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# Student Engagement and Academic Achievement in Learning Calculus

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***Abstract:*** *This study aimed to determine the level of student engagement, academic achievement and their relationship. 217 students were purposively sampled at Sichuan Minzu College in China. This study used the descriptive-correctional method, to analyze the collected data. Based on the result, the students had a high level of student engagement in learning Calculus. 80.18% of the students scored "Pass" (41.01%) and "Good" (39.17%). Moreover, no significant correlation exists between student engagement and academic achievement in learning Calculus. (r=0.08, P=0.228). Similar studies may be conducted where additional variables will be included, and teachers may be taken as respondents for cross validation.*

***Keywords:*** *Student engagement, academic achievement, correlation, Calculus*

## 1. Introduction

The educational philosophy of pragmatism aligns with the problem-solving approach in mathematics, making it an effective strategy for Calculus learning and teaching. Constructivism emphasizes that learners construct knowledge by their experiences and explorations, while highlights the importance of practical application and the role of mathematics in solving real-world problems [1, 2]. They are both student-centered approaches to education, which mean that students are actively engaged in learning and encouraged to explore the world around them [1]. By promoting student engagement, constructivism helps create a more learner-centered and participatory approach to education that can lead to more meaningful and lasting learning outcomes [3]. An essential objective of pedagogies that involve active learning is to promote student engagement throughout the process of learning [4]. The fundamental issue of educational quality lies in how to ensure students' learning outcomes and personal growth, and the key to achieving learning outcomes is student engagement [5].

Student engagement in science and mathematics is crucial for their academic achievement as well as their willingness to participate in STEM courses and related careers in the long term [6]. Despite a variety of best teaching practices in undergraduate STEM education, student engagement has been widely leveraged to improve student learning [7]. Student engagement has been highlighted by educators as a crucial factor in addressing issues of low academic performance, high levels of low achievement, high levels of student boredom, alienation and high dropout rates [8]. Student engagement has been identified as one of the mechanisms can act as an antidote to the problems of high dropout and poor academic achievement [9]. Yin [10] has stressed that the level of student engagement is the key to the high-quality development of undergraduate education. According to MOE of China [11], the construction of first-class undergraduate courses requires an enhancement of student engagement. Stanberry and Payne [7] have pointed out that to assess student proficiency in Calculus courses, it is crucial to create a learning environment that fosters student engagement and supports their learning. Thus, effective measurement and promotion of student engagement have emerged as crucial aspects in the reform of Calculus instruction.

Developing high-quality STEM talent is a common goal pursued by all nations. As a result, the quality of education has received increasing attention worldwide, most of which is focused on students' academic achievements. Assessing student outcomes and the quality of education in different countries relies heavily on academic achievement, which is considered one of the most important indicators. Academic achievement at university is crucial for students' personal growth and future career prospects, and this point is beyond doubt [12]. Positive student development is reflected through good academic performance, which can create a virtuous cycle in the students' development process. College Calculus is a prerequisite

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for all STEM disciplines and has great potential to increase the proportion of students majoring in STEM majors. However, student performance in college Calculus has been poor, causing many students to leave STEM majors. Therefore, this study aims to assess the level of student engagement in learning Calculus. Additionally, the relationship between student engagement, and academic achievement will be explored.

## 2. Theoretical Framework

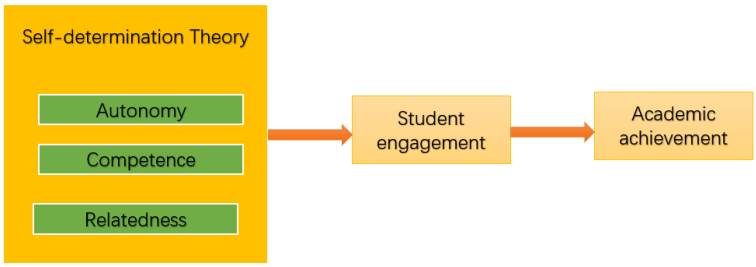


*Figure 1: SDT and Student Engagement*

Self-determination Theory (SDT) has been identified as a relevant theoretical framework for understanding college students' academic achievement and engagement [13]. SDT has been utilized to clarify the influence of meeting psychological needs on academic achievement and engagement, as demonstrated by research conducted by Deci and Ryan [14]. Intrinsic motivation has been identified as a significant predictor of academic achievement and engagement [15]. Thus, by applying self-determination theory, the three basic needs that influence student engagement are shown in Figure 1. Based on Fredricks et al. [16], student engagement is identified as behavioral, emotional, and cognitive. Behavioral engagement refers to the time and energy students devote to academic tasks while emotional engagement refers to the positive emotional responses, sense of belonging, identity, interest in learning, and attitudes and values students develop toward school. Cognitive engagement describes the cognitive activities involved in the learning process. These three aspects of student engagement consider what students do, feel, and think during the learning process and are therefore widely adopted in empirical surveys [17].

## 3. Methodology

This study used a quantitative approach, particularly the descriptive-correlational design. It is descriptive because it aimed to describe the level of student engagement and their academic performance. These two variables were also correlated; hence this study was also correlational.

### *3.1. Participants*

The study involved the first-year undergraduate students majoring in Computer Science and Technology and Data Science and Big Data Technology at Sichuan Minzu College who had taken Calculus courses during the first semester of academic year 2022-2023. All 217 students, comprising 125 from three Computer Science and Technology classes and 92 from two Data Science and Big Data Technology classes, were included.

### *3.2. Instrumentation*

The study utilized the following data gathering tools:

Student Engagement Questionnaire. The questionnaire from [18] was administered to the participants to assess the level of student engagement in learning Calculus. According to Whitney et al. [18], the survey questionnaire has been subjected to both reliability and validity testing. The findings from the study indicated that the reliability and validity of the SEQ were deemed acceptable. This suggests that the questionnaire is a reliable and valid tool for measuring student engagement among individuals. SEQ has three sub-categories: affective engagement (8 items), behavioral engagement (9 items), and cognitive engagement (7 items). The first to eighth items in the questionnaire reflect affective engagement. The ninth to seventeenth items represent behavioral engagement. The last seven items are cognitive engagement. The survey will use a 5-point Likert Scale. Negative items were reversed during the survey. Participants responded to a set of 24 statements by indicating whether they “Strongly Disagree”,

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"Disagree", "Neither agree nor disagree", "Agree" or "Strongly Agree". A numerical value was assigned to each response, and the mean score of the participants was calculated. The average score of items within each subscale was calculated to derive the three subscale scores. The composite score of all 24 items was obtained by computing their average, representing the participants' level of engagement in learning Calculus.

Final exam paper scores for Calculus I. The participants' final exam paper score for Calculus 1 is considered as their academic performance in Calculus. Although the final exam paper score accounts for only 60% of students' academic performance, the final exam paper scores are only considered as the academic performance indicator of Calculus in order to eliminate human interference.

### *3.3. Data Analysis*

*Table 1: Scale for interpreting the participants' level of academic achievement for Calculus I*

| Score Range | Descriptive Interpretation |
|---|---|
| Above 80 | Excellent |
| 70-79 | Good |
| 60-69 | Pass |
| Below 60 | Fail |

Frequency and Percentage were used to characterize the participants' academic achievement in final grades for Calculus I. The Scale presented in Table 1 was employed to interpret the level of academic achievement of the participants in Calculus. Mean was used to determine the level of student engagement in learning Calculus. The Scale presented in Table 2 was employed to interpret the level of student engagement and the extent of teacher support in learning Calculus. Pearson Product Moment Correlation of Coefficient was used to test the significant relationship between academic performance, student engagement and teacher support in learning Calculus.

*Table 2: Scale for interpreting the level of student engagement in learning Calculus*

| Mean | Descriptive Interpretation (DI) |
|---|---|
| 4.21-5.00 | Very High (VH)/Very Great Extent (VGE) |
| 3.41-4.20 | High (H)/ Great Extent (GE) |
| 2.61-3.40 | Moderate (M)/ Moderate Extent (ME) |
| 1.81-2.60 | Low (L)/ Low Extent (L) |
| 1-1.80 | Very Low (VL)/ Very Low (VL) |

## 4. Results

### *4.1. Level of student engagement in learning Calculus*

*Table 3: Participants' Level of affective engagement*

| Affective Engagement | | |
|---|---|---|
| Indicators | Mean | DI |
| 1. I am very interested in learning Calculus. | 3.74 | H |
| 2. I think learning Calculus is boring. | 2.38 (2.62)* | L |
| 3. I am motivated by my desire to learn Calculus. | 3.53 | H |
| 4. I enjoy learning new things in this class. | 3.79 | H |
| 5. I find ways to make this course interesting to me. | 3.79 | H |
| 6. My classwork makes me curious to learn other things. | 3.60 | H |
| 7. I see how the work I am doing now will help me after college. | 3.84 | H |
| 8. I like to discuss Calculus problems for which there are no clear answers. | 3.31 | M |
| Category Mean | 3.53 | H |

*Values obtained after reverse scoring, used in the computation of the category mean

Table 3 presents the assessment regarding affective engagement in Calculus. Student ratings indicated a high level of affective engagement with a category mean of 3.53. Particularly, student participants expressed the highest rating of 3.84 on their affective engagement when considering the item "I see how the work I am doing now will help me after college." Meanwhile, the item "I think learning Calculus is boring" got the lowest mean of 2.62 after reverse scoring, indicating some level of boredom or disinterest

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among some student participants. Positive emotions are correlated with higher achievement and self-regulation [19]. Affective engagement connotes emotional reactions linked to task investment. The greater the student's interest level, enjoyment, positive attitude, the positive value held, curiosity, and a sense of belonging, the greater the affective engagement.

Table 4 illustrates the assessment regarding behavioral engagement in Calculus. Student ratings indicated a high level of behavioral engagement with a category mean of 3.45. Particularly, participants displayed the highest rating of 3.78 on their behavioral engagement when considering the item " I stay up to date with my grades in this class." Conversely, the item “I do just enough to get by” got the lowest mean of 2.49 after reverse scoring. Researchers have found that effectively performing an activity can positively impact subsequent engagement [20].

*Table 4: Participants' Level of behavioral engagement*

| Behavioral Engagement | | |
|---|---|---|
| Indicators | Mean | DI |
| 1. I make sure to study on a regular basis. | 3.50 | H |
| 2. I take good notes in class, on readings, and/or on video lectures. | 3.76 | H |
| 3. I often review my class notes. | 3.40 | M |
| 4. Worked harder than I thought I could to meet other people's standards or expectations. | 3.53 | H |
| 5. I stay up to date with my grades in this class. | 3.78 | H |
| 6. I listen and/or read carefully. | 3.54 | H |
| 7. I talk to my teacher about my progress in the class. | 3.52 | H |
| 8. Reviewed my assignments before turning them in. | 3.57 | H |
| 9. I do just enough to get by. | 2.51 (2.49)* | L |
| Category Mean | 3.45 | H |

*Values obtained after reverse scoring, used in the computation of the category mean

*Table 5: Participants' Level of cognitive engagement*

| Cognitive Engagement | | |
|---|---|---|
| Indicators | Mean | DI |
| 1. When studying, I try to connect different topics from course material. | 3.50 | H |
| 2. I combine ideas from different courses to help complete assignments. | 3.51 | H |
| 3. I summarize the material I learn in class or from other course materials. | 3.58 | H |
| 4. If given, I identify key information from any reading assignment. | 3.52 | H |
| 5. I examine the strengths and weaknesses of my own views on a topic or issue. | 3.56 | H |
| 6. I discuss course topics, ideas, or concepts with my teacher outside of class. | 3.35 | M |
| 7. Asked questions o contributed to course discussions in other ways. | 3.40 | M |
| Category Mean | 3.49 | H |

*Table 6: Level of student engagement*

| Student Engagement | | |
|---|---|---|
| Indicators | Category Mean | DI |
| Affective engagement | 3.53 | H |
| Behavioral engagement | 3.45 | H |
| Cognitive engagement | 3.49 | H |
| Overall Mean | 3.49 | H |

Table 5 presents the assessment regarding cognitive engagement in Calculus. Student ratings indicated a high level of cognitive engagement with a category mean of 3.45. Particularly, student participants expressed the highest rating of 3.58 on their cognitive engagement when considering the item "I summarize the material I learn in class or from other course materials." Meanwhile, the item “I discuss course topics, ideas, or concepts with my teacher outside of class.” got the lowest mean of 3.35. Deep cognitive engagement involves elaboration processes, while shallow involves more rote memorization and other strategies that engage the new information in more superficial ways [19]. Toth [21] stated that both student engagement and learning increase when students have access to truly rigorous tasks.

Table 6 shows a summary of the level of student engagement in learning Calculus. Participant ratings indicated a high level of student engagement with the overall mean of 3.49. These results are consistent with the study of Joshi et al. [22], which found that affective engagement obtained the highest mean rating among students.

ISSN 2663-8169 Vol. 6, Issue 2: 18-23, DOI: 10.25236/IJNDE.2024.060204

### *4.2. Participants' Academic Achievement in Calculus*

*Table 7: Participants' academic achievement of Calculus I*

| Score Range | Frequency | Percentage | DI |
|---|---|---|---|
| Above 80 | 29 | 13.36 | Excellent |
| 70-79 | 85 | 39.17 | Good |
| 60-69 | 89 | 41.01 | Pass |
| Below 60 | 14 | 6.45 | Fail |
| Total | 217 | 100.00 | |
| Mean | 69.77 | | Pass |

Table 7 presents the frequency and percentage distribution of participants' academic performance in Calculus I. As seen on Table 8, among the participants, 89 students or 41.01% achieved the 'Pass' level, 85 students or 39.17% attained the 'Good' level, 29 students or 13.36% obtained the 'Excellent' level, and 14 students or 6.45% fell into the 'Fail' level. The overall mean score of 69.77 indicates that most participants demonstrated a passing performance in Calculus I. In summary, Table 8 provides a clear representation of the distribution of students' performance levels in Calculus I. The data shows that a significant portion of students performed at the 'Pass' and 'Good' levels, indicating a satisfactory level of understanding and achievement. Additionally, a smaller percentage of students attained the 'Excellent' level, demonstrating exceptional performance, while a small proportion fell into the 'Fail' category, indicating the need for additional support and improvement. The mean score reinforces that most participants achieved a passing level in the course. These results are consistent with the study of Huang et al. [23].

### *4.3. Relationship between academic achievement and student engagement*

Table 8 presents the correlation between academic performance and student engagement in learning Calculus I. The results indicate that there is a very weak correlation between the participants' academic performance and their affective, behavioral, and cognitive engagement, as evidenced by the correlation coefficients of 0.09, 0.09, and 0.06, respectively. Additionally, the correlation coefficient for overall student engagement is 0.08, also indicating a very weak correlation. Furthermore, the p-values for all correlations are provided, and they are higher than the specified level of significance (0.05), indicating that none of the correlations are statistically significant. This means that the academic performance of the participants in Calculus I is not significantly related to their levels of engagement in the class. The result contradicts the findings of Abid et al. [24] which state that there is a positive moderate relationship between student engagement (per indicator) and achievement.

*Table 8: Significant Correlation between Academic achievement and Student Engagement*

| | Dependent | r | DI | P-value | DI |
|---|---|---|---|---|---|
| Academic achievement | Affective engagement | 0.09 | Very Weak Correlation | 0.184 | Not significant |
| | Behavioral engagement | 0.09 | Very Weak Correlation | 0.190 | Not significant |
| | Cognitive engagement | 0.06 | Very Weak Correlation | 0.420 | Not significant |
| | Student engagement | 0.08 | Very Weak Correlation | 0.228 | Not significant |

Legend: *Significant at 0.05 level of Significance. 0.0-0.19-Very Weak Correlation; 0.20-0.39-Weak Correlation; 0.40-0.59-Moderate Correlation; 0.60-0.79-Strong Correlation; 0.80-1.0-Very Strong Correlation

## 5. Conclusion

Based on the findings, the researcher concluded that the students had a positive attitude towards in learning Calculus, specifically in the self-confidence, value, enjoyment and motivation. It was also concluded that a significant portion of students performed at the 'Pass' and 'Good' levels. Furthermore, the academic performance of the participants in Calculus I is not significantly related to their levels of engagement in the class (r=0.08, P=0.228). Therefore, it is hereby recommended that teachers may continue to prepare tasks and activities that would engage students in learning Calculus and focus more on their cognitive engagement. Similar studies may be conducted where additional variables will be included, and teachers may be taken as respondents for cross validation.

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