ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

Effect of Mathematical Proficiency on Senior High School Students' Performance in Basic Calculus

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Publication Date: 2026/08/04

Abstract: This study Basic Calculus is one of the core subjects in STEM Education in the K-12 Curriculum by the DepEd. It is recognized globally as a conceptually demanding subject that exposes weaknesses in foundational mathematical proficiency, particularly when instruction emphasizes rote procedures over reasoning and problem solving. Five Strands of Mathematical Proficiency, relative to conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition, was the framework that guided research and curricular reform internationally, underscoring the importance of balanced proficiency for meaningful mathematical learning. With this, the study aimed to determine the students' level of performance in Basic Calculus, to assess the student's level of mathematical proficiency relative to conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition, to find out the relationship between student's performance in Basic Calculus and their mathematical proficiency, and to prepare and interactive learning material in Basic Calculus based on the results.

The study used a descriptive-correlational design and the Raosoft Sample Calculator to compute the 245 SHS STEM students in public schools in the SDO of Batangas Province. The findings indicated that students demonstrated a very satisfactory level of performance in Basic Calculus, reflecting effective learning outcomes. Their mathematical proficiency across the five strands relative to conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition was generally above average, suggesting well-developed mathematical skills. A significant relationship was found between students' mathematical proficiency and their performance in Basic Calculus, emphasizing the importance of these competencies in learning calculus. In response to these findings, a web-based interactive learning material in Basic Calculus was developed to support and enhance students' learning.

Keywords: *Basic Calculus, Mathematical Proficiency, Interactive Learning Material, Conceptual Understanding, Strategic Competence.*

How to Cite: Raynan A. Tobeo (2026) Effect of Mathematical Proficiency on Senior High School Students' Performance in Basic Calculus. *International Journal of Innovative Science and Research Technology,*
11(3), 4234-4253. https://doi.org/10.38124/ijisrt/26mar1572

I. INTRODUCTION

Mathematics education is essential for developing analytical reasoning, problem-solving, and quantitative skills needed in higher education and a data-driven world. Modern frameworks emphasize that mathematical competence goes beyond procedural mastery and includes cognitive, strategic, and affective dimensions. The Five Strands of Mathematical Proficiency—conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition—provide a comprehensive model for understanding mathematical learning. These strands are interconnected, meaning weaknesses in one area can affect overall performance.

In senior high school, Basic Calculus serves as a key subject for STEM readiness, introducing concepts like limits, derivatives, and integrals. However, it is widely recognized as challenging, especially when students lack strong foundational skills or when instruction focuses more on procedures than understanding. In the Philippines, despite K–12 curriculum reforms that integrate calculus to improve college readiness, evidence from Batangas Province shows persistent difficulties in mathematics. Many students perform at low proficiency levels, particularly in foundational areas like algebra and geometry, which are crucial for success in calculus.

Local studies further reveal that even STEM students, while capable in procedural tasks, often struggle with conceptual understanding and analytical reasoning. This results in students being able to perform routine computations but having difficulty with complex, unfamiliar problems. Such gaps are concerning because calculus requires the integration of multiple strands of mathematical proficiency.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

Despite these challenges, there is limited research in the Philippine context—especially at the district level—examining how different aspects of mathematical proficiency influence performance in calculus. This lack of comprehensive, theory-based studies creates a gap in both research and instructional practice, leading to fragmented approaches in teaching mathematics.

In response, this study is grounded in the Five Strands of Mathematical Proficiency to examine how these dimensions relate to students' performance in Basic Calculus. It also aims to develop interactive learning materials to address identified gaps and support more holistic, proficiency-oriented mathematics instruction for senior high school students.in senior high school mathematics.

- *Objectives*

This The primary objective of this study was to determine the correlation between SHS students' mathematical proficiency and students' performance in Basic Calculus. This study seeks to provide valuable insights for educators, curriculum developers, and policymakers to improve mathematical instruction and assessment practices, ultimately fostering better student performance in Basic Calculus.

Specifically, it aimed to:

- Describe the students' level of performance in Basic Calculus.
- Assess the students' level of mathematical proficiency relative to:

✓ Conceptual understanding;
✓ Procedural fluency;
✓ Strategic competence;
✓ Adaptive reasoning, and
✓ Productive disposition.

- Find out the relationship between students' performance in Basic Calculus and their mathematical proficiency.
- Ascertain the effect of mathematical proficiency on the students' performance in Basic Calculus.
- Prepare an interactive learning material in Basic Calculus.

II. MATERIALS AND METHODS

This This study employed a descriptive correlational research design to examine the effects of mathematical proficiency on students' performance in Basic Calculus and to determine the relationships among conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, productive disposition, and performance among Senior High School students in the Division of Batangas Province. A quantitative approach was used to collect numerical data through an adopted and tailored survey questionnaire, ensuring objective measurement of students' competencies.

According to Creswell and Creswell (2018), quantitative research involves the systematic investigation of phenomena using statistical, mathematical, or computational techniques. In this study, no variables were manipulated; instead, it focused on determining whether significant correlations exist among conceptual understanding, procedural fluency, and academic performance, as well as the overall effect of mathematical proficiency on students' performance in Basic Calculus.

The respondents were SHS STEM students from public senior high schools in the Division of Batangas Province, specifically in the San Juan Batangas Sub-Office.

Table 1 Distribution of Respondents

School	Population	Sample
Buhaynasapa INHS	112	41
Calubcub I SHS	79	29
Laiya INHS	132	48
Palahanan INHS	168	61
San Juan SHS	112	41
Sico 1.0 INHS	70	25
TOTAL	673	245

Data This study utilized a questionnaire as the primary data-gathering instrument to collect information on students' performance in Basic Calculus and to assess their level of mathematical proficiency.

The instrument consisted of two parts. Part I focused on the respondents' profile, particularly their final grade in Basic Calculus, based on DepEd Order No. 8, s. 2025. Part II assessed mathematical proficiency across five strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition.

The questionnaire was adapted and modified from Mendoza R. (2025), with items revised to fit the context of the study. It underwent validation through consultations with the research adviser and internal and external panels, followed by approval from the panel chairman. Pilot testing was conducted, and reliability was measured using Cronbach's Alpha, with results ranging from 0.892 to 0.925, indicating good to excellent reliability across all strands.

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The questionnaire was distributed via Google Forms, with respondents completing it in 1–3 minutes, and data collection was completed within approximately one week.

The study used a four-point Likert scale to interpret responses based on mean scores. A mean score of 3.50–4.00, described as "Strongly Agree," indicates that respondents demonstrate a high level of and deep conceptual understanding, accurate and flexible use of procedures, effective problem-solving strategies, and clear logical reasoning. A mean score of 2.50–3.49, or "Agree," reflects an above-average level, with sound understanding and correct procedural application in routine problems, along with generally appropriate strategies and explanations. Meanwhile, a mean score of 1.50–2.49, labeled "Disagree," suggests below-level and partial understanding, reliance on memorized procedures, and difficulty with multi-step or unfamiliar problems. Lastly, a mean score of 1.00–1.49, or "Strongly Disagree," indicates low-level and limited understanding of basic concepts, frequent procedural errors, weak reasoning, and heavy dependence on assistance.

The researcher obtained permission from the PSDS, ASDS, and school heads in the Division of Batangas Province, particularly in the San Juan Sub-Office, before data collection. Approved letters were also sent to school principals, explaining the study's purpose and assuring confidentiality. The questionnaire was distributed through Google Forms, and responses were collected, converted to Excel, organized, and analyzed. Statistical tools used included frequency and percentage, mean, weighted mean, standard deviation, Pearson's r, and regression analysis to describe performance, measure proficiency, determine relationships, and assess the effects of mathematical proficiency on students' performance in Basic Calculus.

Ethical standards were strictly followed, with informed consent obtained and participation kept voluntary. Confidentiality and anonymity were ensured in compliance with RA 10173 (Data Privacy Act) by using codes and securing data in password-protected files. The study also secured approval from relevant authorities and validated all instruments before use.

Additionally, generative AI tools were used to assist in organizing the literature review, interpreting results, and refining the manuscript. However, the researcher maintained full responsibility by verifying accuracy, ensuring proper interpretation, and upholding the integrity and ethical standards of the study.

III. RESULT AND DISCUSSION

➢ *Pro Students' Level of Performance in Basic Calculus*

The students' level of performance in basic calculus was based on their final grades, which are interpreted in accordance with the DepEd Order No. 08, s. 2025. Table 2 presents the frequency distribution and the percentage of the students' level of performance in basic calculus.

Table 2 Students' Level of Performance in Basic Calculus

Level of Performance	Frequency	Percentage
Outstanding	107	44
Very Satisfactory	122	50
Satisfactory	16	7
TOTAL	245	100
Mean=87(Very Satisfactory); SD=0.605; Min.=80(Satisfactory); Max.=98(Outstanding)		

The descriptive analysis shows that students demonstrated a very satisfactory level of performance in Basic Calculus, with most of the 245 learners meeting or exceeding standards. Based on DepEd Order No. 08, s. 2015, 44% (107 students) achieved an Outstanding rating (90–100), 50% (122 students) were Very Satisfactory (85–89), and only 7% (16 students) were Satisfactory (80–84). With 94% of students in the top two categories, the results suggest effective instruction or interventions that supported mastery of content. The mean score (M = 87, SD = 0.605), with grades ranging from 80 to 98, further indicates strong overall performance and a solid grasp of basic calculus concepts and procedures.

These findings contrast with national and international reports such as PISA 2022 and EDCOM II, which highlight significant gaps in mathematics proficiency in the Philippines, with most students performing below basic levels. While these reports describe systemic issues like mass promotion and low mastery rates, the present study—conducted among STEM students in the San Juan Sub-Office, Batangas Province—revealed a very satisfactory level of performance. This supports Robles (2020), who noted that strong mathematical skills contribute to better calculus performance, suggesting that strengthening foundational skills in STEM contexts can improve outcomes despite broader challenges.

➢ *Students' Level of Mathematical Proficiency*

This section pertains to students' level of mathematical proficiency in relation to conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition.

- *Conceptual Understanding.*

This refers to the integrated, functional grasp of mathematical ideas that enables students to learn new ideas by connecting them to what they already know. This section assessed the level of students' conceptual understanding.

The findings presented in Table 3 indicate that the students' overall level of mathematical proficiency in terms of conceptual understanding is above average, as evidenced by a composite mean score of 3.27 and a relatively low

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

standard deviation (SD = 0.51). The distribution further shows that nearly all respondents fall within the above average (70%) and high (29%) levels, with only a negligible proportion classified as below average. This result directly sought to assess students' conceptual understanding as a core component of mathematical proficiency in Basic Calculus.

Table 3 Students' Level of Mathematical Proficiency in terms of Conceptual Understanding

Level of Conceptual Understanding	Frequency	Percentage
High	71	29
Above Average	172	70
Below Average	2	1
Total	**245**	**100**
Mean=3.27 (Above Average); SD=0.51; Min.=2.33 (Below Average); Max.=4.00 (High)		

The A closer examination of the indicators shows that students demonstrate a strong level of conceptual understanding in Basic Calculus. They agreed that they can recognize examples and counterexamples, understand mathematical terms and definitions, and distinguish among different mathematical ideas, indicating their ability to organize knowledge meaningfully. They also showed competence in connecting models, diagrams, and symbols, translating representations, and interpreting solutions in context, suggesting fluency in multiple representations and deeper engagement with mathematical meaning rather than mere computation.

Students' ability to integrate concepts in problem-solving, derive formulas, and apply prior knowledge further indicates that conceptual understanding serves as a foundation for reasoning and application. The consistent mean scores across indicators suggest that this understanding is stable and well-developed. These findings align with constructivist theories and previous studies, which emphasize that connecting concepts and promoting reasoning led to improved mathematical performance, suggesting that instructional practices effectively support conceptual learning.

However, these results contrast with international studies such as PISA, which report persistent difficulties in conceptual understanding, particularly in applying mathematics to unfamiliar or real-world contexts. While students in this study demonstrated above-average proficiency, this difference may reflect variations in assessment focus, with local measures emphasizing curriculum-based understanding and international assessments requiring broader application and transfer.

Overall, the findings support theoretical and empirical research highlighting the effectiveness of concept-focused instruction, indicating that students possess solid conceptual understanding in Basic Calculus. However, the gap between local and international results suggests the need for further investigation into how conceptual understanding is assessed and applied across different contexts.

- *Procedural Fluency.*

This refers to the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately. Table 4 exhibits the level to which students demonstrated procedural fluency.

Table 4 Student's Level of Mathematical Proficiency in Terms of Procedural Fluency

Level of Procedural Fluency	Frequency	Percentage
High	66	27
Above Average	179	73
Total	**245**	**100**
Mean=3.24 (Above Average); SD=0.51; Min.=2.50 (Above Average); Max.=4.00 (High)		

As The results show that most students (73%) have an above average level of procedural fluency, while 27% demonstrate a high level, with no students falling into below average or low categories. The composite mean of 3.24 (SD = 0.51) indicates that students generally have a strong ability to perform mathematical procedures accurately and efficiently, consistent with established definitions of procedural fluency. Item-level findings reveal that students are confident in identifying variables, selecting and applying formulas, substituting values, interpreting algorithms, and solving both routine and applied problems. Higher performance in tasks such as formula substitution and recognizing known quantities suggests strong mastery of well-practiced procedures, likely due to repeated exposure within the SHS STEM curriculum and an instructional focus on procedural accuracy.

However, slightly lower scores in adapting procedures to unfamiliar situations and in geometric constructions indicate that students' flexibility in applying knowledge to new contexts is less developed. This aligns with research suggesting that procedural fluency is easier to develop than other aspects of mathematical proficiency. The findings are also consistent with studies in similar educational contexts were emphasis on practice and exam performance leads to high procedural skills.

Interestingly, the results differ from international assessments like PISA and TIMSS, which often show that

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

strong procedural skills do not always lead to better overall mathematical performance, particularly in higher-order thinking tasks. In contrast, students in the San Juan Sub-office not only demonstrate strong procedural fluency but also report being able to apply these skills to real-life problems. This suggests that, in this context, procedural fluency supports learning in Basic Calculus rather than limiting it. Overall, while procedural fluency is well-developed, there is still a need to strengthen students' ability to adapt procedures and integrate conceptual understanding for more balanced mathematical proficiency.

- *Strategic Competence.*

This refers to the ability to formulate mathematical problems, represent them, and solve them. This is similar to what has been called problem solving and problem formulation in the literature of mathematics education and cognitive science. This section determined the level to which students exhibited strategic competence.

Table 5 Student's Level of Mathematical Proficiency in terms of Strategic Competence

Level of Strategic Competence	Frequency	Percentage
High	76	31
Above Average	167	68
Below Average	2	1
Total	**245**	**100**
Mean=3.26 (Above Average); SD=0.52; Min.=2.33 (Below Average); Max.=4.00 (High)		

The findings in Table 5 show that students demonstrate an overall above average level of strategic competence (M = 3.26, SD = 0.52), with most classified as above average (68%) or high (31%), and very few below average. This indicates that SHS STEM students in the San Juan Sub-office are generally capable of formulating, selecting, and applying appropriate strategies in solving Basic Calculus problems. Consistent "Agree" ratings across indicators—such as adjusting strategies when needed, planning solution approaches, following logical steps, monitoring progress, and evaluating answers—suggest that students engage in deliberate and reflective problem-solving rather than relying solely on rote procedures. The low variability in responses also points to a shared instructional approach that likely emphasizes structured problem-solving and strategic thinking.

These results align with theoretical views of strategic competence as the ability to represent problems, explore multiple solution methods, and justify decisions. They also support prior studies showing that students who can flexibly choose and monitor strategies tend to perform better in advanced mathematics. Research in similar contexts further suggests that explicit instruction in problem-solving strategies enhances students' ability to connect prior knowledge to new situations.

However, the findings contrast with international assessments like PISA and TIMSS, which often report that students struggle with non-routine problem solving despite having procedural skills. In this case, students show above average strategic competence even in areas typically considered weak, such as monitoring and evaluating solutions. This difference may be due to contextual factors like curriculum design, teaching practices, or assessment methods that emphasize strategic thinking. Still, caution is needed since the results are based on self-reports, which may reflect perceived rather than actual ability, especially in complex or unfamiliar problems.

Overall, the results suggest that students' strategic competence contributes positively to their performance in Basic Calculus. At the same time, the contrast with international findings highlights the influence of local educational contexts and the need for further research, particularly using performance-based assessments, to better understand and validate students' strategic competence.

- *Adaptive Reasoning.*

This is the capacity for logical thinking and the ability to reason and justify why solutions are appropriate within the context of problems that are large in scope. This section assessed the extent to which students exhibited adaptive reasoning.

The results in Table 6 show that most students demonstrate an above average level of adaptive reasoning, with 71% classified as above average and 27% as high, resulting in a composite mean of 3.23 (SD = 0.52). This indicates that SHS STEM students in the San Juan Sub-office are generally capable of logical thinking, reflecting on their solution processes, and understanding mathematical concepts beyond routine procedures.

Table 6 Student's Level of Mathematical Proficiency in Terms of Adaptive Reasoning

Level of Adaptive Reasoning	Frequency	Percentage
High	65	27
Above Average	174	71
Below Average	6	2
Total	**245**	**100**
Mean=3.23 (Above Average); SD=0.52; Min.=2.08 (Below Average); Max.=4.00 (High)		

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

Item-level findings support this, as students reported being able to justify solutions, verify correctness in complex situations, explain mathematical claims clearly, and draw sound conclusions. Higher ratings in linking concepts and procedures, checking solution logic, recognizing patterns, and using reasoning to guide computations suggest that students engage in reflective thinking and meaningful sense-making rather than simple procedural checking.

These findings align with theoretical perspectives that define adaptive reasoning as the ability to think logically, explain, justify, and connect mathematical ideas. They also suggest that instruction in Basic Calculus may emphasize reasoning, explanation, and justification, consistent with reform-oriented approaches in mathematics education. Supporting studies likewise show that students who actively engage in reasoning and argumentation tend to develop deeper understanding and stronger overall mathematical proficiency.

However, despite the students' strong adaptive reasoning skills, the results indicate that this does not always translate into consistently high performance in Basic Calculus. This differs from international assessments like PISA, which typically find a strong link between reasoning ability and academic achievement. The discrepancy may be explained by contextual factors such as curriculum alignment, assessment methods, time constraints, or gaps in prior knowledge. In some cases, strong reasoning skills may not be fully reflected in performance if assessments prioritize procedural accuracy over conceptual understanding.

Overall, the findings suggest that adaptive reasoning is well developed among students and likely supports their mathematical learning. However, its impact on actual performance may be limited by contextual and structural factors, highlighting the need for teaching and assessment practices that better emphasize and reward reasoning, justification, and conceptual understanding in Basic Calculus.

- *Productive Disposition.*

This refers to the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics. This section determined the level to which students exhibited productive disposition.

Table 7 Student's Level of Mathematical Proficiency in Terms of Productive Disposition

Level of Productive Disposition	**Frequency**	**Percentage**
High	89	36
Above Average	154	63
Below Average	2	1
Total	**245**	**100**
Mean=3.31 (Above Average); SD=0.54; Min.=2.17 (Below Average); Max.=4.00 (High)		

The results in Table 7 show that students generally have an above average level of productive disposition toward mathematics, with 63% classified as above average and 36% as high (M = 3.31, SD = 0.54), and only 1% below average. This indicates that most students hold positive attitudes toward mathematics, see it as meaningful and useful, and believe in their ability to engage successfully with mathematical tasks.

These findings suggest that productive disposition is a relative strength among the respondents and complements other strands of mathematical proficiency. Item-level results further show that students can justify solutions, verify correctness, explain reasoning, recognize patterns, and draw conclusions, reflecting not only cognitive engagement but also confidence, persistence, and reflective thinking—key aspects of productive disposition. This may be influenced by the STEM learning environment, which likely promotes reasoning, explanation, and active engagement, helping students develop positive mathematical beliefs through repeated success and supportive instruction.

The results are consistent with previous studies showing that students with positive attitudes and strong self-belief are more likely to engage deeply in problem solving and achieve better academic outcomes. Productive disposition is therefore recognized as an important, though less visible, component of mathematical proficiency that supports learning and performance.

However, despite these positive dispositions, the findings also reveal that high levels of proficiency do not always lead to equally high performance in Basic Calculus. This contrasts with international studies that often show a strong direct relationship between positive disposition and achievement. The difference may be due to contextual factors such as curriculum alignment, assessment practices, instructional quality, or sociocultural influences that affect how positive attitudes translate into actual performance.

Overall, while students demonstrate strong productive disposition, its impact on academic achievement may depend on local educational conditions. This highlights the need for teaching and assessment strategies that better translate students' positive beliefs and attitudes into measurable success in mathematics.

- *Relationship Between Students' Performance in Basic Calculus and Their Mathematical Proficiency*

The relationship between mathematical proficiency and Basic Calculus performance is detailed in Table 8.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

Table 8 Relationship Between Students' Performance in Basic Calculus and their Mathematical Proficiency

Mathematical Proficiency	Pearson's r-value	Degree of Relationship	p-value	Decision on Ho	Interpretation
Conceptual Understanding	.188	Weak	.003	Reject	Significant
Procedural Fluency	.226	Weak	<.001	Reject	Significant
Strategic Competence	.156	Weak	.015	Reject	Significant
Adaptive Reasoning	.183	Weak	.004	Reject	Significant
Productive Disposition	.224	Weak	<.001	Reject	Significant

Legend: Coefficient of correlation (r): +1.0 (Perfect relationship), +.76 to .99 (Very Strong relationship), +.51 to .75 (Strong relationship), +.26-.50 (Moderate Relationship, +.11 to .25 (Weak relationship), +.01 to .10 (Very weak relationship), .00 (No relationship)

The correlational analysis presented in the above table indicates a statistically significant but weak positive relationship between all five strands of mathematical proficiency and students' mathematics performance in Basic Calculus. Among the variables, procedural fluency exhibited the highest correlation ($r = 0.226$, $p < 0.001$), implying that a student's ability to execute algorithms and formulas is the most direct predictor of success in a subject traditionally dominated by rule-based computation.

Among the variables, procedural fluency exhibited the highest correlation ($r = .226$, $p < .001$), implying that a student's ability to execute algorithms and formulas is the most direct predictor of success in a subject traditionally dominated by rule-based computation. This finding aligns with the research of Zakariya (2021), who observed that procedural self-efficacy often acts as the primary gateway for students navigating the technical rigors of undergraduate mathematics. Similarly, Productive Disposition ($r = .224$, $p < .001$) showed a nearly identical strength, reinforcing the Social Cognitive Career Theory (Lent et al., 2018), which posits that a positive disposition viewing mathematics as sensible and useful is a critical affective driver of academic achievement and persistence.

Despite the significance of these results, the weak nature of the r-values (ranging from 0.156 to 0.226) suggests a notable disconnect between how students perceive their skills and how they actually perform on objective assessments. The lowest correlation was found in strategic competence ($r = .156$, $p = .015$), which may indicate that while students believe they possess problem-solving strategies, current calculus assessments may prioritize routine expertise over the novel, strategic thinking described by Hatano (2003). This discrepancy supports the observations of Dunning et al. (2016) regarding the limitations of self-assessment; students in rigorous tracks like STEM often maintain a high Above Average self-perception that is not always perfectly mirrored in their technical output. Furthermore, as Rittle-Johnson (2017) points out, the relationship between conceptual and procedural knowledge is iterative and bidirectional; the weak correlations here may suggest that students are struggling to integrate these strands, leading to a fragmented understanding where high confidence in one area does not adequately support performance in the abstract environment of calculus.

The educational and practical implications of these findings highlight the need for a more balanced approach to STEM instruction that moves beyond fostering feeling proficient to ensuring objective mastery. Since the relationship is significant, it is clear that building student confidence is beneficial; however, the weakness of the correlation implies that educators must also address external variables such as prior algebraic knowledge and cognitive load management, which Sahmbi (2020) identifies as primary hurdles in calculus success. Practically, this means that while students possess a productive reasoning profile that keeps them motivated, they require targeted, high-stakes practice in strategic competence and adaptive reasoning to align their self-perceptions with actual professional-grade accuracy. A limitation of this study is the potential for self-report bias, where students might overestimate their fluency to align with the expectations of the STEM strand.

Therefore, while the rejection of the null hypothesis proves that proficiency perceptions matter, the results ultimately advocate for a pedagogical shift toward adaptive expertise, ensuring that the Above Average confidence reported by students is translated into the High level of technical precision required for future engineering and scientific innovation.

- ➤ *Effect of Mathematical Proficiency on the Students' Performance in Basic Calculus.*

Table 9 illustrates the effect of mathematical proficiency on the students' performance in Basic Calculus. The model yielded an overall correlation coefficient of $r = 0.261$, indicating a low positive relationship between the set of mathematical proficiency predictors and students' calculus performance.

The coefficient of determination ($R^2 = 0.068$) showed that approximately 6.8% of the variance in students' performance in Basic Calculus was explained by the

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

combined effects of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Although the explained variance was relatively small, the ANOVA results revealed an F-value of 3.497 with a p-value of 0.005, indicating that the regression model as a whole was statistically significant.

Table 9 Effect of Mathematical Proficiency on the Students' Performance in Basic Calculus

Predictors	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
(Constant)	3.053	0.362	8.442	<.001	Reject	Significant
Conceptual Understanding	0.056	0.178	0.315	.753	Failed to Reject	Not Significant
Procedural Fluency	0.38	0.212	1.795	.074	Failed to Reject	Not Significant
Strategic Competence	-0.27	0.22	-1.246	.214	Failed to Reject	Not Significant
Adaptive Reasoning	-0.01	0.208	-0.060	.952	Failed to Reject	Not Significant
Productive Reasoning	0.253	0.146	1.727	.085	Failed to Reject	Not Significant
r=0.261; R² =0.068; F-value=3.497; p-value=0.005						

This implies that, taken together, the components of mathematical proficiency had a significant effect on students' performance in Basic Calculus. With respect to the individual predictors, the constant term was statistically significant (B = 3.053, p < .001), indicating the expected level of students' performance in Basic Calculus when all predictor variables were held constant. Conceptual understanding yielded a positive regression coefficient (B = 0.056), suggesting a positive but minimal contribution to performance; however, its p-value of .753 indicated that the effect was not statistically significant. Thus, the null hypothesis for conceptual understanding was not rejected, implying that this variable did not independently predict students' calculus performance when other proficiency components were considered simultaneously.

Procedural fluency showed a positive regression coefficient (B = 0.380), indicating that higher procedural fluency tended to be associated with higher performance in Basic Calculus. Nevertheless, the p-value of .074 exceeded the .05 level of significance, leading to the failure to reject the null hypothesis. This result suggests that procedural fluency did not have a statistically significant unique effect on performance within the regression model, despite its positive direction. Strategic competence, on the other hand, had a negative regression coefficient (B = −0.270), indicating an inverse relationship with performance when controlling for other variables; however, this effect was also not statistically significant (p = .214). Consequently, the null hypothesis for strategic competence was not rejected.

Adaptive reasoning recorded a very small negative coefficient (B = −0.010) with a p-value of .952, indicating no significant effect on students' performance in Basic Calculus. This result suggests that adaptive reasoning did not contribute uniquely to predicting performance when analysed alongside the other components of mathematical proficiency. Similarly, productive disposition (labelled as productive reasoning in the table) showed a positive coefficient (B = 0.253), implying a favourable influence on performance; however, its p-value of 0.085 indicated that the effect was not statistically significant, leading to the failure to reject the null hypothesis.

Overall, the regression results indicate that while the combined components of mathematical proficiency significantly influenced students' performance in Basic Calculus, none of the individual components emerged as a significant predictor when considered simultaneously. This finding points to possible overlap or intercorrelation among the proficiency components, where their collective contribution was meaningful, but their independent effects were diminished. It further implies that students' performance in Basic Calculus was influenced by the integrated development of mathematical proficiency rather than by any single component in isolation.

Borji, Radmehr, and Font (2021) found that emphasizing either conceptual understanding or procedural fluency alone did not lead to immediate significant differences in students' calculus performance, suggesting that isolated proficiency strands may not directly translate into higher achievement. Similarly, Hechter, Stols, and Combrinck (2022) argued that success in calculus relies on the integrated use of multiple forms of mathematical knowledge rather than on a single proficiency component, which aligns with the non-significant regression coefficients observed in this study. However, other research contradicts these findings by demonstrating that mathematical proficiency can significantly predict calculus performance. For instance, studies examining the relationship between Calculus I and Calculus II achievement have reported strong and significant correlations, indicating that prior mathematical knowledge and skills are meaningful predictors of later calculus success. In addition, meta-analyses on mathematics education have shown that factors

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related to proficiency, such as self-efficacy and reasoning abilities, have a significant impact on students' mathematics performance. These contrasting findings illustrate that while individual proficiency components may not emerge as significant predictors in isolation, mathematical proficiency as a broader, interconnected construct can still play a crucial role in students' success in calculus.

➢ *Interactive Learning Material in Basic Calculus.*

The web-based interactive learning material in Basic Calculus is designed to improve students' performance by aligning its features with the five strands of mathematical proficiency: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. By combining instructional content with interactive and visual tools, it addresses common difficulties in understanding abstract calculus concepts.

Conceptual understanding is enhanced through dynamic visualizations and simulations that allow students to manipulate variables and observe real-time changes in graphs and functions. This helps transform abstract ideas like limits, derivatives, and integrals into more concrete and meaningful representations. Procedural fluency is developed through interactive exercises that provide instant feedback, step-by-step guidance, and detailed solutions, enabling students to practice efficiently while correcting mistakes and building confidence in applying calculus procedures.

The platform also strengthens strategic competence by guiding learners through progressively challenging tasks that encourage selecting appropriate strategies and solving contextualized problems. Adaptive reasoning is promoted through activities that require explanation, justification, and reflection, as well as simulations that allow students to test ideas and understand why solutions work.

Additionally, the website fosters productive disposition by creating an engaging and supportive learning environment. Features such as user-friendly design, progress tracking, and gamified elements help motivate students, build confidence, and encourage persistence in learning calculus.

Compared to existing platforms, the proposed website offers a more balanced approach. While platforms like Khan Academy focus mainly on procedural practice, and tools like Desmos and GeoGebra emphasize visualization without structured instruction, and ALEKS prioritizes assessment, this website integrates visualization, structured learning, adaptive support, and motivation in one system.

Overall, despite challenges such as maintenance and content updates, the platform represents an innovative approach to calculus education by supporting all five strands of mathematical proficiency, leading to deeper understanding, improved problem-solving, and sustained student engagement.

Figure 1 presents the homepage of the Web-Based Interactive Learning Material in Basic Calculus, which serves as the primary gateway for users to access the educational platform.

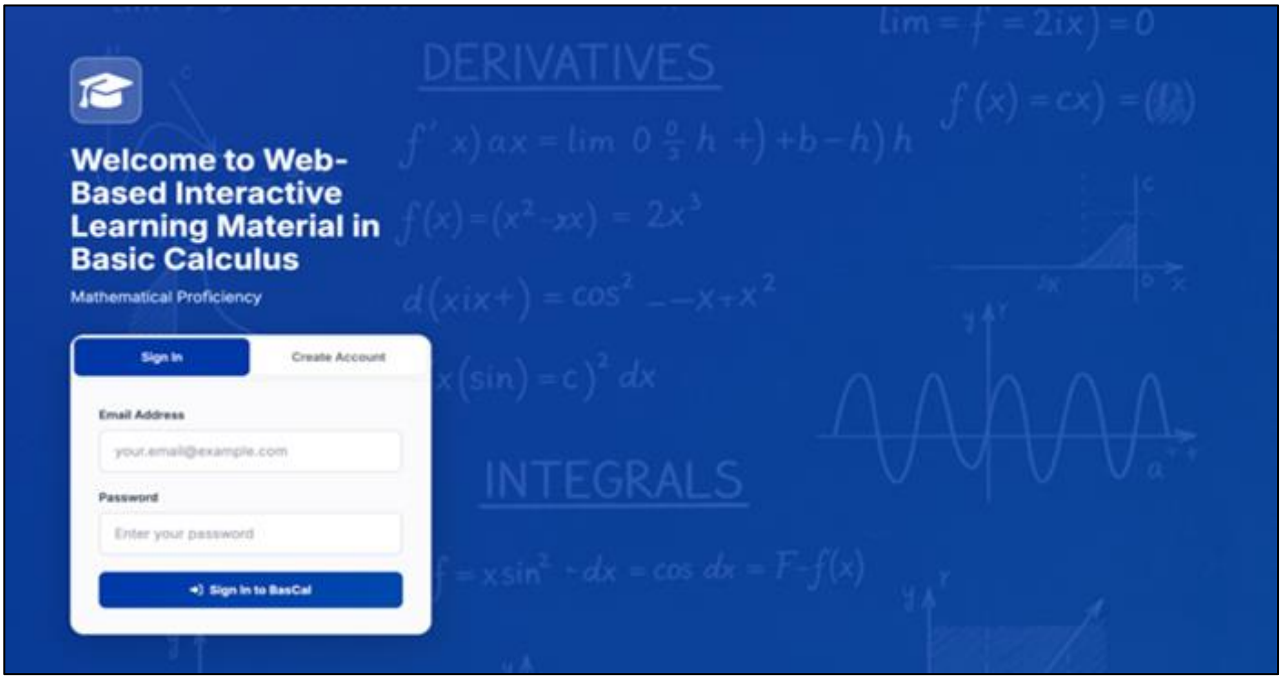

Fig 1 Homepage of the Web-Based Interactive Learning Material in Basic Calculus

Following the login process, Figure 2 illustrates the Teacher's Dashboard, which serves as a centralized hub for educators to manage their instructional environment and monitor learner performance in real-time

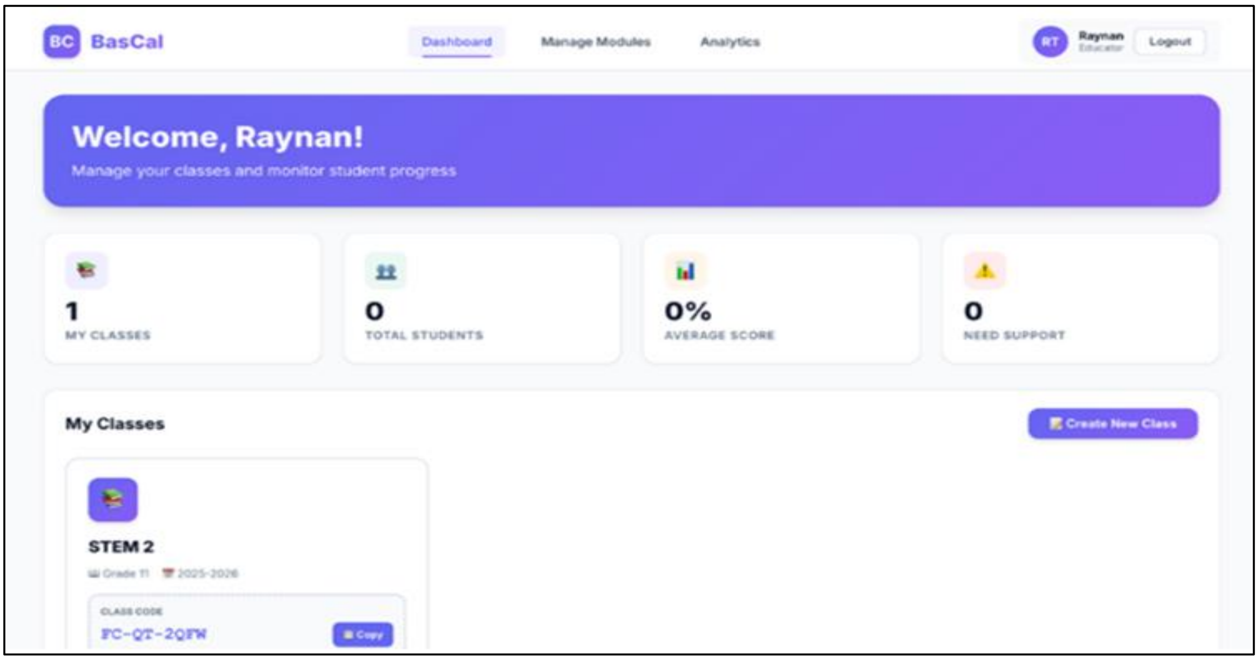

Fig 2 Teachers' Dashboard

Figure 3 showcases the Students' Dashboard, which provides a personalized and gamified environment designed to help learners track their academic progress and navigate their calculus coursework efficiently. At the top of the interface, a vibrant greeting banner displays high-level statistics, including the number of active modules, completed tasks, and the student's current average score, offering an immediate snapshot of their standing. A prominent Join Your Class! section allows students to enter specific codes provided by their teachers to sync with classroom activities and quizzes. Below this, the dashboard is organized into four intuitive navigation tiles— Browse Modules, Continue Learning, View Analytics, and Practice Mode—which facilitate a seamless transition between studying new content and reviewing previous lessons.

Additionally, a My Learning Path section and an Achievements tracker are visible, encouraging consistent engagement by rewarding milestones as the student progresses through the basic calculus curriculum.

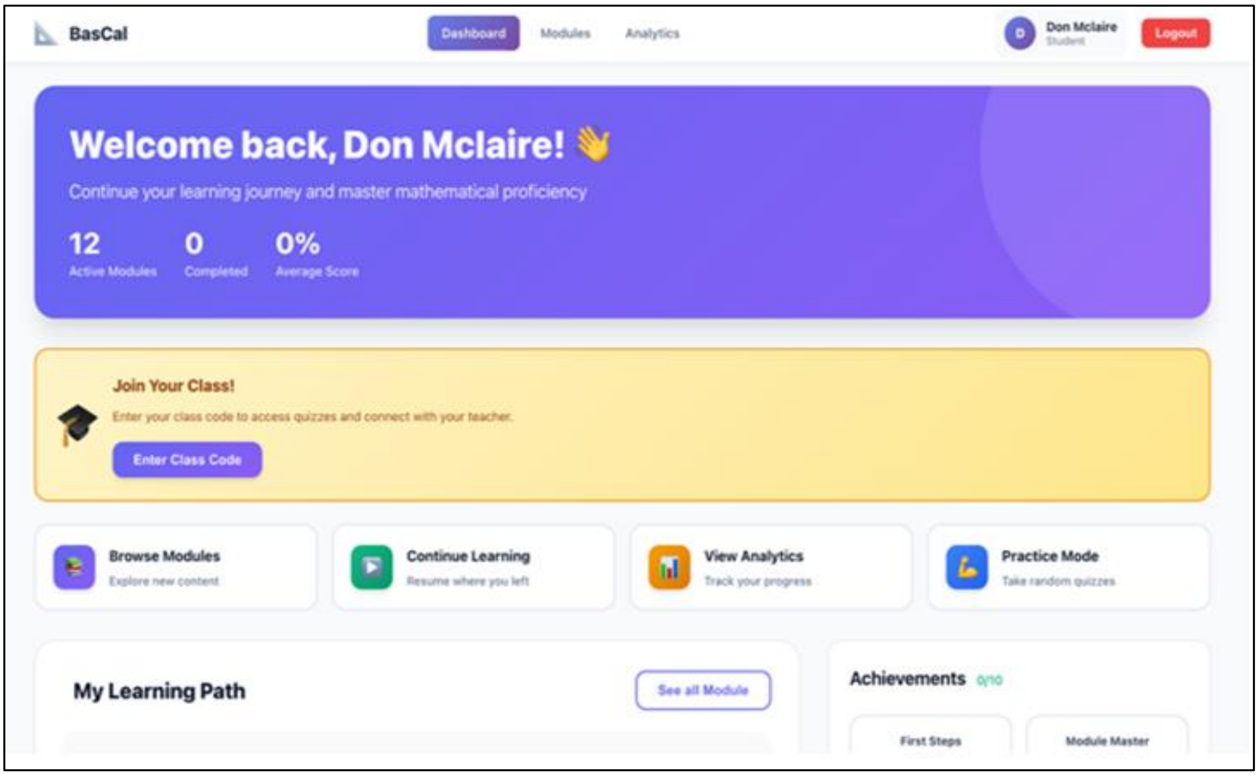

Fig 3 Students' Dashboard

Volume 11, Issue 3, March – 2026 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

Figure 4 details the Teachers' Module Selection interface, where educators can curate and customize the instructional content tailored to their students' specific learning needs.

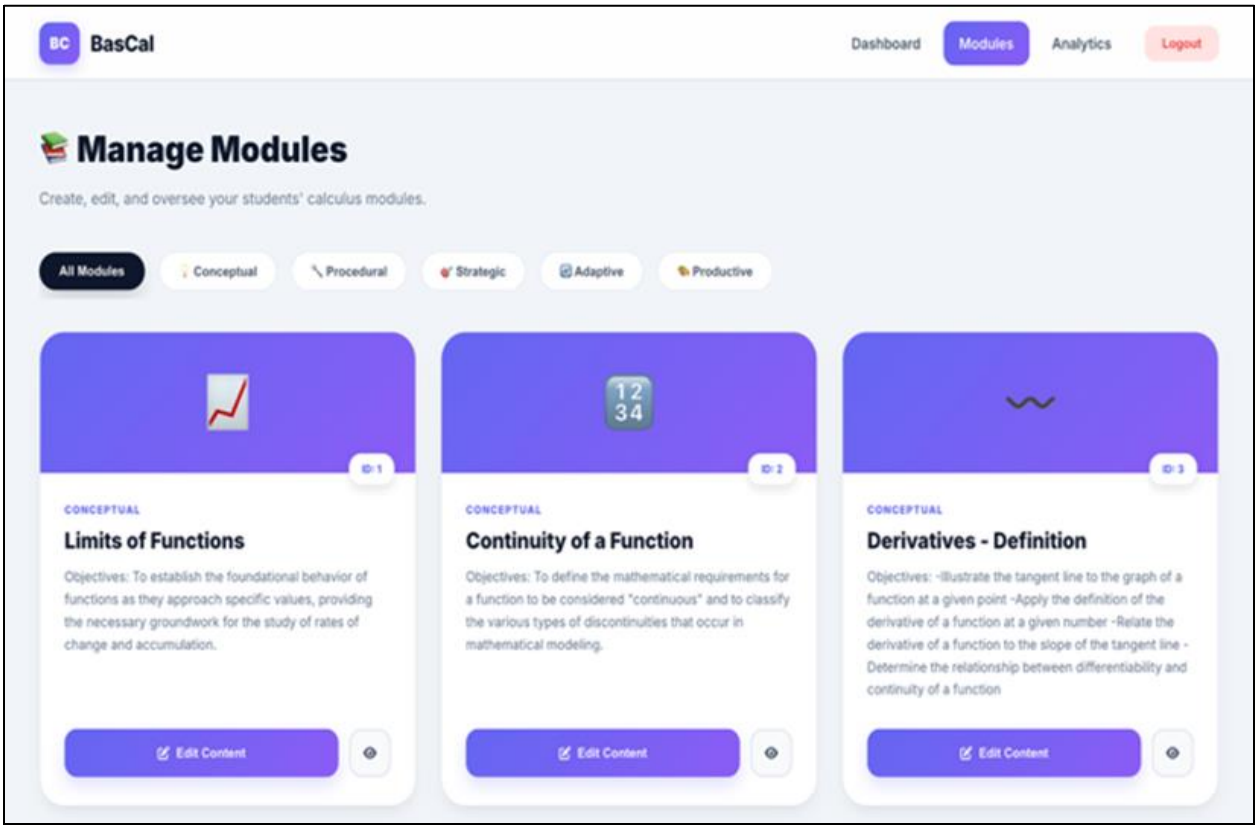

Fig 4 Teachers' Module Selection Interface

Figure 5 illustrates the Students' Module Selection interface, which provides a structured and progressive learning path designed to ensure mastery of foundational concepts before advancing to more complex topics.

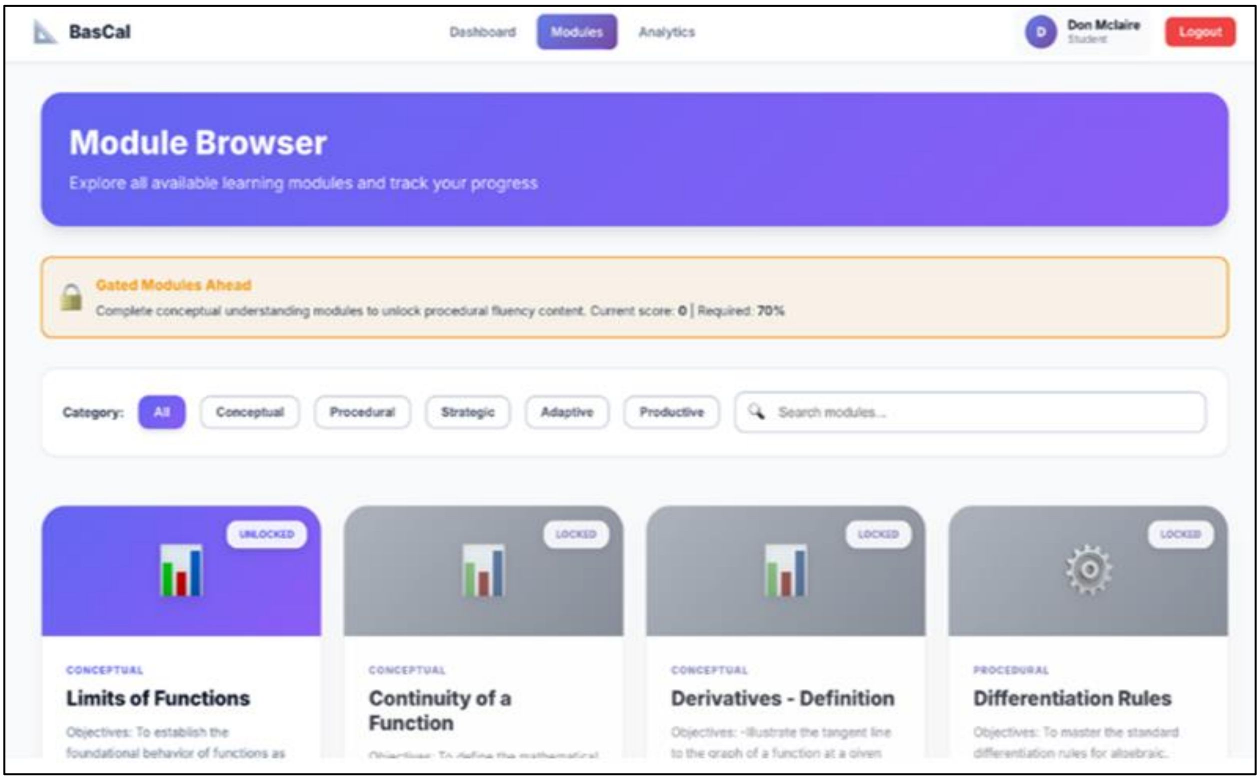

Fig 5 Students' Module Selection Interface

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Figure 6 presents the Teachers' Analytics Interface, a dedicated space for educators to monitor real-time class progress and pinpoint specific learning challenges across the curriculum.

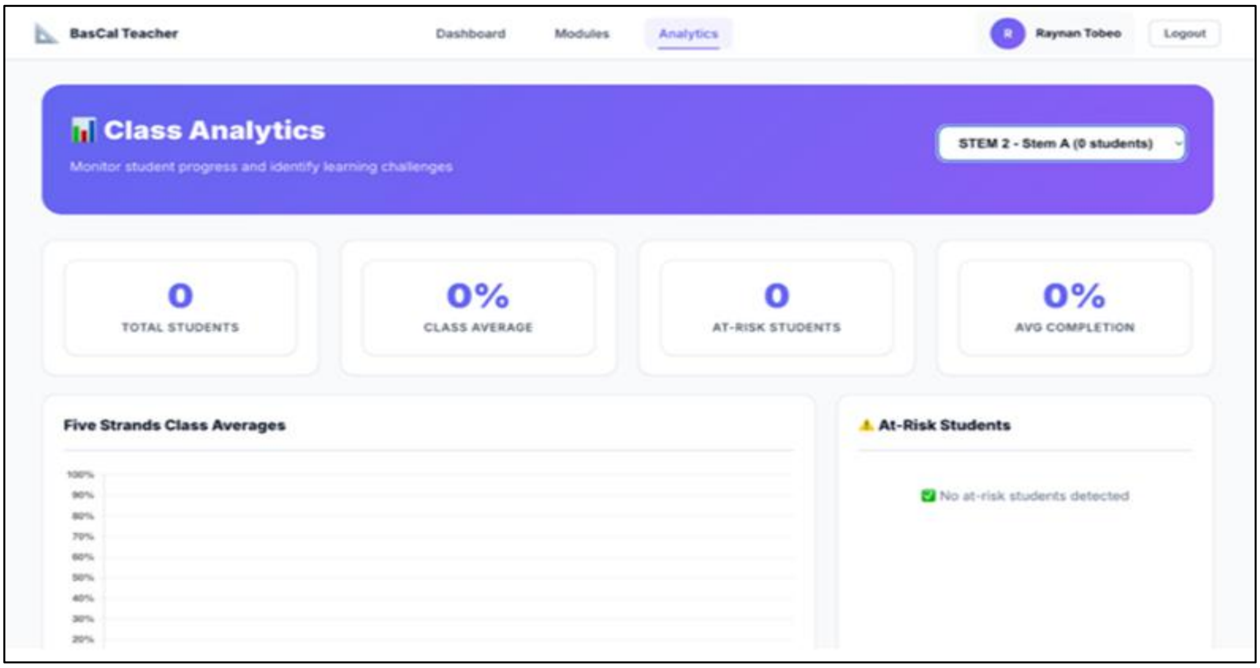

Fig 6 Teachers' Analytics Interface

Figure 7 illustrates the Students' Analytics interface, which is designed to provide individual learners with a comprehensive overview of their progress and mastery within the basic calculus curriculum. The dashboard begins with a summary section featuring four performance metrics: the student's overall average, passing rate, total quizzes taken, and the number of modules completed out of the total twelve available. Central to this interface is the Your Proficiency Strands section. Each strand includes a progress bar, allowing students to visualize how close they are to achieving standard proficiency targets. By displaying the number of attempts and completed modules for each category, this interface encourages metacognitive awareness, helping students identify their personal strengths and specific areas that require additional practice to reach their learning goals.

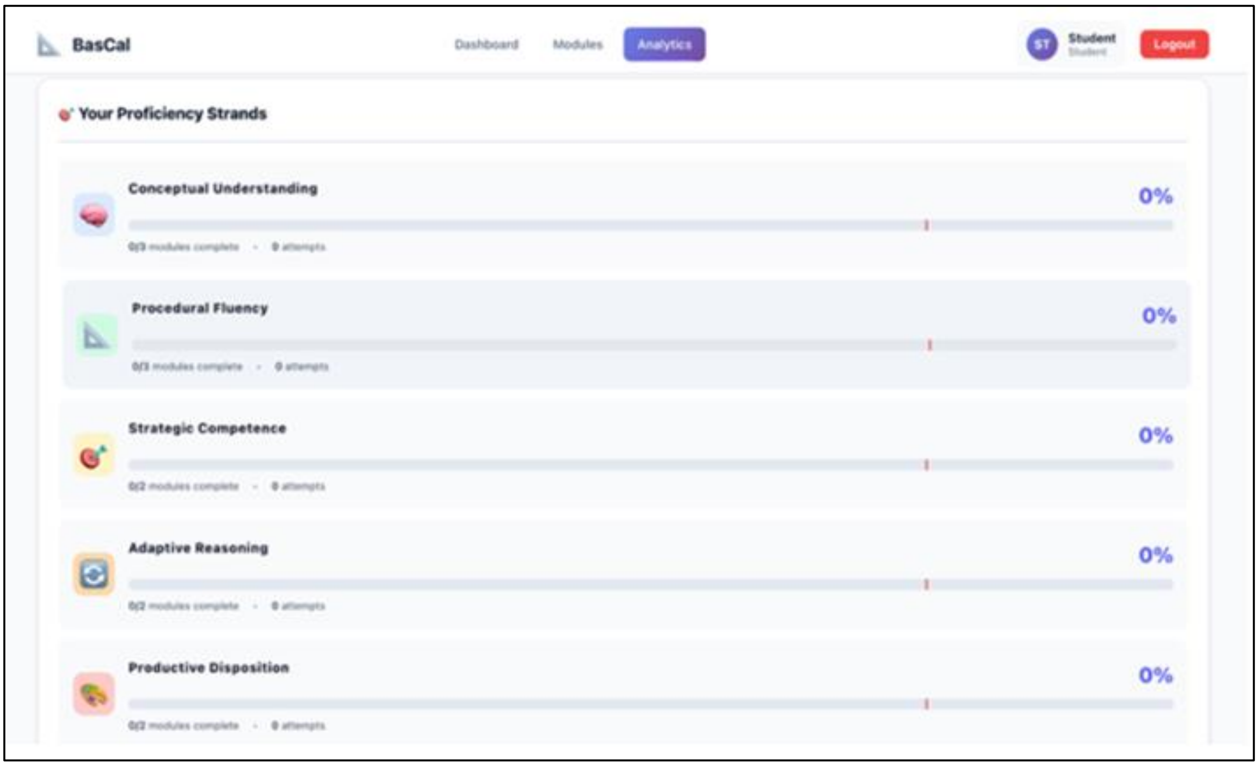

Fig 7 Students' Analytics Interface

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

Figure 8 presents the Teachers' Lesson Interface, specifically for the Limits of Functions module, which allows educators to manage and organize granular instructional content.

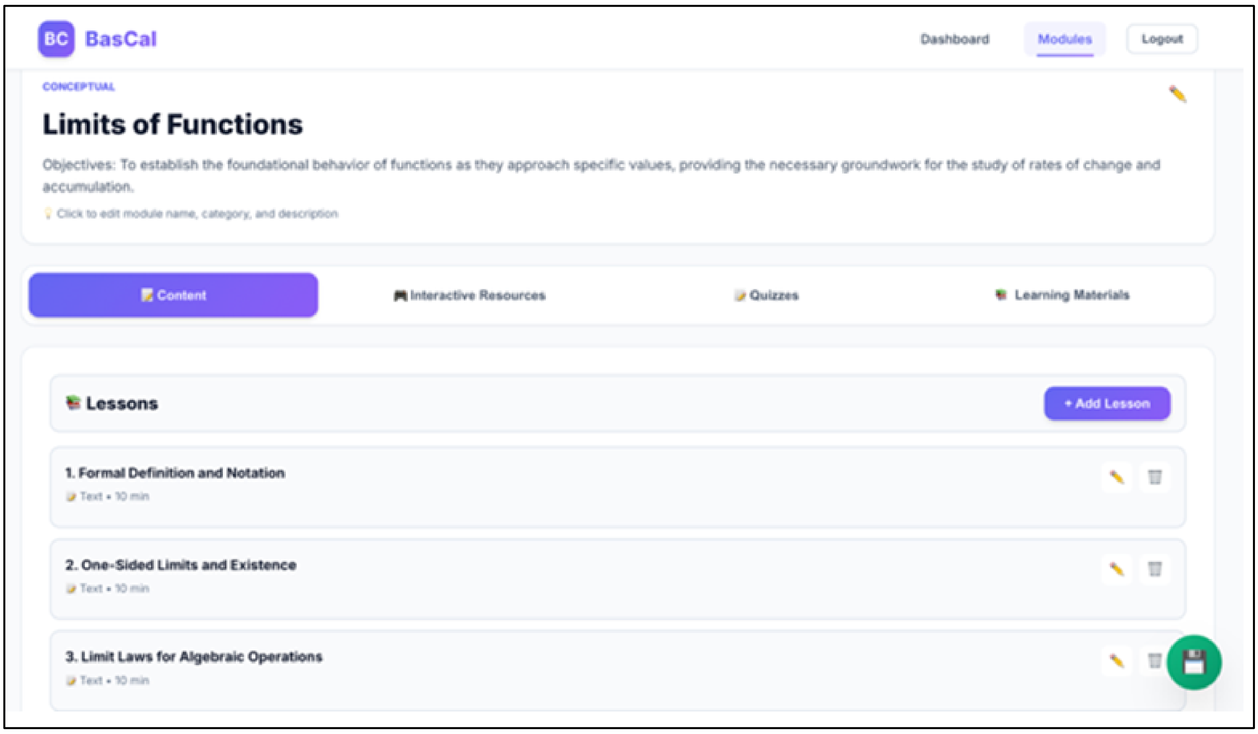

Fig 8 Teachers' Lesson Interface

Figure 9 depicts the Students' Lesson Interface, specifically showcasing the Formal Definition and Notation lesson within the conceptual module for Limits of Functions.

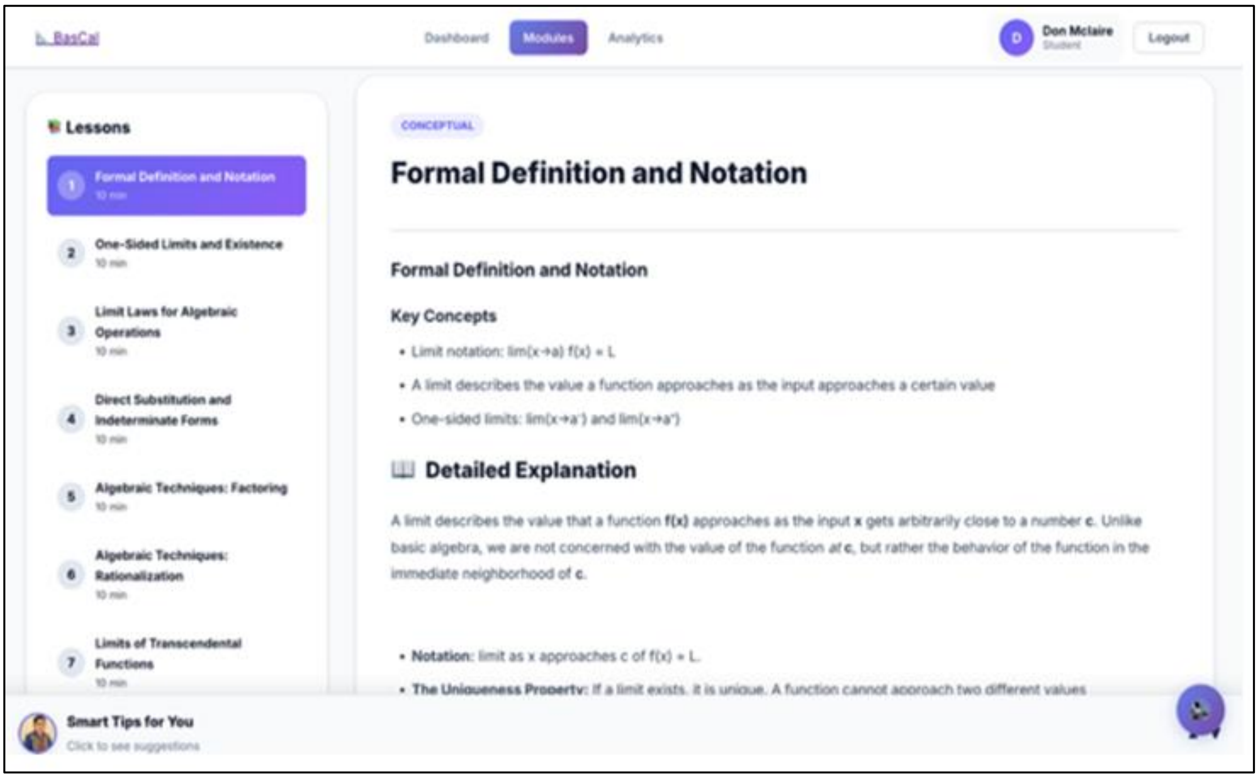

Fig 9 Students' Lesson Interface

Figure 10 displays the Teachers' Interactive Resources Interface, a specialized section within the module management system that allows educators to integrate third-party tools and simulations into their basic calculus lessons.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

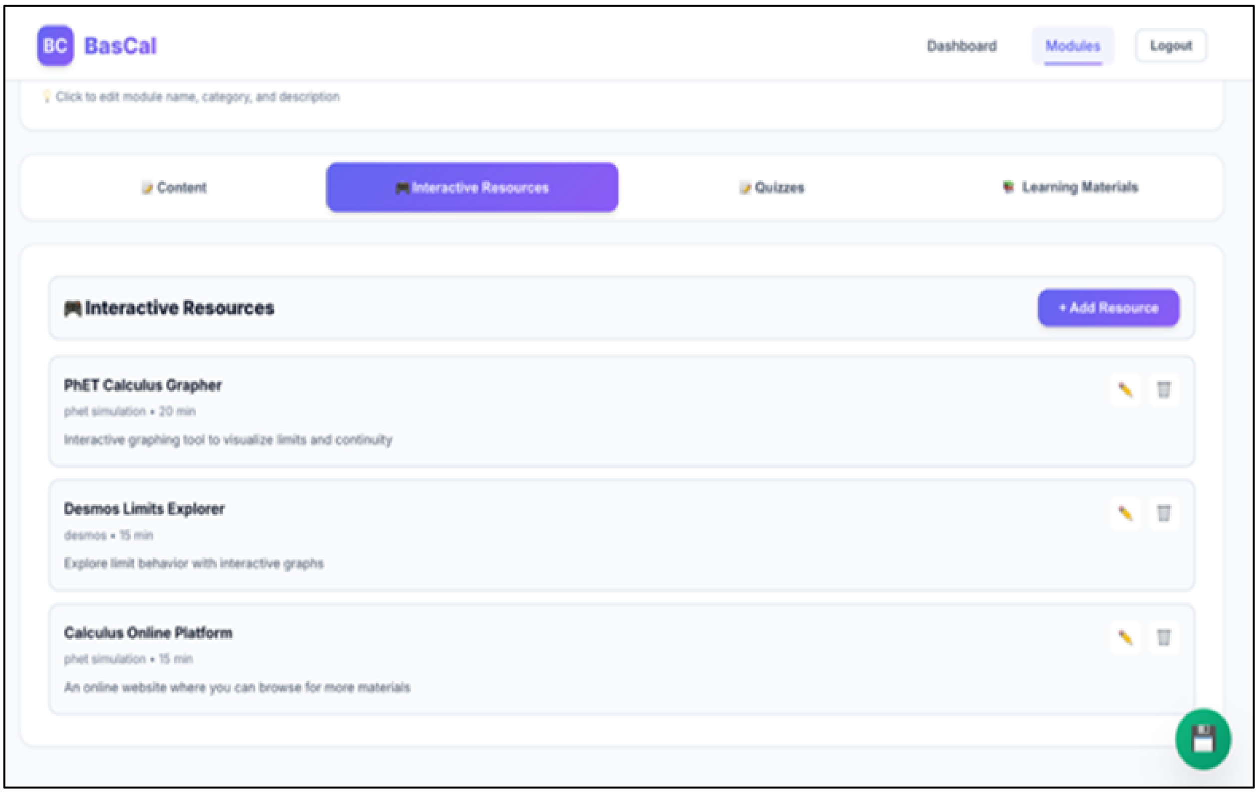

Figure 10 Teachers' Interactive Resources Interface

Figure 11 presents the Students' Interactive Resources interface, which provides learners with a hands-on environment to supplement their theoretical study of basic calculus through visual and investigative tools.

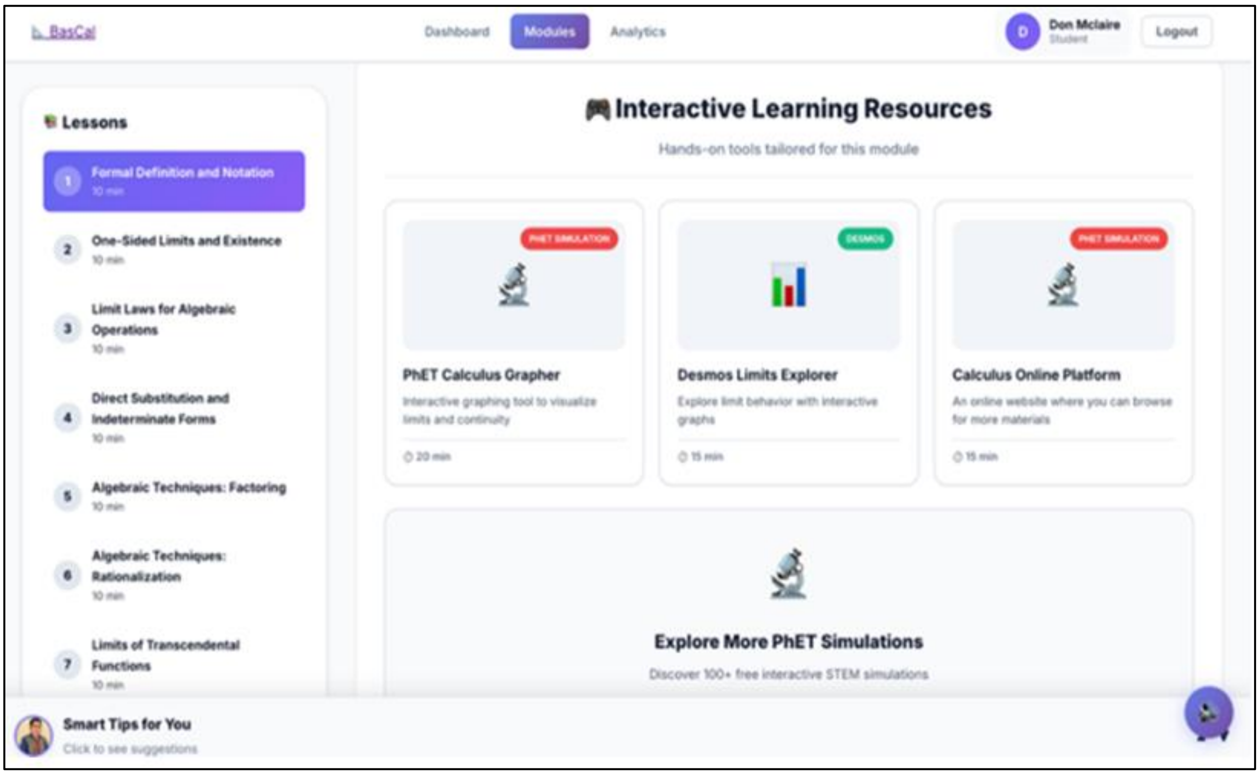

Fig 11 Students' Interactive Resources Interface

Figure 12 illustrates the Students' Practice Mode interface, which offers a versatile and adaptive environment for learners to refine their basic calculus skills through varied exercise formats.

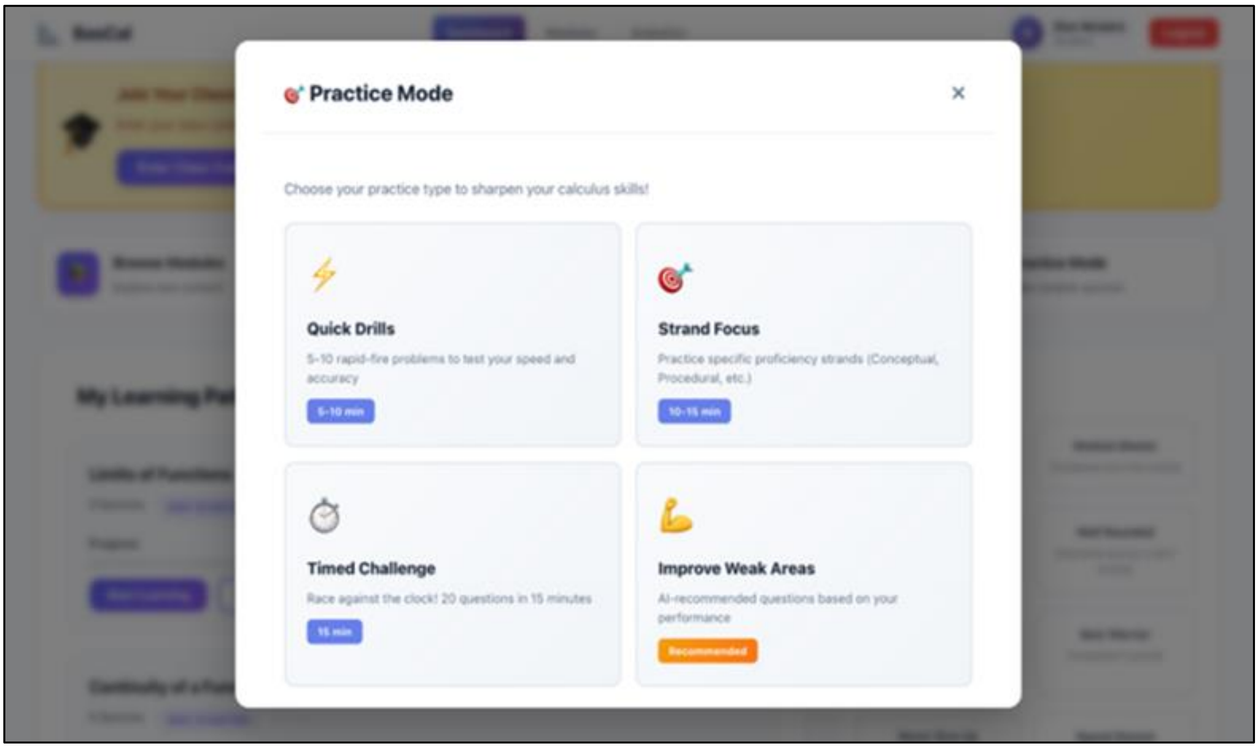

Fig 12 Students' Practice Mode Interface

Figure 13 presents a sample quiz interface within the Practice Mode, demonstrating how the platform assesses strategic competence and procedural knowledge through interactive problem-solving.

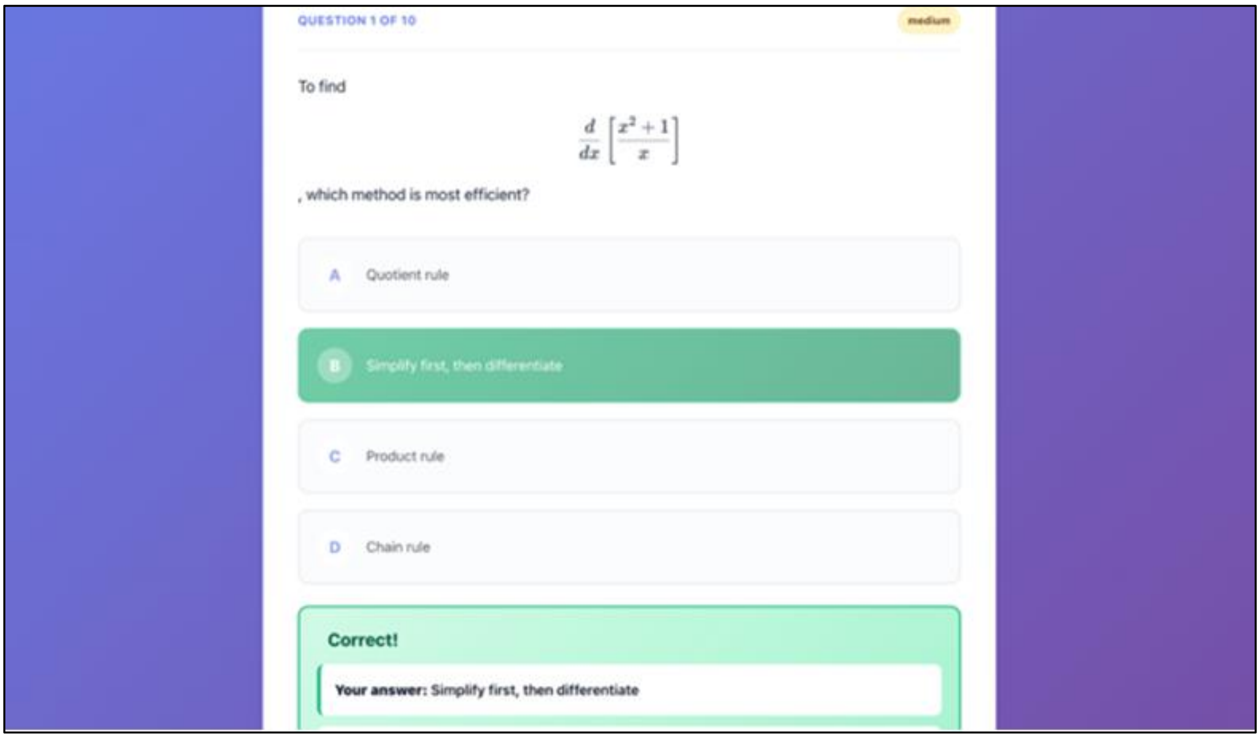

Figure 13 Sample Quiz in Practice Mode Interface

Figure 14 illustrates the Students' Smart Tips and Learning Materials interface, which provides a comprehensive support layer designed to deepen conceptual understanding and offer immediate academic assistance. The top section of the view features a Learning Materials repository where students can download supplemental resources in PDF format, such as One-Sided Limits, Limits of Exponential Functions, and a general Introduction to Limits, ensuring they have access to offline study aids.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

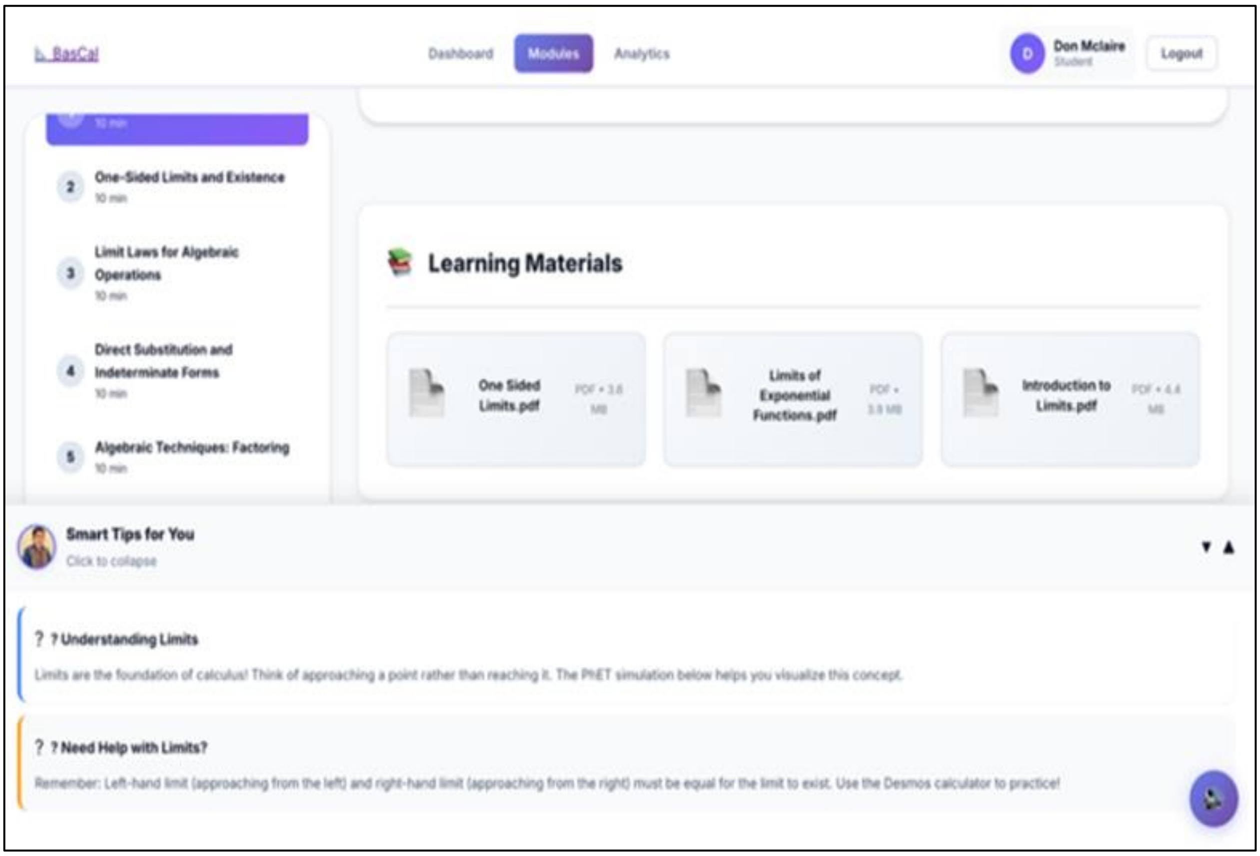

Fig 14 Students' Smart Tips and Learning Materials Interface

Figure 15 presents a sample visualization tool interface, specifically the PhET Calculus Grapher, which serves as a dynamic laboratory for students to explore the fundamental connections between a function and its derivative or integral.

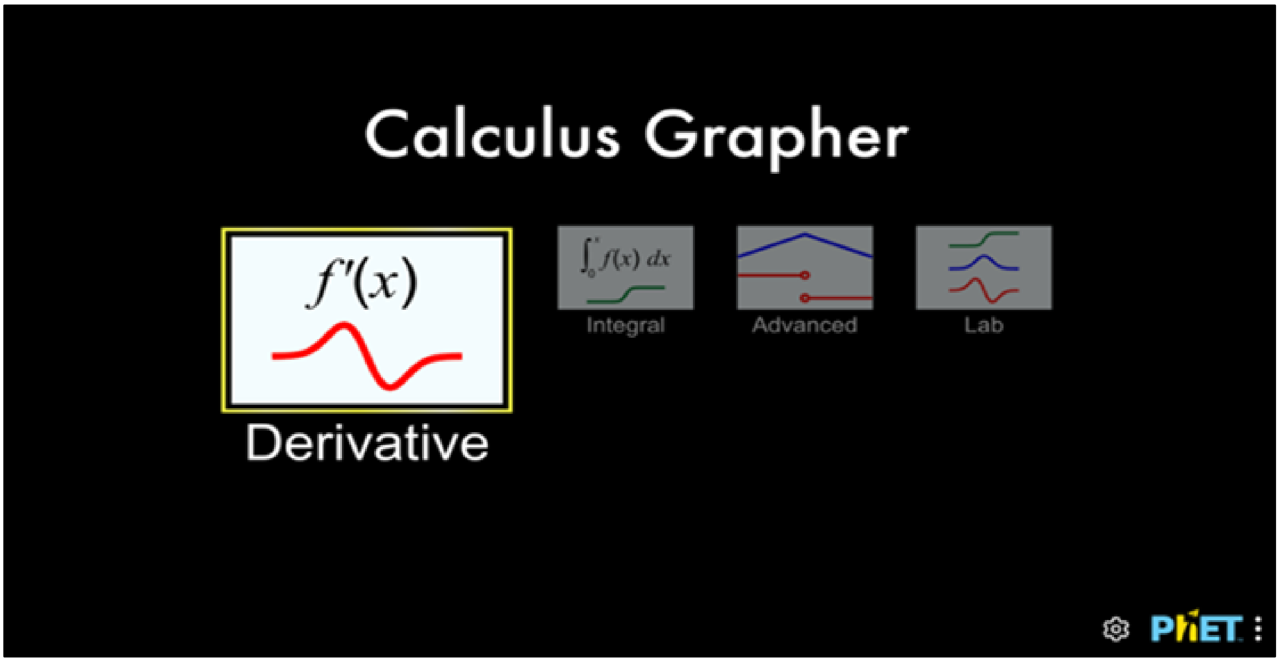

Fig 15 Sample Visualization Tool Interface

Figure 16 illustrates the Students' Interactive Quiz interface, which serves as the formal assessment environment where learners demonstrate their mastery of specific calculus modules.

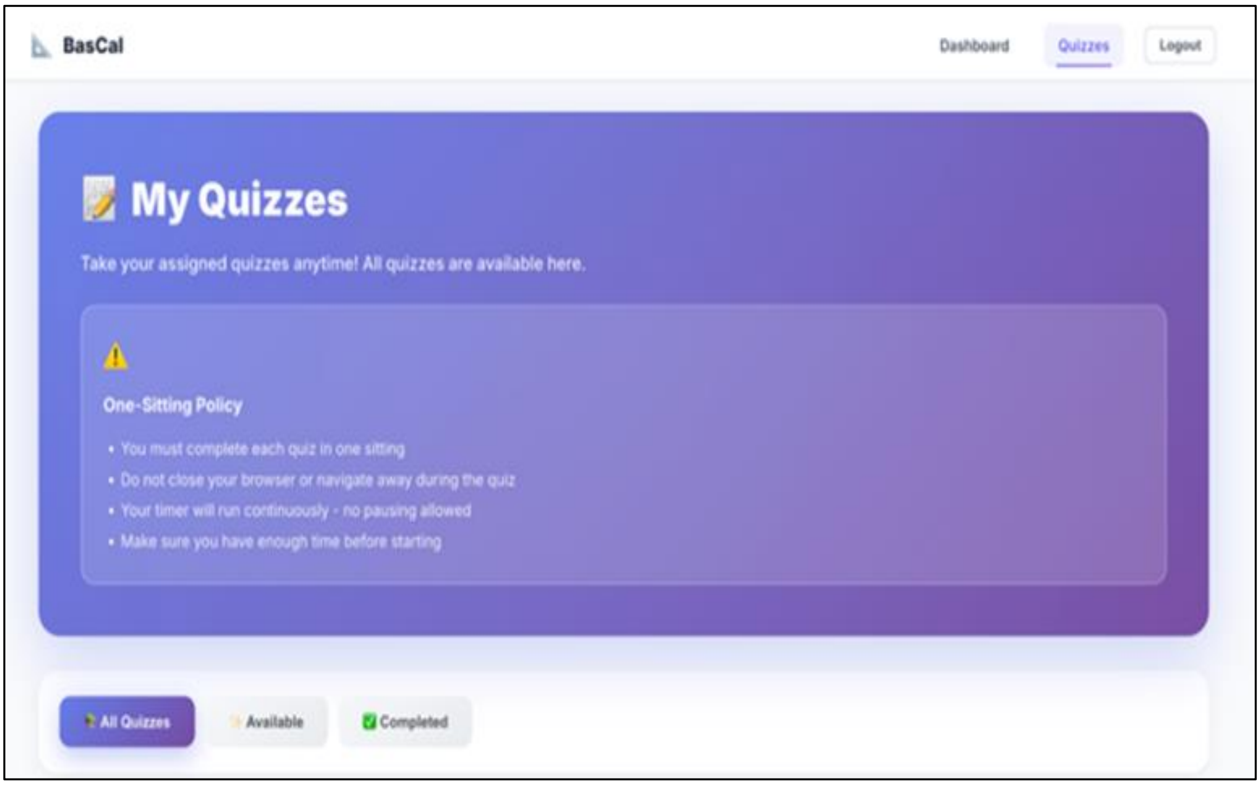

Fig 16 Students' Interactive Quiz Interface

Figure 17 presents the Teachers' Interactive Quiz interface, which offers educators a powerful set of tools to design and manage student assessments with both automation and manual control.

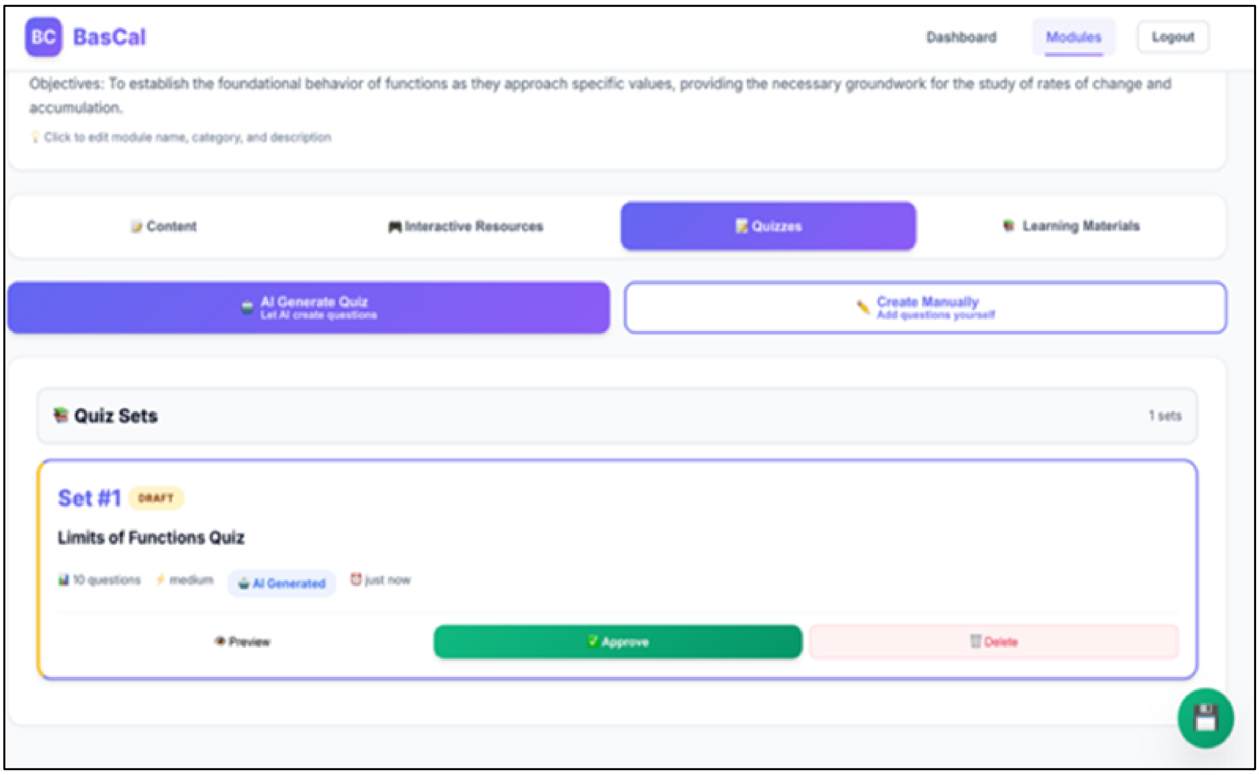

Fig 17 Teachers' Interactive Quiz Interface

Figure 18 displays the active Students' Interactive Quiz interface, showcasing a live assessment session that integrates real-time feedback and time-management tools.

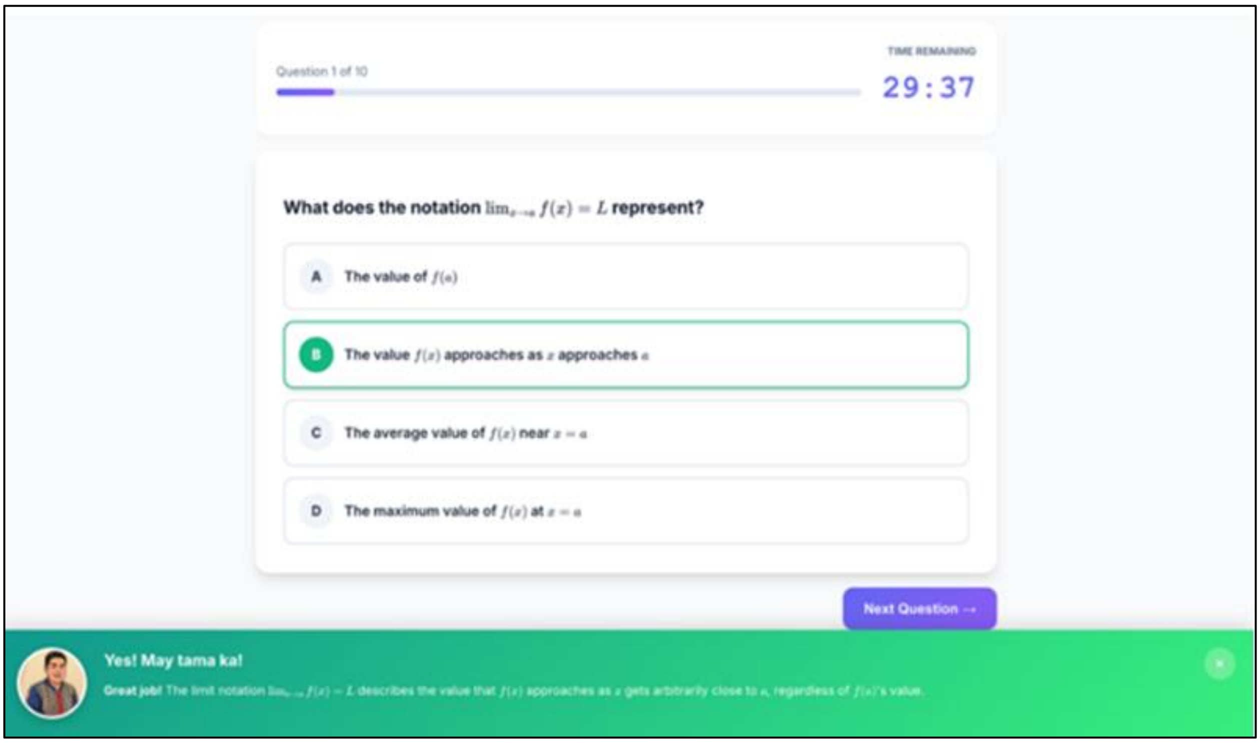

Fig 18 Students' Interactive Quiz Interface

IV. CONCLUSIONS & RECOMMENDATIONS

➢ *Conclusions*

Based on the findings, the following conclusions are drawn:

- The students' have a Very Satisfactory level of performance in Basic Calculus.
- The students' level of mathematical proficiency relative to conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition was all described as Above Average.
- There was a significant relationship between students' performance in Basic Calculus and their mathematical proficiency.
- There was no significant effect of mathematical proficiency, in relation to conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition, on students' performance in Basic Calculus
- Web Based Interactive Learning Material in Basic Calculus was prepared.

➢ *Recommendations*

In light of the above conclusions, the following recommendations are offered:

- The web-based interactive learning materials may be used to enhance students' engagement, understanding, and performance.
- Future study may be conducted to include a mediating variable in the relationship between mathematical proficiency and mathematical performance in Basic Calculus.
- Future study may be conducted to include a moderating variable on the relationship between mathematical proficiency and mathematical performance in Basic Calculus.
- Future study may be conducted about SEM- Structural Modeling of Mathematical Performance, Mathematical Proficiency, and other cognitive and non-cognitive variables.

ACKNOWLEDGEMENT

The researcher would like to acknowledge with sincere thanks, heartfelt gratitude, and appreciation to the special people who contributed much for the fulfillment of this study.

To Almighty God, whom the researcher offers all her hard work, for He is the ultimate source of strength and inspiration, the light that uncovers blind eyes towards ignorance and a lack of knowledge and experiences that enable her to face the challenges of life.

To Dr. Realiza M. Mame, Dean of the College of Teacher Education, for allowing the researcher to conduct the study, and for the kind assistance extended to her;

To Dr. Emil C. Alcantara, the research adviser and statistician, for his boundless patience and unconditional support in all stages of the research work. The researcher is grateful for all of his valuable suggestions, assistance, thoughtfulness, and understanding, particularly during the height of this research project, and for reviewing the manuscript's writing;

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1572

To Dr. Renson Robles, the chair of the panel, with Dr. Charity A. Aldover, Dr. Realiza M. Mame, who were the panelists, and especially to Dr. Ronie A. Mendoza, who was the external panelist, for letting the researcher modify and tailor his dissertation instrument, for their insightful comments that enlightened their understanding of the limitations of their own abilities. The researcher was grateful for the panel's assistance in developing her skills, as well as their honest criticisms and advice for future improvements, which resulted in a perfect and much more presentable study that she can be proud of;

To the respondents who cooperatively and honestly answered the questionnaire;

To the researcher's co-teacher who gives their support in making this research study;

To the researcher's friends, Sir Raymart Ilagan, Sir Jerwin Bagnes, Mam Minerva S. Magisa, and Engr. Honey Vie J. Awit, for their continuous support and understanding when undertaking this research. Their prayers were what sustained the researcher this far.

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