IMPLEMENTATION OF TABULAR INTEGRATION BY PARTS IN DBM2013 TEACHING AND LEARNING PROCESS FOR STUDENTS OF CIVIL, ELECTRICAL AND MARINE ENGINEERING DEPARTMENT IN POLITEKNIK UNGKU OMAR

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ABSTRACT

Integration by Parts is a subtopic covered in Engineering Mathematics 2 (DBM2013) for second semester Politeknik Ungku Omar engineering students. Based on previous Teaching and Learning (T&L) experiences, majority of the students typically facing difficulties in solving the by part integral problems. In the effort to ease the process in traditional integration by parts as well as improving performance of the students, this work attempts to study the effectiveness of implementing tabular integration by parts technique. This study involved in total of 107 students from Civil, Electrical and Marine Engineering Department in Politeknik Ungku Omar who enrolled Engineering Mathematics 2 (DBM2013) for December 2018 session. The effectiveness of the implementation of tabular integration by parts is measured by analyzing the data obtained from pre-test (by part technique) and post-test (by tabular integration technique). Survey of students' interest was conducted and the result of final examination was adopted as the benchmark to evaluate the performance of students' by part integral skill. Based on the collected December 2018 session final examination answer script, 52 students had answered Question 5 (i.e by parts integral problems) by using tabular integral by parts technique. Integration by parts is an optional question in DBM2013 final examination, hence almost half of the students confidently chosed to answer Question 5. According to the marked answer script, 96% of the students obtained perfect solutions by using tabular integral by parts technique. This indicates a promising achievement in T&L by using tabular integral.

Keywords: Integration by Parts, Tabular Integration by Parts

1. Introduction

There are several techniques of integration which can be used to evaluate the integrals of elementary functions as mentioned by Mardeli and Mohammad (2018). According to Sanjay K. Khattri (2008), integration by parts and tabular integration are used to integrate product of two functions. The technique of tabular integration is very well known. But still it has not found its way into textbooks. Traditionally we teach integration of product of two functions by technique of integration by parts. It is our experience that students take more time to learn and successfully apply this technique. Especially in the case that we need to apply the technique of integration by parts repeatedly. We find that students make mistakes. On the other hand, we find that students easily apply the tabular integration technique even in complex situations.

Quoted from David Horowitz's (1990), Tabular Integration by Parts for The College Mathematics Journal, only a few contemporary calculus text books provide even cursory presentation of tabular integration by parts. This is unfortunate because tabular integration by parts is not only a valuable tool for finding integrals but can also be applied to more advanced topics including the derivations of some important theorem in analysis. The technique of tabular integration allows one to perform successive integrations by parts on integrals of the form.

One of those techniques is the Integration by Parts which is a subtopic covered in the topic Integration in DBM2013. It is very useful in many integrals involving product of functions. The theorem relates the integral of a product of functions to the integral of their derivative and anti-derivative.

The formula for integration by parts is derived from the integration of the product rule of differentiation as shown in Equation (1).

$$\int (u\frac{dv}{dx})dx = uv - \int \left(v\frac{du}{dx}\right)dx \qquad (1)$$

Using this formula needs the students to identify the function to be differentiated and the other to be integrated.

Emil C. Alcantara (2014) stated that an abbreviation that is very helpful to remember when solving integration by parts is LIATE. The word LIATE stands for Logarithmic, Inverse trigonometric, Algebraic, Trigonometric and Exponential. Based from the rule, product of functions that appear first from LIATE is *u* and *dv* whatever is left. It only provides the students to determine product of functions to differentiate and integrate not simplifying the steps in by parts integral. However, repeated by parts integral needs to be done when dealing with integrating power of product of functions which this may leads to mistakes as the students contend doing repeated by parts integrals.

David Horowitz (1990) commented that only a few contemporary calculus textbook provide even a cursory presentation of tabular integration by parts. This is unfortunate because tabular integration by parts is not only a valuable tool for finding integrals but can also be applied to more advanced topics.

The general objective of this study is to improve the students understanding and skill in solving integration by parts questions. This study aims to:

i. Simplify the conventional method and introduce the tabular method which is far more systematic.
ii. Attempt to improve students understanding towards learning integration by parts topic.
iii. Examine the effect of the implementation of tabular integration by parts.

By using the formula by Parts Integral needs the students to identify the function to be differentiated and the other to be integrated. In a study made by Emeje and Onalo (2016), the process can be lengthy and may required serious algebraic details as it will involves repeated iteration hence causing confusion among students. They tend to do errors in their working. Students often find it too tedious to remember and to follow exactly in order to reach to the final answer as needed.

Lecturer's reported that the students usually have difficulties in choosing *u* and *dv* from the functions given and get out of the sequence of the workings while doing a long calculation. A common mistake by those using integration by parts is to neglect *dx* with the term in both *dv* and *du*. This is a minor point, but in order to get the solutions, it needs to be included on intermediate steps. Whenever we use integration by parts, we take all the terms in the integral for *u* and *dv*, that includes the *dx.*

2. Methodology

This study has been conducted to encourage using tabular integration by parts as part of the advanced tools.

2.1. Target Group

The population for the study were from Semester 2 Engineering Students in Ungku Omar Polytechnic. The sample was a group of selected 107 engineering students that 20 students of Diploma in Geomathic (DGU2C), 33 students of Diploma in Civil Engineering (DKA2A), 23 students of Diploma in Marine Engineering (DKP2) and 31 students of Diploma in Electric and Electronic Engineering (DTK2A).

2.2. Research Instruments

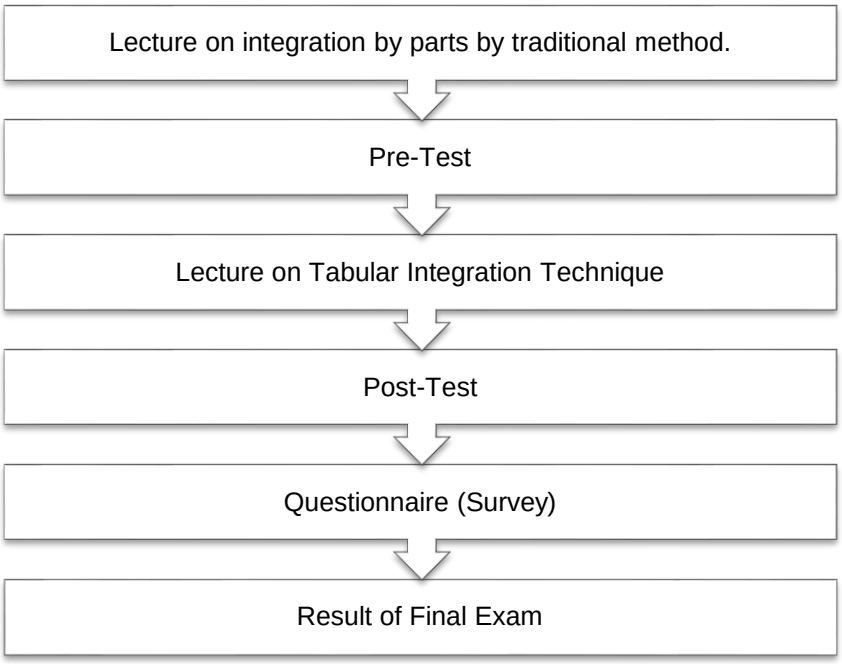


Figure 1 : Flowchart of Methodology of This Study

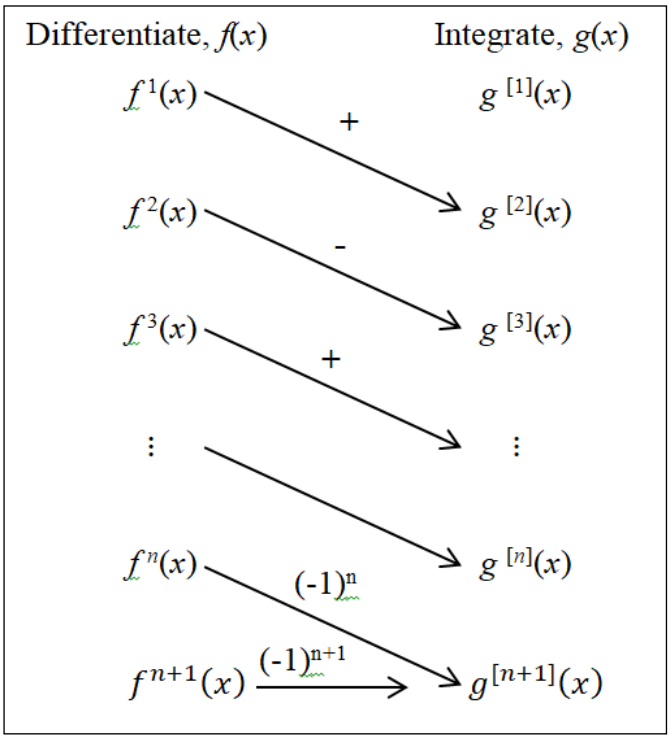
Figure 1 showed that steps taken in completing this study. Lecture explained on integration by parts using the traditional method to the target group with a few examples and exercises were given to the target group. Then, they had pre-test to identify the level of students' understanding and skill in integration by parts technic. The pre-test question focused on integration by parts involving algebra, trigonometry and exponential. Time given to complete the pre-test was 10 minutes. Next the students were thought tabular integration by parts technic and they were given examples and exercises.

The target group were given a 5 minutes post-test using tabular integral technic which consist the same questions they answered in pre-test. According to Emil C. Alcantara (2014), tabular integration by parts is a tool which shortcuts the process and organizes work in table and it is proven from the post-test given. This tool allows students to save tremendous amounts of time in obtaining their answers as quoted by Stolyarov G II (2007). The time given were shorter due to simplification steps in tabular integral technic. Then survey on students' interest using tabular integral was made to the target group and finally results from their final exam were obtained.

Tabular Integration by Parts comes as a much easier visual representation of the process below. This can be seen in Figure 2. This valuable tool is done in a table form which gives a better and clearer vision to the students in the process of understanding it. This method works to avoid tedious steps that occur in repeated iterations and same answer is obtained. The only difference is that, tabular integration by parts delivers the working in a more systematic way compared to the traditional method. Tabular

integration by parts is a great tool allows student to perform successive answer with smooth steps compared to lengthy traditional method.

$$\int u\left(\frac{dv}{dx}\right)dx = \int f(x)g(x)\,dx$$



(Source : David Horowitz, 1990)

Figure 2 : Integrating product of functions

3. Result and Discussion

3.1. Quantitative Analysis

From Figure 3, good marks gain from students accounted for very little, which only small group of students answered correctly. In order to achieve good results from students, effort in discover new tools or technics are important to give conducive learning environment for the students. Preparing for the study of mathematics is essential in order to master at any conditions of calculations in mathematics. The unorganized steps in by part integral technic makes students tend to do mistakes which results not to understand the product of functions integral at all. Lengthy steps in by part integral reduced their interest in answering the question and not completing their solutions appropriately.

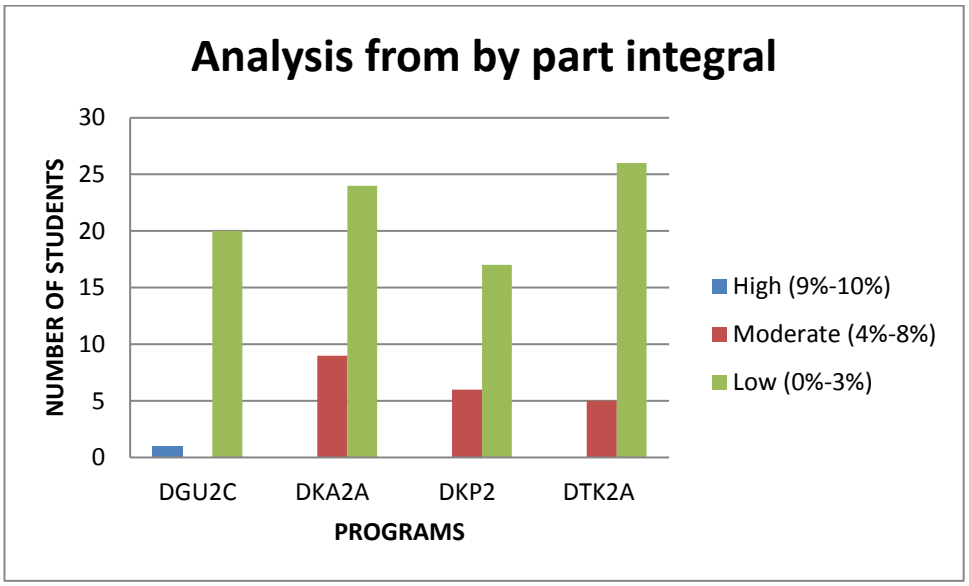


Figure 3: Analysis from by part integral.

According to analysis in Figure 4, we can see the students achieved good marks in the task given. They managed to solve problems given providing with simpler technic. In order to gain good results from students, it requires lecturers to discover new technics in teaching to bring the students positive view in mathematics and to improve the degree of attention from them. Tabular integral technic improved the efficiency of teaching in classroom.

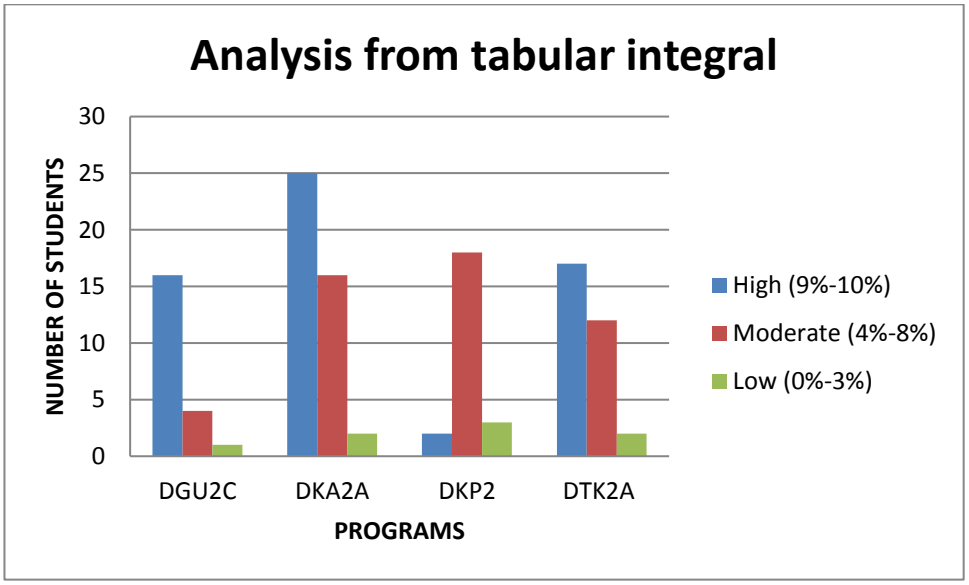


Figure 4: Analysis from tabular integral

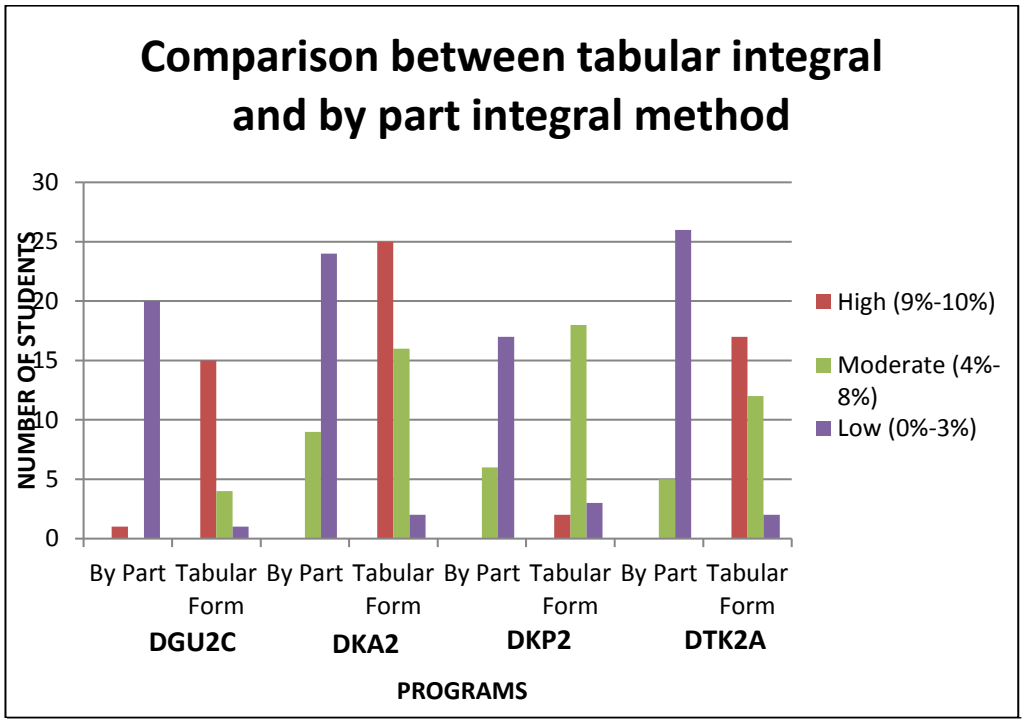


Figure 5: Analysis between tabular integral and by part integral

According to analysis, we can see that students keen to use tabular integral technic which this leads to high marks in the post-test questions given. With organized steps in tabular integral technic improved the students learning method. Hence they confidently chose tabular integral technic to obtain answer from the task given. Big differences seen from above Figure 5, proved that by changing to different technic students were competent in solving the problems given.

Table 1. Analysis from final examination December 2018 session

Programs	***Students answered Number of Question 5 (tabular integral only)***					
	Number of students	***Percentage of students***	***Number of students Failed***	***Percentage of failure***	***Number of students passed***	***Percentage of passing mark***
DGU2C	10	32.25%	-	0%	10	100%
DKA2A	19	57.58%	-	0%	19	100%
DKP2	12	50%	-	0%	12	100%
DTK2A	11	35.48%	2	18.18%	9	81.82%

From Table 1, students successfully answered Question 5 which voted 96% students obtained perfect solutions in their final examination paper. Only a small group of students didn't perform where they desperately lack of mathematical knowledge. They were 2 tabular integral questions from Question 5 which contribute 13 marks out of 25 marks in total of Question 5.

3.2. Qualitative Analysis

Table 2. Analysis between tabular integral technic and by part integral technic based on students' responses

No.	***Student's Interest***	***Total Score***			
		Agree		***Not Agree***	
		Total Num. Of Students	***%***	***Total Num. Of Students***	***%***
1	Students understand the technic of tabular form	107	100	0	0
2	Students prefer technic of tabular form compared to Traditional Technic By part Integral	99	92.5	6	7.48
3	Students is given sufficient time to solve the problem by using Tabular form compared to Traditional Technic By Part Integral	90	84.11	7	7.78
4	Students have gained confidence in problem solving	98	91.59	9	8.41
5	Students motivated to do more exercise by using Tabular Integral	89	94.38	5	6.49

As evidenced in Table 2 most students surveyed enjoyed learning tabular integral technic in obtaining their answer. Obviously it is proven that tabular integral technic is a miracle tool for all students. Students able to understand hence mastered this technic which contributes interest in product of functions integral. Tabular integral technic proven most favorite technic since it simplifies the hassle students went through when they were doing by parts integral technic. Students strongly agreed this technic stimulate the students' learning motivation and give them positive view in mathematics.

4. Conclusion and Recommendation

From this study, it is concluded that a better understanding in solving by parts integral by using tabular integration technic has helped students from getting confused to solve the by parts integral problems. It has upgraded the level of knowledge of the students to another level and enables students to master product of functions integral. This implementation has improved their learning efficiency in solving the problems of integration by parts. Consequently, by parts integral became favourite questions instead the most hated questions due to its tedious working. Students enjoy doing tabular integral and increased confident in math problems. This results support the study carried out by Emil C. Alcantara (2014), tabular integral as an alternative, efficient and elegant way of finding the integrals of product of elementary functions are provided. It aims to help the students to appreciate the techniques of integration in a more interesting way.

Mathematics is an abstract subject. Teaching it in the best method that could give a better and easier understanding to students would make the teaching job more effective. A magic technique in mathematics would bring conducive learning to promotes students' learning enthusiasm and stimulate the students' learning motivation.

Further studies are recommended to extend the results of the study in helping the students. There are many more mathematics topics that applied in Ungku Omar Polytechnic which need clear observation to come up with an easier method of teaching it rather than traditional teaching methods.

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