection on the concept in different ways (Haripersad, 2011). Therefore, in teaching Integral Calculus, being one of the Mathematics subjects, there should be sufficient means to ensure that basic concepts that the students' needs are catered.

Through these findings of previous studies, the researcher is prompted to focus on a particular strategy, which is the development of a review guide for engineering students enrolled in Integral Calculus. Knowing and understanding the difficulties and errors commonly experienced by the students in this course and providing them a review material for these identified misconceived topics, may help them on their way to success.

The findings of this study may also be a way to strengthen the teaching of prerequisite subjects, most especially on topics where errors are mostly committed by the engineering students.

This study aimed to determine the errors of engineering students in Integral Calculus in the University of Eastern Philippines as basis in developing a review guide.

MATERIALS AND METHODS

The University of Eastern Philippines is a non-profit institution of higher learning created under Republic Act 4126 with primary objectives geared towards quality instruction, research, extension and production. It is the only comprehensive state university in the Province. It has ten colleges; one of which is the College of Engineering where this study was conducted.

The College of Engineering exists with a goal to provide quality education and technical training to all engineering disciplines and technical courses it offers for global competitiveness. It offers four (4) engineering courses, namely: Bachelor of Science in Agricultural Engineering (BSAE), Bachelor of Science in Civil Engineering (BSCE), Bachelor of Science in Electrical Engineering (BSEE), and Bachelor of Science in Mechanical Engineering (BSME).

The research design employed in this study is the developmental research design. This is appropriate for this study since it seeks to develop a review guide that serves as intervention to improve the performance of the engineering students in Integral Calculus by uncovering the errors they commonly commit.

The respondents of this study came from the engineering students who are officially enrolled during the Second Semester of School Year 2016-2017 taking up the subject Integral Calculus. The respondents of this study, who are totally enumerated, were from the four engineering courses, of which 3 are BSAE, 63 are BSCE, 75 are BSEE and 21 are BSME students.

In gathering the data for this study, the researcher only used a survey questionnaire to determine the profile of the respondents in terms of gender, specific engineering course taken, their grades in pre-requisite subjects, and number of times the students took Integral Calculus.

The profile attributes of the respondents like the gender and course of the respondents were just recorded but were not considered as independent variables in this study. Grades of the students provided by the students in their pre-requisite subjects were double-checked through student's evaluation of grades from the registrar. Number of times the student took Integral Calculus were identified by the students if it is their first or second time and double-checked again through their evaluation of grades from the registrar.

The researcher asked permission from the University President, the College of Engineering Dean, the Department heads and the professors handling Integral Calculus subject from the different departments to allow her to conduct the survey.

The researcher obtained the final grades of the students in the subjects Algebra, Trigonometry, Plane and Solid Mensuration, Analytic Geometry and Differential Calculus from the UEP Registrar's Office.

The researcher got a copy of the long examinations conducted for all classes of Integral Calculus from the subject professor. Before identifying the errors, preliminary analysis of the test given by the professors was done. This is to classify the topics covered in every examination. There is pre-identified list of topics of each pre-requisite subject related to Integral Calculus. For errors which did not fall on the list, the researcher added another classification.

Treatment of the errors for each of the five (5) long quiz and for the midterm examination was done separately. After

every examination, the researcher scrutinized the checked papers and recorded the errors committed by the students as well as classified them whether they were errors in Algebra, Trigonometry, Plane and Solid Mensuration, Analytic Geometry or Differential Calculus. Errors were further classified into the different important topics covered in these subject areas. After which, these data were tallied and tabulated for the frequency of each error per topic in the prerequisite subjects.

The data gathered were tabulated, analyzed and treated statistically using Microsoft Excel Software. The statistical measures such as weighted mean, percentage, and ranking were used.

The percentage was used as a descriptive measure to show the relationship between two or more magnitudes as in the errors committed by students in Integral Calculus and whether they fall to topics in Algebra, Trigonometry, Plane and Solid Mensuration, Analytic Geometry or Differential Calculus. Ranking was used to determine which pre-requisite subjects have the most classified error.

Finally, the researcher developed a review guide emphasizing all topics where the students committed errors. Topics were arranged per pre-requisite subject starting from Basic Mathematics, Algebra, Trigonometry, Analytic Geometry and Differential Calculus. Topics in each subject area were arranged according to areas with the most to least committed errors.

Objectives for each topic were enumerated. Concepts were discussed first. It was followed by the instances where students tend to commit error on this topic. Examples of the error were taken from the actual error they committed and followed immediately with the correct solution. Series of examples were given. Finally, the researcher presented exercises to be answered by the students.

RESULTS AND DISCUSSION

Academic Profile of Engineering Students Taking Integral Calculus

Final Grades in Algebra, Trigonometry, Plane and Solid Mensuration, Analytic Geometry, and Differential Calculus.

Table 1 shows the frequency distribution of final grades of 162 students in the pre-requisite subjects of Integral Calculus, such as Algebra, Trigonometry, Plane and Solid Mensuration, Analytic Geometry, and Differential Calculus.

In College Algebra, one (1) student got a grade of 1.25, one (1) student got a grade of 1.50, six (6) students got a grade of 1.75, seven (7) students got a grade of 2.0, ten (10) students got a grade of 2.25, 20 students got a grade of 2.50, 51 students got a grade of 2.75 and 66 students got a grade of 3.0. The weighted mean of the grades of students in this subject is 2.70 which is a "fair" grade.

In Plane & Spherical Trigonometry, two (2) students got a grade of 1.50, three (3) students got a grade of 1.75, eight (8) students got a grade of 2.00, ten (10) students got a grade of 2.25, 11 students got a grade of 2.50, 51 students got a grade of 2.75 and 77 students got a grade of 3.0. The weighted mean of the grades of students in this subject is 2.75 which is a "fair" grade.

In Advanced College Algebra, one (1) student got a grade of 1.25, two (2) students got a grade of 1.50, seven (7) students got a grade of 1.75, three (3) students got a grade of 2.0, 14 students got a grade of 2.25, 35 students got a grade of 2.50, 48 students got a grade of 2.75, 51 students got a grade of 3.0 and one (1) student got no grade. The weighted mean of the grades of students in this subject is 2.63 which is a "fair" grade.

In Analytic Geometry, one (1) student got a grade of 1.25, one (1) student got a grade of 1.50, four (4) students got a grade of 1.75, five (5) students got a grade of 2.0, 12 students got a grade of 2.25, 17 students got a grade of 2.50, 38 got a grade of 2.75, 82 students got a grade of 3.0 and two (2) got incomplete grade. The weighted mean of the grades of students in this subject is 2.71 which is a "fair" grade.

In Solid Mensuration, three (3) students got a grade of 1.25, seven (7) students got a grade of 1.50, 20 students got grades 1.75, 18 students got a grade of 2.0, 33 students got a grade of 2.25, 40 students got a grade of 2.50, 17 students got a grade of 2.75, 20 students got a grade of 3.0, one (1) student got an incomplete grade, two (2) students got no grades and one (1) student got dropped. The weighted mean of the grades of students in this subject is 2.26 which is a "good" grade.

In Differential Calculus, three (3) students got a grade of 1.25, four (4) students got a grade of 1.50, eight (8) students got a grade of 1.75, 12 students got a grade of 2.0, 21 students got a grade of 2.25, 27 students got grades of 2.5 and 2.75, 53 students got a grade of 3.0, six (6) students got incomplete grade and one (1) student got no grade. The weighted mean of the grades of students in this subject is 2.44 which is a "fair" grade.

Table 1 Final Grades of Engineering Students in Pre-Requisite Subjects

Grades	College Algebra	Wtd. Mean	Plane and Spherical Trigono-metry	Wtd. Mean	Advanced College Algebra	Wtd. Mean	Analytic Geometry	Wtd. Mean	Solid Mensuration	Wtd. Mean	Diffe-rential Calculus	Wtd. Mean
	Frequency		Frequency		Frequency		Frequency		Frequency		Frequency	
1.00	-	2.70	-	2.75	-	2.63	-	2.71	-	2.26	-	2.44
1.25	1		-		1		1		3		3	
1.50	1		2		2		1		7		4	
1.75	6		3		7		4		20		8	
2.00	7		8		3		5		18		12	
2.25	10		10		14		12		33		21	
2.50	20		11		35		17		40		27	
2.75	51		51		48		38		17		27	
3.00	66		77		51		82		20		53	
INC	-		-		-		2		1		6	
N.G.	-		-		1		-		2		1	
DR	-		-		-		-		1		-	

Number of Times the Students Took Integral Calculus

Table 2 shows the number of times the students took Integral Calculus. It shows that out of 162 students, 139 are first takers and 23 are repeaters in which five (5) students are second takers and 18 are third takers. The findings show that majority of the students taking up Integral Calculus are first takers.

Table 2 Number of Times the Students Took Integral Calculus.

No. of Times	Frequency	Percentage
1	139	85.80
2	5	3.09
3	18	11.11
TOTAL	**162**	**100.00**

Classification of Errors in Integral Calculus

Table 3 shows the summary of all the errors committed by engineering students in Integral Calculus. It further presents the topics in each subject in which the students particularly committed the error. As shown, the students had a hard time understanding integral concepts which accounted for 55.20% of the total error, errors in Algebra which accounted for 17.16%, errors in Analytic Geometry which accounted for 10.72%, errors due to carelessness which accounted for 6.93%, errors in basic Mathematics which accounted for 4.08%, errors in Differential Calculus which accounted for 3.71%, and errors in Plane Trigonometry which accounted for 2.19%.

Table 3 Classification of Errors in Integral Calculus

Topics	TOTAL	%
Algebra	**1,189**	**17.16**
Multiplication of Polynomials	19	0.27
Division of Polynomials	155	2.24
Simplifying an Equation	66	0.95
Binomial Expansion	89	1.28
Factoring Polynomials	255	3.68
Laws of Exponents	203	2.93
Simplification of Radical Expressions	26	0.38
Operation on Radicals	35	0.51
Operations Exponential Functions	25	0.36
Operations Logarithmic Functions	61	0.88
Systems of Linear Equations	55	0.79
Operations on Rational Expressions	51	0.74
Partial Fraction	166	2.40
Analytic Geometry	**743**	**10.72**
Curve Sketching	743	10.72
Plane Trigonometry	**152**	**2.19**
Measurement and Properties of Angles	33	0.48
Trigonometric Identities	103	1.49
Functions of Two or More Angles	1	0.01
Value of Function of an Angle	15	0.22

Differential Calculus	**257**	**3.71**
The Chain Rule and the General Power Rule	73	1.05
Derivatives of Trigonometric Functions	91	1.31
Derivatives of Inverse Trigonometric Functions	7	0.10
Derivatives of Logarithmic Functions	67	0.97
Derivatives of Exponential Functions	18	0.26
Derivatives of Hyperbolic Functions	1	0.01
Others	**4,588**	**66.21**
1. Integral Concept	**3,825**	**55.20**
Trigonometric Functions	276	3.98
Power Formula	376	5.43
Inverse Trigonometric Functions	240	3.46
Inappropriate Technique used	30	0.43
Exponential Functions	166	2.40
Natural Logarithm	282	4.07
Trigonometric Substitution	389	5.61
Algebraic Substitution	339	4.89
Integration by Parts	375	5.41
Partial Fraction	158	2.28
Definite Integrals	335	4.83
Definite Integrals (Wallis' Formula)	307	4.43
Definite Integrals (Substitution of Limits)	148	2.14
Plane Areas	248	3.58
Volume of Revolution	156	2.25
2. Basic Mathematics	**283**	**4.08**
Operations on Fractions	98	1.41
Fractions Simplification	90	1.30
Simplifying Answers	53	0.76
Fraction Rationalization	42	0.61
3. Carelessness	**480**	**6.93**
Miswritten Items	248	3.58
Sign	137	1.98
Not putting a grouping symbol	40	0.58
Multiplier not distributed to the group	28	0.40
Wrong answer to basic operations (+,-,x,/)	27	0.39
TOTAL	**6,929**	**100.00**

The findings of this study show that majority of the students in Integral Calculus got fair to passing grades in their pre-requisite subjects. In College Algebra, Plane & Spherical Trigonometry, Advanced College Algebra, Analytic Geometry, and Differential Calculus students have fair grades. In Solid Mensuration, students have good grades. It is therefore concluded that the students got "fair" to "passing" grades in their pre-requisite subjects.

It was evident that most of the students taking up Integral Calculus are first time takers of the subject.

As shown in the results, the students had a hard time understanding Integral Calculus concepts which comprises the majority of the total errors committed. The other errors committed were concepts in Algebra, Analytic Geometry, Basic Mathematics, Differential Calculus and Plane Trigonometry and due to carelessness in their solutions. There were no committed errors in Solid Mensuration. Among the pre-requisite subjects, the students committed most errors in Algebra. They may be experiencing some difficulty in recalling the concepts learned in this subject.

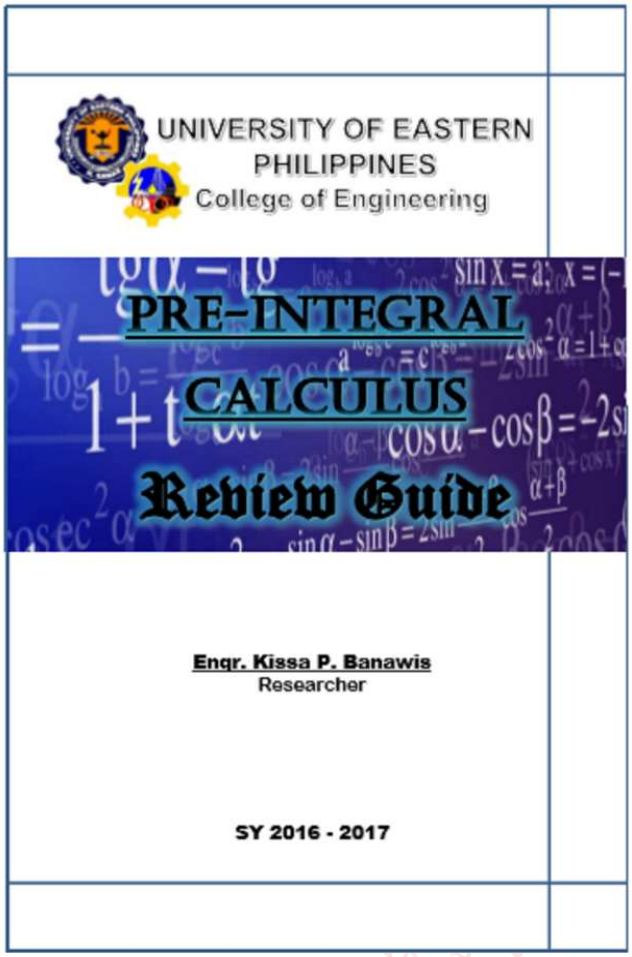
For the higher integration techniques topics in Integral Calculus, most of the students are having a hard time understanding these integration concepts. Although students are already oriented of the basic integration techniques and the formulas needed, they still find difficulty in applying these concepts to related topics. This may be because the students are confused as to what particular integration technique to use. The students lack the skills in sketching the graph which is a requirement in finding plane areas under and between curves and volumes of revolutions.

The development of a review guide for remedial instruction prior and at an early part of taking of Integral Calculus is very essential, so that the students may be helped to recall the pre-requisite topics identified in this study.

The importance of understanding deeply prior mathematical knowledge is evident in this study. As a verification to the constructivist principles, in order for this basic knowledge to be stored and ready for retrieval in students' minds, these should be taught in a way that the students are motivated and activated. The students should be involved in activities in which they can have hands-on experience and appreciate the importance of each lesson.

Generally, findings affirmed the Piaget's notion on being an active learner of a student because problem-solving skills cannot be taught, they must be discovered. There is no way that a lesson can be forgotten if the students have unraveled and explored by themselves the depth of the topic and the means to solve the problems involved. Furthermore, it is the duty of the teacher to motivate, to find ways to activate their learners, and guide them in their pursuit of learning.

Based on the findings of this study, the researchers developed a Review Guide for Integral Calculus Students with the following contents:



1. REVIEW GUIDE DETAILS

Review Guide Title:	Review Guide in Integral Calculus
Course(s):	BSAE, BSCE, BSEE, BSME
School Year and Semester	2016 - 2017, 2nd Semester
Review Guide Coordinator:	Engr. Kissa P. Banawis
RGC Contact Details (Tel, Email)	+63-9488812960 kissapujante@gmail.com
Subject Area:	College Algebra Advanced Algebra Plane Trigonometry Analytic Geometry Solid Mensuration Differential Calculus

2. SHORT DESCRIPTION

This Review Guide is a product of a research made by Engr. Kissa P. Banawis. The topics included are the identified concepts where the engineering students commonly commit errors. Topics will be arranged per pre-requisite subject starting from Algebra, Trigonometry, Plane and Solid Mensuration, Analytic Geometry and Differential Calculus. Topics in each subject area will be arranged according to areas with the most to least committed errors.

3. AIMS OF THE REVIEW GUIDE

This Review Guide, generally, aims to help the students taking up Integral Calculus in recollecting the concepts in its pre-requisite subjects like Algebra, Trigonometry, Plane and Solid Mensuration, Analytic Geometry and Differential Calculus.

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