

Tailoring Calculus Instruction: A Study on the Relationship between Learning Styles and Assessments of Differentiated Instruction for Personalized Teaching Strategies

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Abstract

The study investigated the correlations among students' learning styles, and their assessments of the elements of differentiated instruction utilized in teaching Calculus. The research was focused on the educational landscape of 108 STEM students at Talisay Senior High School in Tumaway, Talisay, Batangas during a specific academic year. This research aimed to provide a comprehensive overview of the students' experiences within a specific timeframe, with the outcomes intended to enhance the customization of educational content, process, product, and learning environment to better suit individual student preferences. The data collection involved the administration of a self-constructed questionnaire to assess the elements of differentiated instruction, along with the utilization of VARK version 8.01 to identify the students' learning styles.

A quantitative research method was used to examine the associations between students' learning styles and their assessments of the elements of differentiated instructions within the group of 108 STEM students. A convenience sampling technique was employed to select the participants, specifically focusing on the STEM students who are part of the researcher's academic institution and currently enrolled in the Calculus subject.

According to the results, there is a significant relationship between students' learning styles and their assessments of the elements of differentiated instructions in terms of content, process, product, and learning environment.

Based on the findings, the researcher suggested a customized teaching strategies for diverse learners in Calculus.

Keywords: Differentiated Instruction, Visual, Auditory, Read/Write, Kinesthetic

Introduction

Differentiated instruction recognizes the inherent diversity among learners. Students have unique learning styles, strengths, and preferences. Some students grasp concepts better through visual aids, while others may excel with auditory explanations (Chetty et al., 2019). Moreover, students' progress at different paces, making it essential to tailor teaching methods to individual learning speeds. Differentiated instruction emphasizes

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the use of a variety of teaching strategies that cater to different learning styles and paces. It promotes an inclusive environment where every student can thrive academically. By recognizing and accommodating these differences, educators can create a more engaging and effective learning experience for all students.

In the Philippines, the educational system is actively adapting to the diverse needs of learners. The Department of Education (DepEd) in 2022 has implemented initiatives and policies related to differentiated instruction, reflecting the national commitment to providing quality education to all students. These initiatives aim to enhance the teaching-learning process by recognizing and accommodating the diverse learning styles and abilities of students. By integrating differentiated instruction into the national curriculum, the Philippines is taking proactive steps to create an inclusive educational environment.

Despite the growing recognition of the importance of differentiated instruction, there exists a research gap concerning its application in teaching Calculus, particularly in the context of specific learning styles. While numerous studies have explored differentiated instruction in general, few have delved deeply into its implementation within the domain of Calculus education. Understanding how different learning styles—visual, auditory, read/write, and kinesthetic—affect the comprehension and retention of Calculus concepts is a significant gap in the existing literature.

In the context of Calculus education, students often struggle with abstract concepts and complex problem-solving (Case & Speer, 2021). Different learning styles can significantly influence how students' approach and understand these intricate mathematical ideas. Visual learners may benefit from graphical representations of functions and derivatives, while auditory learners might grasp concepts better through verbal explanations and discussions. Read/write learners may excel when provided with written explanations and textbooks, whereas kinesthetic learners could comprehend Calculus principles through interactive, hands-on activities.

Several studies have examined the impact of differentiated instruction on high school mathematics performance (Xue & Schimann, 2021; Hattie et al., 2021; Fehlauser et al., 2021; Firnberg & Steward, 2022; Leung & Yang, 2022). While their findings were significant, the studies did not specifically focus on calculus education, nor did they investigate the influence of different learning styles.

By examining the impact of tailored teaching methods on the understanding and performance of Calculus, this research aimed to contribute valuable insights to both the fields of mathematics education and differentiated instruction. The study will not only provide practical strategies for educators but also add theoretical depth to the existing body of knowledge, enhancing our understanding of how differentiated instruction can be effectively employed in advanced mathematical education.

Methodology

Research Design

For this study, the researcher used the quantitative research method. Quantitative research, as described by Cresswell (2020), is a technique utilized to explore the connections among variables through the collection and examination of data, typically employing statistical methods. This process entails the selection of a representative group of participants, the measurement of variables using standardized tools, and the analysis of data using statistical assessments to formulate conclusions.

Research Locale

The study was conducted at Talisay Senior High School in Tumaway, Talisay, Batangas. The population of the study comprised 108 STEM students enrolled in the school. This locale and population were chosen to ensure a focused and specific sample that aligned with the research objectives.

Research Participants

The respondents of the study were the 108 STEM students at Talisay Senior High School, who were considered as a main provider of data for this research. The data collected included evaluation of the elements of differentiated instruction in teaching Calculus. Additionally, their learning styles were determined through the utilization of VARK version 8.01 questionnaire. A convenience sampling technique was employed to select the participants for this study, specifically focusing on the STEM students who are part of the researcher's academic institution and currently enrolled in the Calculus subject.

Research Instrument

The survey instrument was chosen for quantitative assessment due to its cost-effective design and the ease with which conclusions can be extrapolated from a sample to a larger population. A survey additionally offered a swift turnaround time for gathering data and discussing characteristics of a population from a relatively limited sample of individuals (Cresswell, 2021).

Additionally, for the specific identification of students' learning styles, the VARK questionnaire version 8.01 was utilized. Developed by Neil D. Fleming and Colleen E. Mills, the VARK questionnaire is a well-established tool widely used in educational research. Its validity and reliability have been demonstrated through numerous studies, making it a trusted method for identifying diverse learning preferences. This standardized instrument aided in precisely categorizing students into visual, auditory, read/write, and kinesthetic learning styles, providing a nuanced understanding of their individual preferences and needs.

To test the reliability, the researcher performed pilot testing of the questionnaire on a cohort of 31 STEM students from Talisay High School, a privately owned educational institution located in Talisay, Batangas. It is worth noting that these 31 STEM students were distinct from 108 participants included in the study sample. The Cronbach Alpha coefficient was calculated to evaluate the internal consistency of the item statement. The resulting value of 0.884, which exceeded the threshold of 0.70, indicated that the questionnaire was sufficiently reliable.

Data Gathering Procedure

Upon completion of the validation and reliability testing of the questionnaire, the final version was administered to the respondents after obtaining prior permission from the principal of Talisay Senior High School. The permission granted allowed all 108 students to participate in the survey. The survey questionnaire was personally administered by the researcher, who provided an explanation of the study's objectives and the estimated completion time. Following the survey, the researcher compiled the data and meticulously analyzed it using appropriate statistical tools. Primary data was complemented with references to secondary sources like published articles and studies to validate survey findings.

Results and Discussion

Table 1 illustrates those 41 female responses in the VARK questionnaire, accounting for 37.96% have been identified as auditory learners, indicating a preference for auditory learning among the majority of female respondents. Conversely, 35 male responses in the VARK questionnaire, comprising 32.41%, are categorized as kinesthetic learners, showing a predominant inclination towards kinesthetic learning among male respondents.

Table 1 Description of Learners according to their Learning Styles				
Learning Style	Male	Female	Frequency	Percentage (%)
Visual	8	5	13	12.04
Auditory	-	41	41	37.96
Read/Write	13	6	19	17.59
Kinesthetic	35	-	35	32.41
TOTAL	56	52	108	100

Multiple studies have shown that male students exhibited a higher inclination to utilize the kinesthetic learning style than their female counterparts, which in turn favored the auditory learning style (Wilson & Wilson, 2022; Adescope and Nesbit, 2022; Kim and Lee, 2022; Ahmed and Khan, 2023; Lim and Johnson, 2023; Patel & Patel, 2023). Furthermore, Garcia and Rodriguez (2022) discovered that the variation in learning approaches was particularly noticeable in the fields of science and mathematics. This indicates that the differences in learning styles based on gender may also differ across various academic subjects.

Table 2 Students' Assessment of the Elements of Differentiated Instruction In Terms of Content				
Indicator	Mean	SD	VI	EI
1. Match Calculus lessons to match varying readiness levels that ensures all students grasp fundamental concepts.	3.34	0.71	SA	HP
2. Provide varied materials other than the standard text for handling differences in computing levels.	3.27	0.68	SA	HP
3. Provide supplementary materials that caters to different learning profiles such as visual aids for visual learners or interactive simulations for kinesthetic learners.	3.49	0.69	SA	HP
4. Offer additional readings or advanced problems for students who require more challenging tasks in Calculus.	3.46	0.70	SA	HP
5. Modify examples and exercises to relate to real-life scenarios that enhances students' understanding of complex Calculus concepts.	3.53	0.71	SA	HP
Overall	3.44	0.70	SA	HP

Legend: SD – Standard Deviation; VI – Verbal Interpretation; SA – Strongly Agree; EI – Extended Interpretation; HP- Highly Practiced

Table 2 shows that Differentiated Instruction in terms of content is highly practiced as revealed by an overall Mean of 3.44. Based on the results, it is evident that the students strongly agree that lessons in Calculus should be tailored to their individual readiness levels to enhance their understanding of key concepts.

Highest Mean was indicator 5, “modify examples and exercises to relate to real-life scenarios that enhances students’ understanding of complex Calculus concepts” as evidenced by a Weighted Mean of 3.53 or Highly Practiced. According to Arranz (2023), the act of connecting mathematics to real-life situations can effectively reduce the abstractness of the subject matter and increase student engagement.

Lowest Mean was indicator 2, “provide varied materials other than the standard text for handling differences in computing levels” as evidenced by a Weighted Mean of 3.27 or Highly Practiced. According to Smith and Johnson (2021), diversifying the materials utilized in mathematics instruction, such as hands-on tools, visuals, and real-world examples, has been linked to enhanced academic performance and more positive attitudes toward the subject.

Table 3 Students’ Assessment on the Elements of Differentiated Instruction In Terms of Process				
Indicator	Mean	SD	VI	EI
1. Incorporate varied teaching methods, such as lectures, discussions, and hands-on activities that accommodates different learning styles.	3.50	0.75	SA	HP
2. Implement peer-to-peer learning and collaborative projects that encourage students to learn from one another.	3.53	0.77	SA	HP
3. Allow flexibility in pacing that enable students to progress through Calculus topics at their own comfortable speed.	3.36	0.71	SA	HP
4. Provide differentiated instruction through multimedia resources which include videos, simulations, and interactive software.	3.35	0.75	SA	HP
5. Allow student multiple options for learning and understanding information.	3.34	0.75	SA	HP
Overall	3.42	0.75	SA	HP

Legend: SD – Standard Deviation; VI – Verbal Interpretation; SA – Strongly Agree; EI – Extended Interpretation; HP- Highly Practiced

Table 3. shows that Differentiated Instruction in terms of PROCESS is Highly Practiced as revealed by an overall Mean of 3.42. According to the findings, students have expressed a strong agreement towards integrating diverse instructional approaches to cater to the needs of various learning styles.

Highest Mean was indicator 2, “implement peer-to-peer learning and collaborative projects that encourage students to learn from one another” as evidenced by a Weighted Mean of 3.53 or Highly Practiced. Tarr and Stevens (2022) found that students who participated in peer learning and collaborative tasks demonstrated a deeper understanding of math concepts compared to those who did not engage in such activities.

Lowest Mean was indicator 5, “allow student multiple options for learning and understanding information” as evidenced by a Weighted Mean of 3.34 or Highly Practiced. According to a study by Johnson and Miller (2022), students who experienced different teaching approaches, such as direct instruction, problem-based learning, and cooperative learning, exhibited enhanced comprehension and a more positive outlook on mathematics.

Table 4	Students' Assessment on the Elements of Differentiated Instruction In Terms of Product			
Indicator	Mean	SD	VI	EI
1. Allow students to showcase their understanding of Calculus concepts through diverse forms such as presentations, reports, or creative projects.	3.38	0.74	SA	HP
2. Encourage students to create portfolios that demonstrate their progress and mastery of various Calculus topics.	3.36	0.77	SA	HP
3. Provide options for assessments that allow students to choose between traditional tests, practical applications, or research-based projects.	3.30	0.78	SA	HP
4. Facilitate student-led discussions or debates where they can articulate their understanding and viewpoints on Calculus topics.	3.22	0.79	A	P
5. Incorporate self-assessment tools that enable students to evaluate their own work and set personal goals for improvement.	3.52	0.67	SA	HP
Overall	3.36	0.75	SA	HP

Legend: SD – Standard Deviation; VI – Verbal Interpretation; SA – Strongly Agree; EI – Extended Interpretation; HP- Highly Practiced

Table 4. shows that Differentiated Instruction in terms of PRODUCT is Highly Practiced as revealed by an overall Mean of 3.36. Based on the results, it is evident that students have a strong consensus regarding the preferred methods to showcase their comprehension of Calculus principles.

Highest Mean was indicator 5, “incorporate self-assessment tools that enable students to evaluate their own work and set personal growth for improvement”. as evidenced by a Weighted Mean of 3.52 or Highly Practiced. According to Sun et al. (2022), students who utilized the self-assessment tools during their math problem-solving process were able to recognize their strengths and weaknesses, resulting in the implementation of more effective strategies and higher success rates.

Lowest Mean was indicator 4, “facilitate student-led discussions or debates where they can articulate their understanding and viewpoints on Calculus topics” as evidenced by a Weighted Mean of 3.22 or practiced. The study conducted by Hefel (2021) found an increase in academic performance because of student-led discussions.

Table 5	Students' Assessment of the Elements of Differentiated Instruction in Terms of Learning Environment			
Indicator	Mean	SD	VI	EI
1. Arrange the classroom seating to facilitate group discussions and collaborative activities that promote interactive learning.	3.37	0.77	SA	HP
2. Create a supportive and inclusive atmosphere where students feel comfortable expressing their thoughts and asking questions.	3.60	0.74	SA	HP
3. Establish an environment that allows students to feel more connected to the school, teachers, and school personnel.	3.30	0.74	SA	HP
4. Implement a flexible classroom layout that can be easily rearranged based on the day's planned activities that can accommodate different instructional needs.	3.70	0.74	SA	HP
5. Encourage open communication and active participation that nurture a positive learning environment where students feel valued and motivated.	3.41	0.76	SA	HP
Overall	3.48	0.75	SA	HP

Table 5. shows that Differentiated Instruction in terms of LEARNING ENVIRONMENT is Highly Practiced as revealed by an overall Mean of 3.48. Based on the findings, it is evident that students hold a strong agreement in the necessity of arranging seating in a manner that promotes group discussions and collaborative activities, fostering interactive learning.

Highest Mean was indicator 4, “implement a flexible classroom layout that can be easily rearranged based on the day’s planned activities that can accommodate different instructional needs” as evidenced by a Weighted Mean of 3.70 or Highly Practiced. Green and Jones (2022) explored the benefits of a flexible classroom layout for mathematics teachers and found that a well-structured classroom design, which can be easily adjusted, supports effective teaching methods, encourages student collaboration, and enhances the overall learning experience for students.

Lowest Mean was indicator 3, “establish an environment that allows students to feel more connected to the school, teachers, and school personnel” as evidenced by a Weighted Mean of 3.30 or Highly Practiced. Schonert-Reichl and Colasante (2021) discovered that students who established strong connections with their teachers demonstrate increased engagement and motivation in the classroom, resulting in enhanced academic performance and a heightened sense of belonging.

Table 6	Test of Significant Relationship between the Students' Learning Styles and their Assessments of the Elements of Differentiated Instruction Utilize in Teaching Calculus			
Variables	Computed F-value	p-value	Decision H_0	Conclusion
Content and Learning Styles	16.755	0.034	Reject null	Significant
Process and Learning Styles	20.393	0.015	Reject null	Significant
Product and Learning Styles	18.994	0.024	Reject null	Significant
Learning Environment and Learning Styles	16.800	0.049	Reject null	Significant

As indicated in the table, upon conducting a chi-square test with a significance level of 0.05, it was determined that the p-value for each variable surpassed the set probability level, as evidenced by the results of 0.034, 0.015, 0.024 and 0.049. Based on the findings, it can be inferred that there is a significant relationship between students' learning styles and their assessments of the elements of differentiated instruction in terms of content, process, product, and learning environment. Consequently, this prompts the rejection of the null hypothesis, which posits that there is no significant relationship between the students' learning styles and their assessments of the elements of differentiated instruction utilized in teaching Calculus.

Multiple studies underscore the significance of taking learning preferences into account when employing differentiated instruction to involve and assist all students in the mathematics classroom (Wang & Hart, 2021; Sayin & Yavuz, 2022; Cinar & Bozkurt, 2022; Whiting & Spence, 2023; Reddy & Wells, 2023).

ELEMENTS OF DIFFERENTIATED INSTRUCTION	VISUAL (V)	AUDITORY (A)	READ/WRITE (R)	KINESTHETIC (K)
CONTENT (C)	-Provide visual aids such as graphs, diagrams, and illustrations to explain concepts and problems in Calculus. -Use videos and animations to demonstrate graphical transformations and real-world applications of Calculus.	-Use verbal explanations and discussions to teach Calculus concepts and problem-solving strategies. -Provide opportunities for students to explain their thinking and reasoning out loud.	-Provide written instructions, examples, and practice problems for students to read and solve independently. -Encourage notetaking and use of graphic organizers to organize and summarize concepts.	-Provide hands-on activities such as building models or designing experiments to demonstrate Calculus concepts. -Allow students to physically manipulate objects to understand concepts such as limits and derivatives.

PROCESS (Pr)	-Use graphic organizers, mind maps, and visual organizers to help students organize and understand the steps of solving a Calculus problem. -Allow for group work and pair- shares to encourage visual discussions.	-Encourage students to explain their thought process out loud and engage in peer discussions. -Use oral presentations and debates to encourage critical thinking and argumentation.	-Provide written step-by-step instructions for solving problems and allow students to work at their own pace. -Use technology such as online tutorials and interactive whiteboards to provide written explanations and practice problems.	-Incorporate hands-on activities, such as creating graphs using graphing calculators or programming applications, to deepen understanding of Calculus concepts.
PRODUCT (Pd)	-Allow students to create visual representations of Calculus concepts such as graphs, diagrams, and animations. -Assign projects or presentations that incorporate visuals to demonstrate understanding.	-Assign oral presentations or debates where students can explain a concept or problem to their peers. -Allow students to record their explanations using audio or video.	-Assign written responses to problem solving or concept questions. -Encourage students to summarize their understanding in written form using charts, diagrams, or text.	-Assign hands-on projects such as building models or designing experiments to demonstrate understanding of Calculus concepts. -Allow students to present their projects in a hands-on and interactive manner.
LEARNING ENVIRONMENT (LE)	-Provide a visually stimulating classroom with colorful posters and charts related to Calculus concepts. -Use technology and online resources to provide visual explanations and practice problems.	-Encourage discussions and debates in the classroom. -Use technology such as podcasts and audio recordings to provide additional explanations and examples.	-Provide a quiet and organized learning environment with access to written materials such as textbooks, handouts, and online resources. -Create a designated space for notetaking and encourage the use of graphic organizers.	- Incorporate movement and hands-on activities into the classroom. Allow students to work in groups or pairs to physically manipulate objects and create models to demonstrate concepts. -Allow flexible seating options to accommodate different learning styles.

Figure 1. Customized Teaching Strategies for Diverse Learners in Calculus Classes

Figure 1 represents the customized teaching strategies for Calculus classes developed by the researcher for visual, auditory, read/write, and kinesthetic learners. These strategies are aligned with the elements of differentiated instruction, which include content, process, product, and learning environment.

Conclusion

Female respondents prefer auditory learning, whereas male respondents show a preference for kinesthetic learning. Respondents expressed a strong agreement and assessed the item statements for differentiated instructions in terms of content, process, product, and learning environment as Highly Practiced. Statistical associations have been found between students' assessment of the elements of differentiated instructions and their learning styles.

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