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# Examining The Students' Understanding Level on the Concept of Differentiation Topics in Calculus I Subject

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**Abstract**

Numerous studies have discovered that students' performance in Calculus I contributed to one of the highest failure rates in Mathematics courses among Universiti Teknologi MARA students. According to the results of Assessment 1 of the March-August 2022 session, which covers the topics of limits, continuity, and differentiation, most students were unable to obtain high or full marks on the topic of differentiation when compared to the topic of limits. Meanwhile, in Assessment 3 (group video presentation), which focuses on differentiation, most students gain nearly full marks. This assessment is used to encourage critical thinking, analytical, and communication skills, as well as effective teamwork and problem-solving methods. Therefore, the purpose of this research is to determine whether group video presentation can assist students in gaining a deeper understanding of the differentiation topic, as well as to investigate students' perceptions of this type of assessment for their learning differentiation topics in the Calculus I subject. The survey questionnaire was distributed to 86 full-time diploma students enrolled in Calculus I. The findings show that students are willing to accept that learning differentiation topics should be approached in a more technological manner.

**Keywords:** Differentiation, Assessment 3, Perception, Calculus I, Group Work

## Introduction

Mathematics is a fundamental subject that needs to be learned from primary school to university. According to Nasir et al (2013), students' understanding of basic mathematics in primary and secondary school will be applied at the university level, particularly during the first year of mathematics courses. Mathematics is a challenging subject that requires creative thinking in solving daily life problems, including telling time, counting, paying for something, measuring something, and solving problems using algebraic operations (Amiruddin et al.,

2022; Pantaleon, 2022). In Malaysia, in order to further study at tertiary level, all students must sit a common examination known as Sijil Pelajaran Malaysia (SPM), where Mathematics is one of the compulsory subjects while Additional Mathematics is an elective subject. The grades in these two subjects will determine the students' tertiary education path.

The branch of mathematics known as calculus deals with the analysis of change. Russell (2020) defined Calculus as the study of the rate of change, which can be divided into two branches: differential calculus and integral calculus. Differential calculus determines the rate of change of a quantity, whereas integral calculus finds the quantity where the rate of change is known. Calculus was invented independently by the 17th-century mathematicians Gottfried Leibniz and Isaac Newton. Although Newton invented it first, Leibniz developed the notations that mathematicians use today.

At the University of Technology MARA (UiTM), Calculus 1 (MAT183) was taken by first-year Diploma students. This subject consists of five chapters. There are limits and continuity; differentiation; application of differentiation; integration and application of integration. Almost every semester, this subject has been recorded as one of the courses with the highest failure rate. According to Ahmad et al (2017), more than 30% of students enrolled in Diploma in Quantitative Science (CS113), Diploma in Computer Science (CS110), and Diploma in Mathematical Science (CS143) students at UiTM Johor have failed this course. This scenario has not happened recently, but Calculus has had a high dropout and failure rate since a long time ago (Cezar et al., 2022). One of the reasons for this scenario is the lack of fundamental mathematical skills (Salleh and Zakaria, 2011). In the survey conducted by Hassim and Abidin (2020), the respondents agreed that having a poor grade in Mathematics and Additional Mathematics during the SPM examination is one of the reasons for the declining student's ability to learn and understand Calculus 1. Therefore, students who cannot master fundamental mathematical skills may struggle to solve other mathematical problems, such as differentiation (Nasir et al., 2013). According to Ahmad et al (2019), most students have difficulties understanding the concept of differentiation, especially when it involves trigonometric functions.

According to Sjoblom (2022), participating in mathematical discussions while working with other students has become a popular way for students to learn mathematics in recent decades. This statement is also supported by Brandt and Schütte (2010), Cobb et al. (2001), and Sfard (2015). Group work plays a vital role in cooperative and collaborative learning methods. It has attracted significant investigative interest. In research by Sofroniou and Poutos (2016), compared to competitive or individualistic experiences, studies show that these pedagogical practices of group work result in higher achievement and more pleasant connections among students. It is expected that the group work will help them to develop skills, knowledge and be more creative in elaborating the problem statement (question) about a specific topic. Webb (1991); Webb et al (1995) revealed that group work is most beneficial when students learn how to work in groups and present, provide, and accept help. Therefore, the purpose of this study is to see if group video presentations of Assessment 3 can help students gain a deeper understanding of the differentiation topic. Aside from that, this study also wants to investigate students' perceptions of the group video presentation for their learning in the Calculus I subject. As a result, it will also encourage lecturers to evaluate the effectiveness of the teaching and learning process in light of the topics covered.

## Methodology

The sample of this study was conducted on 86 diploma students randomly selected full-time from the Diploma of Computer Science (CS110), Diploma of Science (AS120), and Diploma of Science Mathematics (CS143). These students registered for the Calculus I subject of the March–August 2022 academic session at Universiti Teknologi MARA, Perak Branch Tapah Campus. The data was mainly collected through a survey questionnaire that was created using Google Forms. The students were asked to fill out the questionnaire, and some of the questions consisted of a three-Likert scale representing the different satisfaction levels (agree, moderate, and disagree). There are four main sections to the questionnaire:

i. Section A: Socio-demographic Information of Respondents
ii. Section B: General perception of the Calculus I subject and group video presentation of the Assessment 3
iii. Section C: Three main attributes with sub-criteria in the evaluation process of the group video
presentation of Assessment 3 (self-confidence-anxiety, affective-learning enjoyment, and affective - mobility)
iv. Section D: Perception of what contributes to the effectiveness of teaching differentiation topics in the Calculus I subject

This survey questionnaire was distributed after the students completed and presented their group video presentation. Preliminary study of the student's performance in Assessment 1 of Calculus I subject within the March–August 2022 session, which covers the topics of Limit (Question 1) and Differentiation (Questions 2–6), illustrated in Figure 1. The performance involved three groups (67 students) of the overall students taking this course, which showed that most students could not obtain high or full marks on the topic of differentiation compared to other topics.

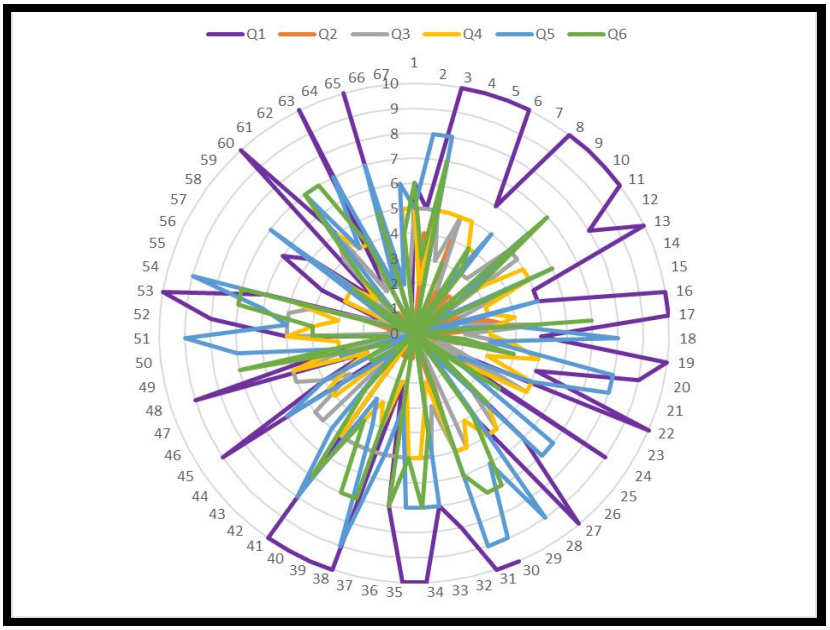


Figure 1: The performance of the students in the Assessment 1.

An Assessment 3, known as the group video presentation, is implemented to develop a range of critical thinking, analytical, and communication skills; effective teamwork;

appreciation and respect for other views, techniques, and problem-solving methods. Hence, Assessment 3 promotes active learning and enhances student learning in the differentiation topics. This study aimed to investigate whether group video presentations of Assessment 3 can help students gain a deeper understanding of the differentiation topic. In addition, this study also aims to explore students' perceptions of the group video presentation for their learning in the Calculus I subject.

The group video presentation of the Assessment 3 consists of three to four students per group. The students were required to create an innovative video based on the problem statement provided by their lecturers. The topic for this task is the application of differentiation and integration. Each group must include an introduction, briefly explaining differentiation or integration topics, problem statement, detailed solution, and conclusion of their presentation. All members are required to participate and present their parts. The Course Learning Outcome (CLO) for Assessment 3 is to demonstrates active collaboration with team members in identifying problems related to the application of differentiation and integration. According to Adam (2004), learning outcomes (LO) are essential strategies in defining the consequences of learning for the student, citizen, employer, and educator. It also emphasizes the connection between teaching, learning, and assessment since it is crucial to the design and development of the curriculum and represents a paradigm shift from teaching to learning (student-centred learning). It is supported by Masnoor (2022) statement that LO can also be utilized to highlight academic achievement that students have acquired and the capability to prove it at some point during the learning process.

**Findings and Discussions**

The qualitative analysis of the findings from the questionnaire survey was divided into four main sections as follows.

*Section A: Socio-demographic Information of Respondents*

Table 1 summarizes the socio-demographic information of respondents from Section A. The respondents comprised 86 Diploma students randomly selected full-time at Universiti Teknologi MARA, Perak Branch, Tapah Campus. The largest number of respondents is the Diploma in Sciences (70.9%), or 61 out of 86 respondents. The second largest group of respondents is the Diploma in Computer Sciences (18.6%), or 16 out of the 86 respondents. Next, only 7%, or six out of the 86 respondents, have a Diploma in Mathematics, and only 3.5%, or three out of the 86 respondents, have a Diploma in Statistics.

Table 1
*Socio-demographic Information of Respondents*

| Respondent's Information | | Frequency | Percent |
|---|---|---|---|
| **Gender** | Male | 21 | 24.4 |
| | Female | 65 | 75.6 |
| | **Total** | **86** | **100.0** |
| **Program of Study** | Diploma in Mathematical Science | 6 | 7.0 |
| | Diploma in Statistic | 3 | 3.5 |
| | Diploma of Science | 61 | 70.9 |
| | Diploma in Computer Science | 16 | 18.6 |
| | **Total** | **86** | **100.0** |

Section B: General perception of the Calculus I subject and group video presentation of the Assessment 3

Figure 2 summarizes the findings of the three questions in this part that required individual opinion comments and groups them thematically based on the frequency of responses.

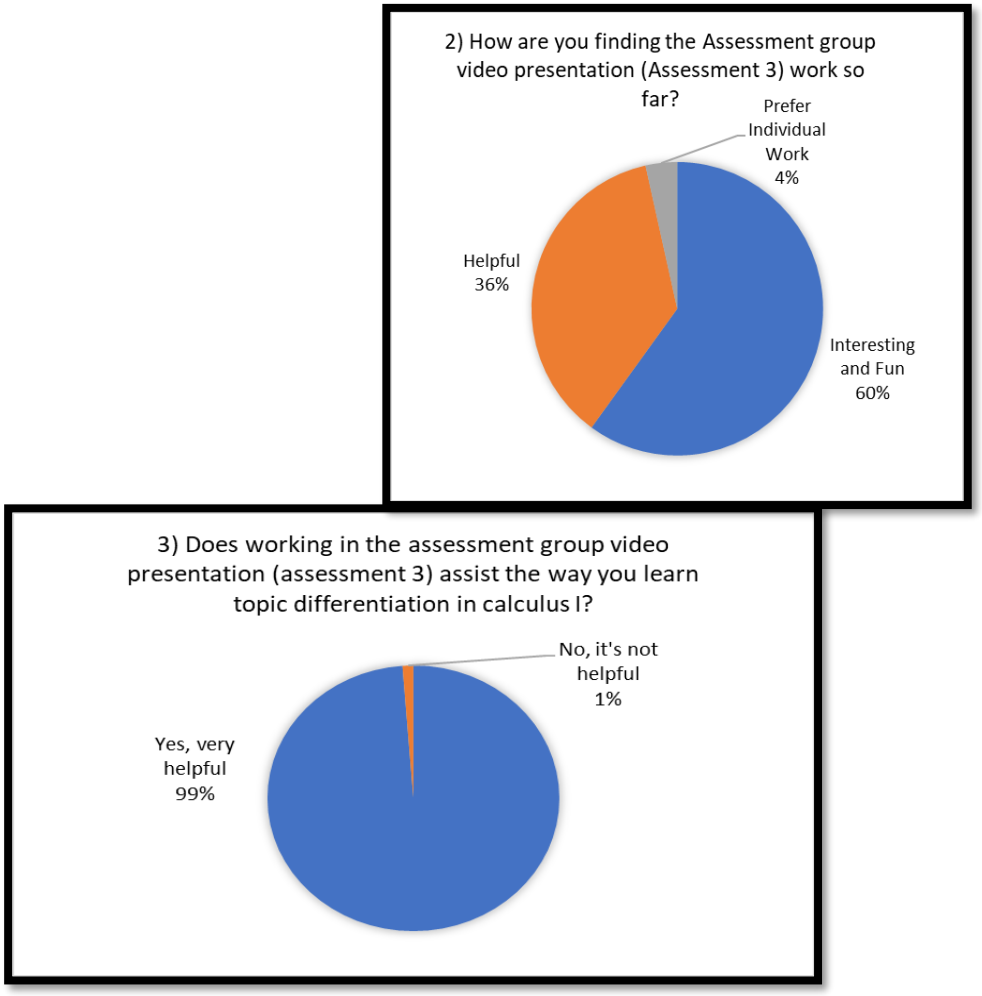


Figure 2: Student responses to Q1–Q3 of the Section B Questionnaire

For question 1, it describes students' experience in learning Calculus 1. It showed that most students agreed that learning Calculus 1 was interesting and fun. From the responses to questions 2 and 3, the majority of students agreed that group video presentations (Assessment 3) have been helpful and enjoyable. It can be recognized that group video presentations of Assessment 3 enabled students to collaborate, boosted their confidence in the differentiation topic, and delivered another pedagogical approach to solidify their Calculus I knowledge.

*Section C: Three main attributes with sub criteria in the evaluation process of group video presentations of the Assessment 3*

Section C was divided into three main attributes, which consist of students' self-confidence, the effect of enjoyment on learning differentiation topics, and the effect of video presentation of the Assessment 3 on differentiation topics towards their learning.

*Self-Confidence (Anxiety)*

A bar chart in Figure 3 shows an analysis of the questionnaire's Likert scale data. The key findings from this study are that the majority of students believe that working in groups encourages them to learn; think that working in groups is a good idea; enjoy working in groups; and believe that all group members have an equal opportunity to contribute to the group activity's finished result.

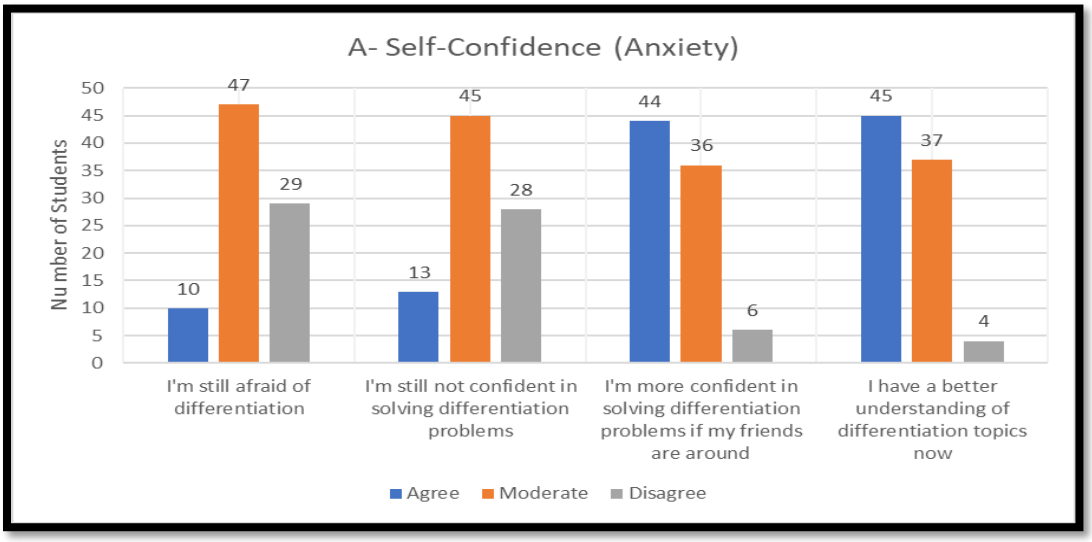


Figure 3: Bar chart showing the number of students responding to the Likert scale Self-Confidence (Anxiety) questions in the questionnaire

Furthermore, based on the educators' perspectives on group work for this intervention, it may be argued that group activity serves social purposes in addition to having a significant impact on learning Calculus I. It was found that group presentations helped students learn Calculus I more enthusiastically and aided those who were having difficulty overcoming their anxieties. Additionally, students appeared to find this approach to learning to be more interesting and fun, which encouraged them to learn through active discussions rather than memorization methods (Kocak et al., 2009).

*Affective (Learning Enjoyment)*

Students' satisfaction with learning enjoyment was depicted in Figure 4. The findings showed that students generally thought that using videos to learn about differentiation was more enjoyable than learning standard formal notes. They overwhelmingly concurred that the use of colorful graphics enhanced learning. The majority of students concurred that learning was made more interesting by group video presentations on differentiation topics.

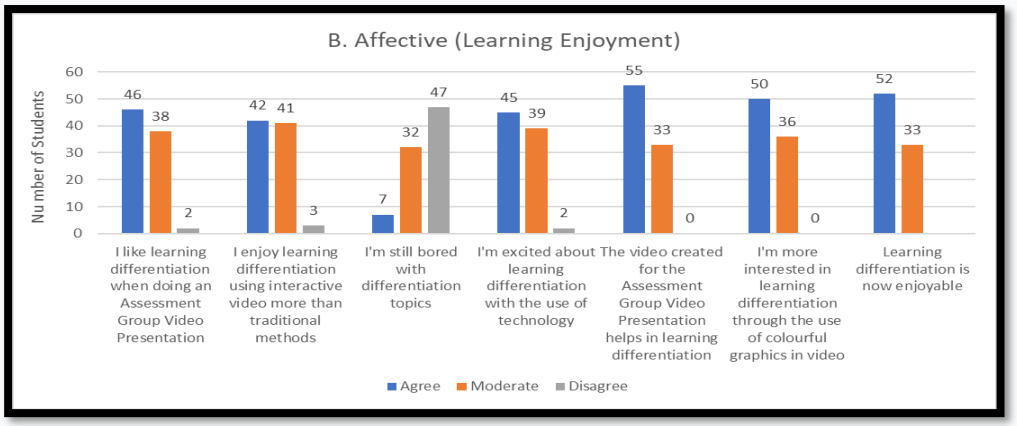


Figure 4: Bar chart showing the number of students responding to the Likert scale Affective (Learning Enjoyment) questions in the questionnaire

*Affective (Mobility)*

Figure 5 presents the effectiveness of video presentation based on mobility attributes. As can be seen from Figure 5, the first question showed the majority of the students agreed to the comfort of using the videos as a tool to learn differentiation topics in the Calculus I subject. Meanwhile, the second question reveals that the majority of the students preferred to watch video presentations repeatedly anywhere and anytime they wanted. This concludes that students are comfortable using video presentations as a tool to enhance their understanding of differentiation topics specifically. Moreover, with the ongoing technological breakthroughs, the students have demanded that the teaching methods be more modern and in line with the evolving technical advancements.

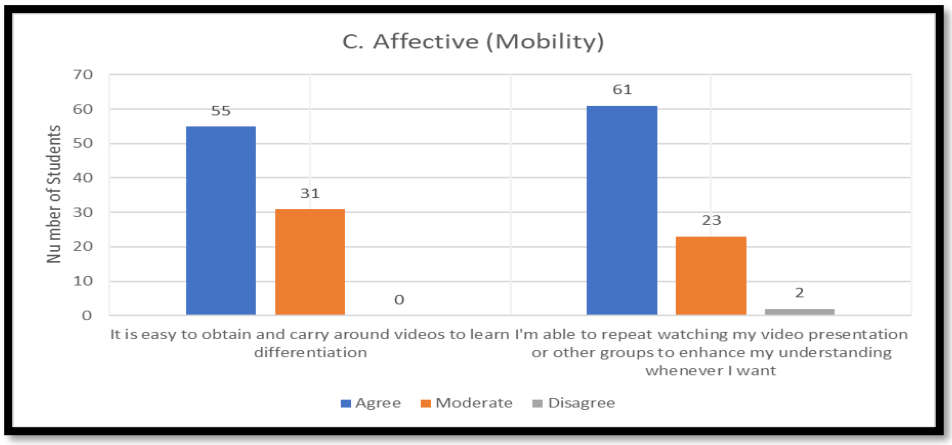


Figure 5: Bar chart showing the number of students responding to the Likert scale Affective (Mobility) questions in the questionnaire

*Section D: Perception of what contributes to the effectiveness of teaching differentiation topics in Calculus*

This section concerns students' responses to the effectiveness of teaching Calculus I subject as illustrated in Figure 6. These questions are significant for educators or lecturers to improve their teaching delivery. Dominantly, 61 out of 86 students (70.9%), preferred the common misconceptions to be exposed and discussed instead of directly discussing the exercise or tutorial questions. It proves that students are well prepared with an active learning approach and critical thinking for their learning process. Secondly, 53 students (61.6%) chose

cooperative small group work as a didactic approach. The small group discussion promotes student-centred learning and makes learning enjoyable.

Thirdly, 43 students (50%) reported that another effective teaching strategy for Calculus I subject is to stimulate reasoning rather than just get the answer. Meanwhile, 41 students (47.7%) believed that using technology in appropriate ways makes them better understand the differentiation topics and creates connections between the topics of the Calculus I subject.

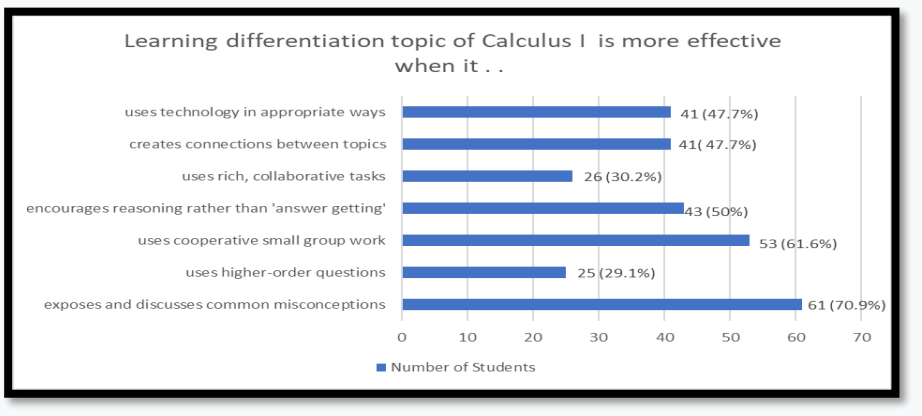


Figure 6: Bar chart showing the number of students responding to the different options for effectiveness of learning differentiation topic of Calculus I

These views seem to convey the idea that lecturers must lead students toward their active participation in the class. Besides, around 62 (30.2%) also agreed to use rich, collaborative tasks, and 25 students (29.1%) highlighted the use of higher-order questions in the effective Calculus I subject.

**Conclusions**

Most students agreed that group video presentations (Assessment 3) have been helpful and beneficial for the purpose of gaining an in-depth understanding of the differentiation topic in the Calculus I subject. More than half of the students considered learning by watching videos were more enjoyable than using the traditional strategy. Most students also felt that Assessment 3 had significantly helped them overcome their Calculus I subject anxiety and strengthened their understanding of the topic.

This research highlighted that students' adaptability to education in the 21st century can be empowered through activities which harness their creativity, critical thinking, communication, and teamwork skills. In conclusion, most of them thought that learning Calculus I, specifically in differentiation topics, was most effective when using a student-centered learning approach. It also motivates the educators to enhance the effectiveness of teaching delivery method and to actively engage with the students in class activities.

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