Perceived Attitude, Perceived Self-Efficacy and Performance in Calculus of the Grade 12 Students in Shanghai China

Agrix N. Go[1], Rosario F. Quicho[2]

[1]Distance, Open, Transnational University, Central Luzon State University, Science City of Muñoz, Nueva Ecija

[2]Department of Advanced Studies in Education, Central Luzon State University, Science City of Muñoz, Nueva Ecija

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ABSTRACT

The study was undertaken to find the relationship between Perceived Attitude, and Self-Efficacy to the Performance in Calculus of Grade 12 students in Shanghai, China. A group of 23 Grade 12 students (treatment group) who are taking International Baccalaureate Degree Program (IBPD) Mathematics: Analysis and Approaches – Higher Level Class were invited to take part in the study, and they provided their responses answering the online survey through Wechat mini app. The "Attitudes toward Mathematics Inventory" (ATMI) through Likert-style, was modified into a set of distinguished answers. Forty (40) semantically differentiated. A survey instrument was used and adapted to measure the perceived self-efficacy of the subjects. Pearson r was used to find out the relationship between perceived attitude and performance in Calculus under the treatment group after receiving instruction using digital textbook (Kognity) and find out the relationship between perceived self-efficacy and performance in Calculus of the subjects under the treatment group after receiving instruction using digital textbook (Kognity). Results showed the impact of students' attitudes and self-efficacy on calculus performance following instruction using the Kognity digital textbook. Analysis of 23 students revealed significant positive correlations between performance and three attitude components: confidence ($r = 0.61$, $p = 0.003$), enjoyment ($r = 0.52$, $p = 0.012$), and perceived value ($r = 0.47$, $p = 0.023$). Regression analysis showed confidence ($\beta = 0.42$, $p = 0.008$) and enjoyment ($\beta = 0.28$, $p = 0.045$) significantly predicted performance, while perceived value did not ($\beta = 0.19$, $p = 0.142$).

A particularly strong relationship appeared between self-efficacy and performance ($r = 0.65$, $p = 0.001$), with self-efficacy accounting for 42% of performance variance ($\beta = 0.65$, $p = 0.001$). Students with higher self-efficacy scored an average of 6.5% higher per unit increase on the self-efficacy scale. Performance outcomes ranged from 63% to 100% ($M = 85.4\%$, $SD = 10.2$), while self-efficacy scores averaged 3.8/5 ($SD = 0.9$).

These results prove that both affective factors and self-belief significantly influence calculus achievement in digital learning environments. Confidence and self-efficacy showed particularly strong predictive power, suggesting digital platforms should prioritize features that build mathematical self-assurance through scaffolded challenges and mastery experiences. While enjoyment stays important, perceived value of calculus showed weaker direct effects on immediate performance outcomes.

Keywords: attitude, self-efficacy, enjoyment, confidence, value

INTRODUCTION

Calculus presents significant challenges which affect how people perceive its difficulty level, so educators need to understand the connection between students' attitude belief and self-efficacy and performance in calculus to enhance math abilities. Educators need to understand student self-perception because it directly influences their academic results when studying challenging subjects including calculus. The knowledge of these relationships enables educators to develop specific intervention strategies that enhance student

performance through targeted measures. The investigation of these relationships will help students develop positive attitudes toward calculus, which will lead them toward academic success. It is a significant predictor of academic achievement in mathematics, particularly in calculus.

A positive attitude towards learning calculus can contribute to better performance, while a negative attitude may result in poorer performance. The quality of instruction, teaching materials, and educational technology such as digital textbook can also affect perceived attitude towards calculus. [29], examined the effects of a supplemental after-school program on attitudes towards mathematics among elementary school students. The outcomes showed that students who actively engaged and took part in the program had suggestively more positive attitudes towards mathematics than those who did not take part. The authors suggest that this positive attitude may lead to improved academic outcomes in mathematics, including calculus, among the students.

Many high school scholars deliberated their positive attitudes towards calculus had deliberated to respond to the essential for bigger analysis of measuring the tools. The difference had disregarded in favor of the Likert-scale and online survey; questions have unsuccessful to increase the admiration through pencil-paper based data gathering approaches. Data gathering through online is not merely an alternative from digital textbook into a pencil and paper strategies, there are added to contemplate to the style of the instruments through online setting. For example, while [8] concluded that (despite low non-coverage) non-response stayed a concern in student web surveys, more recent studies [9] [10] have proven that the direction of questionnaires online has condensed item non-response rates. Furthermore, the benefits of online data collection were confirmed by a study [21] that developed an online instrument for measuring attitudes towards school science.

Self-efficacy is an important aspect of motivation and can change an individual's willingness to engage in learning activities and persist through challenges. In the context of calculus, self-efficacy can influence a student's approach to problem-solving and their willingness to try new techniques or methods. The perceived self-efficacy can be subjective by a diversity of factors, together with earlier experiences, feedback from others, and the nature of the learning environment. Self-efficacy improvement strategies in calculus education focus on creating opportunities for success while offering feedback and support through positive learning environments. Better academic results and complete removal of success barriers require educators and students to recognize how perceived self-efficacy affects calculus learning.

Academic success in mathematics studies requires students to support a positive attitude while being resolute yet students who lack confidence about their abilities might struggle to finish their work and drop out before graduation becomes an overwhelming task for them. Perceived Self-Efficacy serves as a vital premise which plays an essential role during the development of these essential proficiency-based courses. A person with a standard belief level for Calculus will experience multiple negative emotions which result in learner disinterest leading to poor academic results. Success in mathematics lessons depends heavily on students having positive Self-efficacy. The learning experience of calculus students who use digital textbooks from Kognity depends on two factors: Perceived attitude and Perceived Self-Efficacy. Students who keep positive learning attitudes toward calculus will achieve better outcomes and develop confidence alongside appreciation for subject matter while supporting strong material retention.

A negative attitude in students results in disengagement which produces subpar academic performance. People who believe in their abilities toward success tend to stay focused on their work through proper resource acquisition which helps them tackle challenges effectively. Students who have lower self-efficacy tend to avoid demanding work while facing challenges in their academic achievements. Students who use digital textbooks such as Kognity to learn calculus will achieve better results if they keep a positive attitude and strong self-efficacy. Students who keep positive attitudes tend to participate more actively with interactive features while using platform resources to boost their learning experience. Students who demonstrate strong self-efficacy show greater confidence in using the platform to get the most out of it.

The digital textbook Kognity functions as a technological tool that could enhance positive attitude and self-efficacy in students dealing with Calculus difficulties. Teachers must discover proper educational technology solutions alongside methods for maximizing technology benefits in student motivation and learning. The minimal achievement rates of students in developmental mathematics courses reveal the necessity to develop

the most successful teaching methods for material that students need to pass and complete their courses. The researcher argues for finding the relationship between perceived attitude, perceived self-efficacy, and performance in calculus might be driven by the belief that understanding these factors can offer valuable insights into student achievement and inform effective teaching strategies. By investigating how students' attitudes and self-efficacy beliefs in calculus relate to their performance, you aim to uncover the underlying psychological factors that contribute to academic success in this subject. Understanding these relationships can help find potential barriers or facilitators to learning calculus and guide interventions to enhance students' attitudes and self-efficacy, improving their performance and overall learning outcomes.

Conceptual Framework

The study was anchored on the cognitive theory of multimedia learning [25], Cognitive Theory [2] and [3]. The cognitive learning theory supports that prior knowledge and learning ability affect educational outcomes. [25] first described why learning with digital tools can be beneficial: according to the dual channel hypothesis, students can organize information into two different cognitive structures, namely the visual and auditory channel. The second assumption, to avoid overwhelming learners its best for educational settings to use visual and auditory channels in combination, such as presenting spoken or sound-based content along with written text or visuals. The third assumption is that students must actively engage in learning content to understand added information [25]. Interactive learning environments are key in this regard--these allow learners to actively participate and influence their own learning process. Therefore, "the distinguishing feature of interactivity is responsiveness to student action during learning" [27].

Like other cognitive theorists, [2] argued that learning is based on mental schemas or structures by which students organize their perceived environment. He emphasized only when students can relate new material to their existing knowledge structures will they truly grasp concepts beyond simple rote memorization. When it comes to learning there are two ways to go about it - either through machine learning or meaningful learning. Machine learners do not put much effort into relating added information with what they already know while those engaged in meaningful learning consciously try to integrate novel concepts with pre-existing knowledge structures. [2] believed that technology would help students activate prior knowledge which would in turn create more meaningful teaching experiences.

The study was also anchored on self-efficacy theory. According to [3], someone’s notion of finishing a purpose will influence whether they are entire the purpose [3]. Four major records assemble self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states [3].

The conceptual framework presented above helped the researcher to visualize the study Since the study primarily aim was to investigate the effectiveness of using digital textbook (Kognity) on the students’ performance, perceived attitude and perceived self-efficacy in Calculus to allow the subjects in the treatment group obtain new ideas and information that can either be changes or refines their previous knowledge. And to check whether the subjects learned or not the materials to be manipulated, the posttest was given to the subjects under the treatment group. With this, by instrumental conceptualization, the researcher was able to understand the effect of digital textbook (Kognity) to the subjects’ performance. [25], [2] and [3] are found to be helpful and valuable.

To address the problem under this study, the Input – Process – Output (IPO) paradigm was used in accordance with the model used. As shown in Figure 1, the input of the study included the performance of the subjects in Calculus in the treatment group prior to the treatment as revealed by the pretest scores.

Likewise, in Figure 1, the utilization on the use of digital textbook (Kognity) in the treatment group served as the process or the intervention.

And lastly, the output of this study highlighted the effectiveness of using digital textbook (Kognity) in the students’ performance in calculus by comparing the results of the posttest given to the treatment group. The performance of the subjects in the treatment group was compared to setting up the effectiveness of using

digital textbook (Kognity) to the student's performance in Calculus. In addition, the perceived attitude and perceived self-efficacy towards Calculus of the subjects in the treatment group were established prior to the treatment, hence those variables were also being considered as output of the study.

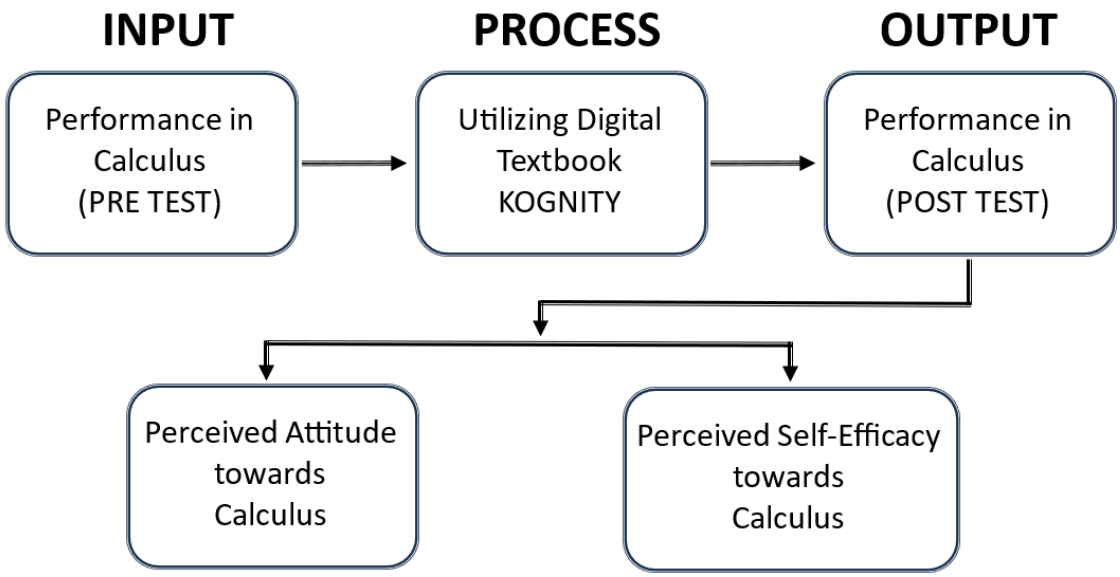

Fig. 1 The research paradigm showing the Input, Process and Output of the Study

Objectives of the Study

This study is aimed to investigate the attitude, self-efficacy, and performance in Calculus of the Grade 12 students in Shanghai United International School (SUIS), Shanghai China during the School Year 2022-2023. Specifically, this study tried to:

1. find out the relationship between perceived attitude and performance in Calculus of the subjects under the treatment group after receiving instruction using digital textbook (Kognity).

2. find out the relationship between perceived self-efficacy and performance in Calculus of the subjects under the treatment group after receiving instruction using digital textbook (Kognity).

Hypotheses of the Study

1. There is no significant relationship between perceived attitude and student's performance in Calculus of the subjects under the treatment group after receiving instruction using digital textbook (Kognity).

2. There is no significant relationship between perceived self-efficacy and student's performance in Calculus of the subjects under the treatment group after receiving instruction using digital textbook (Kognity).

METHODOLOGY

Research Design

This study combined a quasi-experimental pre-post intervention design with correlational analysis to achieve two goals: A quasi-experimental design served as the research method employed in this study aiming at estimating the impact of an intervention on its subject without resorting to randomization techniques. Contrary to controlled experimental designs that cause subject randomization procedures quasi experimental studies allow researchers flexibility in controlling treatment condition assignments using alternative criteria [13]. Quasi experiments are appropriate for investigations when there are impractical or ethical concerns surrounding random assignments.

This also offers advantages to validity since they can be conducted in natural settings thereby improving generalizability of findings to a wider population and situations [13].

This study adopted the Pretest-Posttest design among other quasi experimental options available. To measure the impact of the Kognity digital textbook by comparing students' calculus performance before and after the intervention (paired t-tests).

The Correlational research design was used in this research study. The Correlational research design examines the degree of the relationship that exists between two or more variables. In using this design, data was collected to conduct the structure process. In this study, the sole purpose of correlational research design is to provide accurate and valid representations of the factors under independent variables and their relationship to dependent variables which are the perceived attitude and the perceived self-efficacy of the subjects toward their performance in Calculus.

A correlation research design is a quantitative measure of the degree of the correspondence between two or more variables. Correlational research was used in the study to find out the relationship between perceived attitude and perceived self-efficacy towards performance in Calculus of the subjects under the treatment group after receiving instruction using digital textbook (Kognity).

Study Sites

The study took place during the winter (second) semester of the 2022 – 2023 academic year at Shanghai United International Schools Gubei Campus at Hongsong East Road, Minhang District, and Shanghai, China.

Respondents and Data Collections

Data was collected from twenty-three students through an online survey (treatment group) who are taking International Baccalaureate Degree Program (IBPD) Mathematics: Analysis and Approaches – Higher Level Class were invited to take part in the study, and they provided their responses by completing an online survey.

In preparation for data collection during the latter stage of Academic Year 2022-2023 First Semester at SUIS - Gubei Campus in Shanghai, permission was sought from important administrative officials such as International Curriculum Principal, Director of Studies, and IBDP Curriculum Coordinator.

To participate in this study, each student was required to submit signed consent forms from their parents/guardians and a subject assent form signed by them within a week after receiving them upon which submission advisory classes facilitated collection, only those with both documents would be considered for participation.

The pretest conducted on both groups using the Wechat mini application focused on Calculus Performance; this application explained what survey's objective and utilization of outcomes was. After six weeks of intervention, a questionnaires and posttest were conducted to the treatment groups to investigate the subjects' perceived attitude, perceived self-efficacy and performance in calculus.

Ethical Consideration

Ethics were taken into consideration with the subjects providing consent before accessing the questionnaire and their responses being confidentially stored.

The Ethics and Review Committee of Central Luzon State University approved all protocols used in the study.

Instrument Used

The "Attitudes toward Mathematics Inventory" (ATMI) with Likert-style responses, was adapted into a set of items with semantically differentiated response from "Development of a short form of the attitudes toward mathematics inventory" [23], such as (1) Enjoyment (E); (2) Confidence or (C); (3) Perceived value or

usefulness (V).

Forty (40) differentiated questions were modified and modified from previous perceived attitude instruments with online visual correspondent scales. All survey elements were adapted from the study by [23]

A survey instrument was used to measure the perceived self-efficacy of the subjects in Calculus during the academic year 2022-2023 Second Semester. A pre-existing self-efficacy questionnaire was adapted, developed by Ellen [30]. Advantages of this online survey method include rapid scanning of the information collected and little or no cost [14].

Showing the researcher's keen interest in utilizing measures for his study, the researcher reached out to the authors of the Attitude [23] and self-efficacy questionnaire [30]. To his delight, both authors promptly responded to his message with support, granting permission for their questionnaires' use. Affirming the value of his research, their positive and swift response demonstrated willingness to collaborate and contribute knowledge advancement. The credibility and validity of his study were significantly bolstered by this cooperation, allowing him to proceed with confidence.

Within this scale, participants will rate their perceived self-efficacy in relation to various scenarios commonly experienced during a Calculus course. There are 23 items, rated according to a 5-point Likert format: 1.0-1.80 = Never, 1.81-2.60= Seldom, 2.61-3.40=Sometimes, 3.41-4.20= Often and 4.21-5.0 = Always. The subjects will answer the survey questions to indicate their level of enjoyment, confidence and value in specific situations related to math courses.

Data Analysis

The research used quantitative methods to analyze data obtained from validated questionnaires which studied how psychological factors affected calculus performance after students used the Kognity digital textbook intervention. The collected data underwent statistical analysis with SPSS (Version 27) after initial processing in Microsoft Excel for data organization and descriptive summaries with the help of a statistical consultant. The research employed Pearson correlation analysis to establish relationships between enjoyment and confidence attitudes and self-efficacy with calculus performance while using linear regression to determine predictors of post-test scores and improvement gains from these psychological factors and paired samples t-tests to evaluate the intervention's impact through pre-test and post-test comparisons. The research established $\alpha = 0.05$ as the statistical significance threshold and reported effect sizes for all significant results. Researchers used a detailed analytical framework to analyze both intervention effects and psychological factors that affect student achievement results.

RESULTS AND DISCUSSION

The collected data underwent statistical analysis to fulfill the research objectives. The analysis includes two parts which examine the relationship between perceived attitude towards calculus of the treatment group students who learned from Kognity digital textbooks and the relationship between perceived self-efficacy towards calculus of the treatment group students who learned from Kognity.

Perceived Attitude and Performance in Calculus

Descriptive Statistics

The data presented in table 1 showed essential information about student attitudes and performance in calculus. The mean post-test score reached 85.4% (SD = 10.2) which showed that students performed well but the standard deviation revealed that students had various levels of performance. The Enjoyment (E) subscale scored an average of 18.6 out of 25 (SD = 2.3) which showed students enjoyed calculus but had diverse levels of enjoyment. The Confidence (C) scores reached an average of 32.1 out of 50 (SD = 4.5) which showed students had moderate self-assurance levels. The Values (V) scores reached an average of 35.2 out of 50 (SD = 5.1) which showed students understood the subject's importance but with different levels of intensity.

Table 1 Descriptive Statistics

Variable	Mean	Std. Deviation	Min	Max
Post-Test (%)	85.4	10.2	63	100
Enjoyment (E)	18.6	2.3	12	23
Confidence (C)	32.1	4.5	22	40
Values (V)	35.2	5.1	25	45

These findings aligned with prior research show that positive attitudes correlated with academic success [26]. The low confidence scores suggested that while students performed well, some may have struggled with self-doubt critical factors in math achievement [28]. The variability in Values implied that not all students fully appreciated calculus's real-world applications, which could have influenced their long-term engagement [12]. These patterns highlighted the need for targeted interventions, such as confidence-building exercises and real-world problem-solving tasks, to enhance both perception and performance.

Correlation Analysis

The correlation analysis on table 2 demonstrated significant relationships between attitude components and calculus performance. Confidence (C) showed the strongest correlation ($r = 0.61$, $p = 0.003$), reinforcing [3] that self-belief directly impacted achievement. Students who trusted their problem-solving abilities persisted through challenges, leading to higher scores. Enjoyment (E) also correlated moderately ($r = 0.52$, $p = 0.012$), supporting [15] "broaden-and-build" theory, which posited that positive emotions expanded cognitive flexibility and learning capacity. Meanwhile, Values (V) had a weaker but still significant link ($r = 0.47$, $p = 0.023$), suggesting that while recognizing calculus's utility helped, it was less impactful than confidence and enjoyment in immediate performance.

All three subscales showed moderate positive correlations with performance ($p < 0.05$).

Table 2 Correlational Analysis

Attitude Subscale	Correlation (r)	p-value
Enjoyment (E)	0.52*	0.012
Confidence (C)	0.61**	0.003
Values (V)	0.47*	0.023

These results mirrored past studies where intrinsic motivation (enjoyment), and confidence were stronger predictors of math success than extrinsic factors like perceived usefulness [32]. Educators should thus prioritize fostering a growth mindset and engaging, enjoyable learning experiences to maximize student outcomes.

Regression Analysis

The regression analysis on table 3 further clarified the relative influence of each attitude component. Confidence ($\beta = 0.42$, $p = 0.008$) emerged as the strongest predictor, accounting for a significant portion of performance variance.

Table 3 Regression Analysis

Predictor	Beta (β)	p-value
Enjoyment	0.28	0.045
Confidence	0.42	0.008
Values	0.19	0.142

This aligned with [39] findings that self-regulated learning—rooted in confidence—enhanced problem-solving in STEM fields. Enjoyment ($\beta = 0.28$, $p = 0.045$) also contributed uniquely, underscoring the role of intrinsic motivation in sustaining effort [32]. In contrast, Values ($\beta = 0.19$, $p = 0.142$) did not significantly predict performance when controlling other factors, possibly because abstract beliefs about calculus's importance mattered less than immediate emotional and cognitive engagement [12].

These findings suggested that interventions should first target confidence (e.g., through scaffolded practice) and enjoyment (e.g., via interactive tools like Kognity), as these had the most direct impact on performance. While promoting the value of calculus remained important, its influence might be more long-term, shaping course selection rather than immediate grades.

The relationship between enjoyment and confidence in calculus after the intervention of using digital textbook (Kognity) could be attributed to several factors. Firstly, when students enjoy the learning process, they are motivated and involved in the material that could lead to a deeper level of understanding and retention of the concepts taught. Students need to dedicate themselves to studying mathematical concepts, particularly calculus, in this study while practicing theoretical ideas and their practical applications.

Students who dedicate extra effort to learning will experience improved test results as time progresses. Digital textbooks such as Kognity support individualized education plans for students through their interactive platform which provides simulations and virtual manipulations to explain complex equations and theories through visual illustrations that enhance conceptual understanding and spark interest and motivation for successful comprehension and increase confidence in handling upcoming challenges. The strategy to enhance student posttest results requires teachers to encourage students to think creatively during test question responses.

Through this method students will achieve success in exam questions that require creative application of their knowledge. The use of digital textbook (Kognity) in calculus instruction shows that confidence plays a significant role in academic performance. Instructors who develop student confidence about technology use and calculus understanding will help students reach better posttest scores.

The findings coincide with the study by [11], it was found that enjoyment and confidence with digital learning tools such as digital textbook had a significant positive effect on student achievement in calculus. The study concluded that when students find digital learning tools enjoyable with confidence, they are more likely to invest time and effort into learning and achieve better results.

Moreover, the results also like the study of [35] found that enjoyment and confidence in using digital technology had a significant positive effect on academic achievement in mathematics. The study suggested that when students enjoy using digital technology and have high confidence in their ability to use it, they are more likely to engage in the learning process and perform better on assessments.

Although there was a significant change in the participants' Values after using the digital textbook (Kognity) in the treatment group, the data indicates that there was no significant correlation between this variable and their

performance in Calculus. This is likely because the "Values" parameter focused on the participants' perception of the usefulness and relevance of Calculus in their future careers and as a vital component in their lives. These factors may not directly impact their performance in the Calculus examination. There could be a few reasons why values related to future career might not be significantly related to calculus performance after a posttest: Other factors may have a stronger influence on calculus performance while future career values may be important for motivating students to learn calculus, there may be other factors that have a greater influence on their actual performance, such as prior knowledge, study habits, and teaching quality.

In contrast to the findings, from a study published in the Journal of Career Assessment, [1] researchers found that career values significantly predicted calculus performance among undergraduate engineering students. The study suggested that students who valued their future career in engineering were more likely to perform well in calculus due to their motivation, effort, and engagement in the course material. Students who value their future career and see calculus as a useful tool for achieving their career goals may be more motivated to learn and perform well in the subject.

Improving motivation can have a significant impact on performance outcomes for learners by promoting increased effort and engagement with course material. This research highlights the unique context of 12th grade IBDP students who may not yet appreciate how calculus factors into their future career success, especially if their interests and academic paths shift over time after entering university. While the IBDP Mathematics: Analysis and Approaches - Higher Level curriculum requires calculus study, students should understand that not all students will pursue math-related fields after graduation or as their future career.

Although many do understand the value of mathematics in achieving certain goals, school expectations can sometimes make it seem like merely an end-goal instead of means towards realizing other aspirations – introducing real-world applicability earlier on could potentially shift mindsets positively. Results from this study suggest positive attitudes towards learning calculus using digital resources such as textbooks is central towards improving performance outcomes across diverse subjects including Calculus itself. Thus, the use of the digital textbook (Kognity) could potentially improve students' confidence in learning Calculus while also promoting their enjoyment of the subject.

The results of the current study support the idea that students' attitude towards Calculus plays a critical role in their performance in the subject. This finding is reliable with study that suggests that a positive correlation amongst attitude and performance in Calculus. Thus, the study suggests that students' attitude towards Calculus can significantly impact their performance in the subject. Specifically, the study suggests that the higher a student's attitude towards Calculus is, the better their performance is likely to be, whereas students with lower attitudes towards Calculus may have poorer performance in the subject.

Thus, the null hypothesis which states that there is no relationship between perceived attitude and student’s performance in Calculus of the subjects under the treatment group after receiving instruction using digital textbook (Kognity) is rejected.

Perceived Self-Efficacy and Performance in Calculus

Descriptive Statistics

The descriptive statistics on table 4 revealed important baseline characteristics of students' self-efficacy beliefs and their performance in calculus after using the Kognity digital textbook. The mean post-test score was 85.4% (SD = 10.2), indicating strong overall performance, with scores ranging from 63% to 100%, demonstrating variability in student achievement. The self-efficacy scores averaged 3.8 out of 5 (SD = 0.9), suggesting positive self-belief about mathematical capabilities, though some students reported lower confidence (minimum score = 2).

These findings aligned with [3] self-efficacy theory, which posited that students with stronger self-beliefs tended to achieve better academic outcomes. The moderate standard deviation in self-efficacy scores (0.9) indicated meaningful individual differences, consistent with research showing that self-efficacy developed

through varied experiences [28].. The high performance average suggested that the Kognity intervention may have supported learning effectively, as digital platforms often provided immediate feedback and adaptive challenges that built confidence [39]. However, the presence of lower self-efficacy scores (as low as 2 out of 5) highlighted a subset of students who might have required additional support, such as scaffolded problem-solving tasks or motivational reinforcement [34].

Table 4 Descriptive Statistics

Variable	Mean	Std. Deviation	Min	Max
Post-Test (%)	85.4	10.2	63	100
Self-Efficacy (SE)	3.8	0.9	2	5

This table underscored the importance of examining not just mean scores but also variability, as students entered digital learning environments with differing levels of confidence. Future research could explore whether self-efficacy differences mediated the effectiveness of digital tools like Kognity, particularly for struggling learners.

Correlational Analysis

Table 5 revealed a strong positive relationship (r=0.65, p=0.001) between self-efficacy and calculus performance, indicating that students with higher confidence in their math abilities tended to score higher on the post-test.

Table 5 Correlational Analysis

Variable Pair	Correlation (r)	p-value
Post-Test vs. Self-Efficacy	0.65**	0.001

This result aligned closely with prior research in both traditional and digital learning contexts. [3] demonstrated that self-efficacy predicted academic persistence and achievement, while more recent studies [28] had shown that this relationship was held in technology-enhanced classrooms. The strength of the correlation (r = 0.65) suggested that self-efficacy might have been even more influential in digital learning environments, where students had to independently navigate tools like Kognity. This was consistent with [39] work on self-regulated learning, which emphasized that confident learners engaged more deeply with digital resources.

Interestingly, this correlation was stronger than those found between performance and the attitude subscales (enjoyment, confidence, values), reinforcing the unique role of self-efficacy in academic success. This might have been because self-efficacy directly influenced effort and persistence [34], whereas attitudes like enjoyment were more effective. Educators using digital textbooks should therefore prioritize interventions that built self-efficacy, such as mastery-based learning and positive reinforcement.

Regression Analysis

The regression analysis on table 6 confirmed that self-efficacy was a significant predictor of calculus performance ($\beta = 0.65$, $p = 0.001$), explaining 42% of the variance ($R^2 = 0.42$) in post-test scores. This large effect highlighted the practical importance of self-belief in digital learning environments.

Table 6 Regression Analysis

Predictor	β	p	R^2
Self-Efficacy	0.65	0.001	0.42

These results extend existing literature on self-efficacy in STEM education. For example, a meta-analysis by [20] found that self-efficacy typically accounted for 25-35% of variance in performance; our higher value (42%) might have reflected the unique demands of digital learning, where self-directedness was crucial. The regression coefficient ($\beta = 0.65$) suggested that for every 1-point increase in self-efficacy (on a 5-point scale), performance improved by ~6.5%. This had direct implications for instructional design: digital platforms like Kognity could integrate features that progressively built confidence, such as: Adaptive difficulty to ensure early successes [24] and Positive feedback to reinforce competence [34].

Notably, self-efficacy's predictive power surpassed that of enjoyment and confidence (from the attitude analysis), suggesting it might have been the most critical psychological factor in digital math learning. This is aligned with [28] argument that self-efficacy often mediates the effects of other motivational constructs. Future research could test whether Kognity's design supported self-efficacy development (e.g., through its interactive exercises) or whether explicit self-efficacy training would further enhance outcomes.

This study successfully addressed its primary objective of examining the relationship between students' self-efficacy and their calculus performance after using the Kognity digital textbook. The results revealed a strong, statistically significant positive correlation ($r = 0.65$, $p = 0.001$), demonstrating that students with higher self-efficacy achieved better performance outcomes. Regression analysis further confirmed this relationship, with self-efficacy accounting for 42% of the variance in post-test scores ($\beta = 0.65$, $p = 0.001$). These findings clearly reject the null hypothesis, confirming that a significant relationship exists between self-efficacy and calculus performance in digital learning environments.

The findings from this research have important implications for digital mathematics education. The results demonstrate how self-belief stands as a key factor for academic achievement especially in technology-based learning environments where students need to work independently with content. The results indicate that Kognity and similar digital platforms should focus on developing features which boost self-efficacy through adaptive learning pathways and scaffolded problem-solving tasks and immediate feedback systems. Such tools will optimize learning outcomes by using systematic methods to develop students' confidence in their mathematical abilities.

The research supports current theories about self-efficacy and digital learning by demonstrating the importance of instructional designs which combine cognitive and motivational learning aspects. Digital textbook implementations in the future should include evidence-based strategies to develop self-efficacy because students need both mathematical skills and confidence to effectively use them.

RECOMMENDATIONS

The findings of this study showed that self-efficacy, confidence, and enjoyment play essential roles in calculus performance within digital learning environments. These results align with contemporary educational research and suggest several evidence-based recommendations for improving digital mathematics instruction. Recent studies in digital learning [36], [22] have consistently shown that adaptive learning systems yield the best outcomes when they incorporate scaffolding and mastery-based progression, supporting our recommendation for step-by-step problem-solving guides in platforms like Kognity. The strong predictive power of self-efficacy ($\beta = 0.65$, $R^2 = 0.42$) in our study corroborates findings by [38], who demonstrated that digital environments particularly benefit from confidence-building features. Mastery-based feedback, as suggested in our recommendations, has been shown to significantly enhance learning outcomes in STEM subjects [18],

especially when it focuses on progress rather than just correctness.

For enhancing enjoyment ($r = 0.52$, $\beta = 0.28$), current research on gamification in mathematics education [33], [19] supports our suggestions regarding badges and interactive simulations. These studies have found that well-designed game elements can increase both engagement and conceptual understanding. The recommendation to include real-world applications is bolstered by recent work in situated learning theory [4] which shows that contextualizing abstract concepts improves both motivation and retention. Multimedia explanations, another of our suggestions, have been empirically validated by [25] cognitive theory of multimedia learning, with more recent studies (2020-2023) confirming their effectiveness in advanced mathematics.

The confidence-building strategies we propose, including early wins and peer collaboration, find support in recent intervention studies [37], [7] Growth mindset interventions, specifically, have shown remarkable success in mathematics education [5], with digital implementations demonstrating promise [31]. While perceived value showed weaker direct effects ($r = 0.47$, $\beta = 0.19$), our recommendations for career-connected learning align with utility-value intervention research [17], [6] that demonstrate long-term benefits for STEM persistence.

However, several limitations must be considered when interpreting these findings. The small sample size (N=23) limits generalizability, a common challenge in educational technology research [4]. The brief intervention period prevents assessment of long-term effects, a limitation noted in similar digital learning studies [22]. Self-report measures of attitudes may be subject to bias, as identified in recent methodological reviews [16]. The lack of a control group makes it difficult to isolate the specific effects of the digital textbook, a limitation acknowledged in comparable research [36]. The homogeneous participant pool restricts the applicability of findings across diverse populations, a concern raised in recent critiques of educational technology research [4]. Potential constructs overlap between confidence and self-efficacy measures has been noted as a challenge in similar studies [34]. Finally, the reliance on a single post-test measure aligns with limitations identified in recent reviews of digital learning assessment [4].

Future research should address these limitations through larger-scale, longitudinal studies incorporating multiple assessment methods and diverse populations. Recent work by [6] provides a model for such comprehensive evaluations in digital mathematics learning. Despite these limitations, the convergence between our findings and contemporary research strongly suggests that digital calculus instruction should prioritize both cognitive and affective dimensions of learning. The recommendations presented here, grounded in current empirical evidence, offer practical pathways for enhancing the effectiveness of digital mathematics education.

CONCLUSION

The study demonstrated that three specific attitudes such as enjoyment, confidence, and values strongly affected student calculus performance while using the Kognity digital textbook platform. The study showed that confidence and enjoyment proved to be the most influential predictors of achievement because Kognity's success depended on its ability to develop positive dispositions toward calculus through content delivery. The value perception of calculus remained important for student engagement, yet its effect was less immediate than the motivational strength of confidence and enjoyment.

Kognity should focus on developing platform features which directly target the essential attitudes that influence student performance. Students who used Kognity with enjoyment and confidence achieved better results so the platform should implement additional confidence-building scaffolds and engaging interactive elements and motivational feedback systems. These improvements would support modern educational research which shows affective elements play a crucial role in digital STEM education.

Educators who utilize Kognity should implement additional strategies to develop positive calculus attitudes because the research shows their importance. Future research should investigate ways to enhance Kognity's features for better confidence and enjoyment support through adaptive learning pathways and gamified elements. The research showed that Kognity's best potential rested in its capability to unite advanced calculus

content with psychological design principles which motivated students and strengthened their mathematical self-assurance. Kognity would become an even more effective mathematics education tool by integrating both emotional and cognitive aspects of learning calculus.

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