Misconceptions of Derivative and Integration Techniques among Engineering Students: A Case Study

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Abstract: This study examines and identifies the problems faced by engineering students in Pakistani universities to learn derivatives and integrations techniques in their first semester calculus course. The study based on data collected from 250 engineering students. In the process of data analyzing students’ misconceptions lie as follows: 1) Product and quotient rules of derivatives were applied on integration problems. 2) \( \ln \) Function was integrated by using derivative techniques. 3) Integrations of trigonometric functions were evaluated by using derivative techniques. 4) Students were found confused in the derivatives and integration using substation techniques. The results of this study will identify the students’ problems and will help them getting clear insight to improving their technology aided learning skills.

1. Introduction
Calculus course is usually offered in the first semester of engineering studies. Calculus plays an important role in learning mathematical tools and degree completion requirements for students studying in engineering universities. But previous poor course learning is a significant cause of content misconceptions. The concepts of this course are used in advanced mathematics courses and hard core engineering courses.

The main objective of this study is to identify, and solve the misconceptions of this course. In the domain of all subjects misconceptions exist such as Biology [1] and Statistics [2]. Zembat asserted that misconceptions are not at all connected to expertise field/person [3]. Basically, misconception rise when students make incorrect abstract thought if they learn the concept wrongly [4]. The difference between differentiation and integration is that they are opposite operation to each other.

Derivative literature shows the several misconceptions of the subject [5], [6]. In 1996 Integration concepts and methods were studied in the frame of students understanding [7]. The main objective of their study was to find out the misconceptions when dealing with the integration problems. In this study they found that students lacked certain conceptual understanding of important concepts.

2. Objectives of the study
The main objective of this study was to find out the misconceptions when dealing with the integration problems. In this study they found that students lacked certain conceptual understanding of important concepts.
3. Research Methodology

3.1 Subject

The population of this study was engineering students and out of them 250 was selected as sample. Convenience sampling [8] had been used to choose Karachi, Pakistan based sample. Following research ethics [9] students were asked to solve problems by using integration by parts technique, trigonometric functions with powers by using substitutions and substitutions problems. Following were the problems used in this study.

\[
\begin{align*}
Q - 1 & \int x \sin x \, dx \\
Q - 2 & \int \ln x \, dx \\
Q - 3 & \int \cos x^3 \, dx \\
Q - 4 & \int x^2 (x + 1)^3 \, dx
\end{align*}
\]

After analysing the data four common misconceptions were found.

Figure 1. Students were trying to apply by part technique but they were confused in selection of u and v.

Figure 2. Students were trying to integrate \( \ln x \) function by using derivative formula.
3.2 Instrument
The sample size of this study is n=250 students. Two-fifty students divided in two groups G1 (n=125) and G2 (n=125). The teaching method of G1 group is conventional. G2 group teaching method is change. We taught limit chapter before derivative chapter, conduct tutorial classes, Mathematics software use during lecture and gave practice sheet for polishing mathematics skills related to the topics. Test was conducted for this study. The test used for this study consisted of four integration techniques and questions of this test were selected from past papers and aptitude test materials. This test paper contains eight questions and all questions carry equal marks. Total marks of this test are sixteen and time duration is half hour. Test paper was proofread and moderate by the senior faculty members of the university. Venue, time and syllabus are same for both groups.

3.3 Summary of test result
In this study SPSS.20 is used to analyses the collected data. The summary of test results is described in Table 1 and Table 2.
Table 1. Group-G1 (n=125)

| No | Total Marks | Mean   | Standard Deviation | Pass Percentage |
|----|-------------|--------|--------------------|-----------------|
| 1  | 2           | 0.84   | 0.54               | 64%             |
| 2  | 2           | 0.68   | 0.51               | 52%             |
| 3  | 2           | 0.60   | 0.49               | 47%             |
| 4  | 2           | 0.48   | 0.44               | 40%             |
| 5  | 2           | 0.45   | 0.42               | 38%             |
| 6  | 2           | 0.39   | 0.39               | 35%             |
| 7  | 2           | 0.30   | 0.36               | 30%             |
| 8  | 2           | 0.26   | 0.33               | 26%             |

Figure 5. Question wise passing percentage (G1-Group)

Table 2. Group-G2 (n=125)

| No | Total Marks | Mean   | Standard Deviation | Pass Percentage |
|----|-------------|--------|--------------------|-----------------|
| 1  | 2           | 1.1    | 0.74               | 82%             |
| 2  | 2           | 1.06   | 0.70               | 76%             |
| 3  | 2           | 0.98   | 0.64               | 72%             |
| 4  | 2           | 0.85   | 0.62               | 62%             |
| 5  | 2           | 0.74   | 0.60               | 56%             |
| 6  | 2           | 0.60   | 0.57               | 47%             |
| 7  | 2           | 0.45   | 0.54               | 38%             |
| 8  | 2           | 0.328  | 0.44               | 28%             |
First question of the test paper covered substitution technique of integration. 25 students from G1 and 40 from G2 group correctly solved these questions. 55G1 and 63G2 students got confused when they reached substitution step and passing percentage of this question is 64 and 82 respectively. Second question was also from previous technique and passing percentage decrease than question 1.

Similarly question number 3 & 4 from Integrations of trigonometric functions and passing percentage of these techniques is 47 - 40 from G1 and 58-50 from G2. Question number 5-8 cover by part technique and passing percentage of these questions are lies in 38-26 from G1and 48-40. Degree of understanding is very low in this part Students highly confused in the selection of function i.e. which function select for derivative or integration. Students learnt the derivatives rules wrongly then they had misconceptions [6]. Table-2 shows G2 group result which is slightly better than group G1.

4. Recommendation and Conclusion
Mathematics is basically a difficult and different subject for students and its teaching is also. The concepts of calculus are complex and repeated. For example, in integration, derivative is used in substitution method. In classroom should be occupied with computer and visualization tools like CAS and DGS software. To teach these concepts, teachers incorporate graphing calculators, spreadsheets, and smart phone applications in classes. To resolve the misconceptions, teachers should give clear insight of the terms of derivatives and integrations mathematically, and should use more than one teaching techniques like problem based learning, analogy, concept maps, concepts pictures etc. Practice sheet and concrete example should be provided to students. The findings of this study will be helpful to calculus students and teachers both.

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