Effectiveness of Digital Textbook (Kognity) on the Performance in Calculus of Grade 12 Students in Shanghai China

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ABSTRACT

The study was undertaken to explore whether utilizing digital textbook (Kognity) helps enhance Calculus performance among Grade-12 students at Shanghai, China. Conducted among International Baccalaureate Degree Program Mathematics: Analysis and Approaches – Higher Level Class students 44 individuals who joined the Calculus class and completed an online survey. To measure how effective Kognity is the researcher utilized pretest & posttest assessments that compared results between two groups, control group (traditional way of instruction) and the treatment group (using Kognity). The test questions stemmed from an extensive question bank within Kognity itself which ensured an alignment with International Baccalaureate Diploma Program (IBDP) course syllabus. Control group had 11(52.38%) had attained a grade 7, 6(28.57%) had secured a grade 4, 2(9.52%) had achieved a grade 5; whereas one 1(4.76%) were able to achieve grades 6 and three respectively. A comparison between groups shows that those who received treatment yielded significantly higher grades than their peers in the control group; specifically most subjects from this group achieved Grade 7 or 6 and half secured Grade 5 or above; seven out of twenty three students reached Grade 5 which accounts for thirty point four three percent; six students earned an 7 comprising (26.9%) each for Grades 7 and 6 respectively while 4 subjects achieved grade 4 representing (17.39%). Following intervention however highest attainment was observed among subjects within control group went for Grades 7 almost exclusively and very few achieved Grades 6, five or four. Surprisingly only 1 out of 21 attained grade 5 while the majority bagged grade 7, 15 achieved Grade 7 representing (71.43%), secured Grade 4 which accounted for (14.29%), two earned grade 6 which is (9.52%) and one student earned a Grade 5 accounting for (4.76%). In terms of pretest and post test scores on standardized tests administered in both groups it was perceived indeed there was a significant difference between mean scores of both the control and the treatment. The treatment group averaged at 86.23 with a standard deviation of 10.84 while the control groups pretest mean score came in at 75.40 with a standard deviation of 18.42. These results were significant with a t-value (2.40) and p-value (.02) supporting the rejection of the null hypothesis and reinforcing the importance of technology integration in education for optimal learning outcomes.

Keywords–digital textbook (Kognity), performance in Calculus, definite integral, kinematics, Mclaurin Series and Differential equation

INTRODUCTION

When it comes to unleashing academic potential, few tools are as captivating as Kognity's digital textbook—particularly when examining its impact on calculus performance.

Calculus is an advanced mathematical subject that requires mastery of complex concepts such as limits, derivatives, and integrals. Because this topic presents significant challenges for students seeking success in math education, textbooks are often relied upon heavily by instructors in developing lesson plans, assigning homework and more.

Numerous studies have highlighted the critical role that textbooks play in mathematics instruction; notable examples include research conducted by [5], [9], [13], [14].

Given the difficulty level associated with calculus study combined with pre-requisite requirements of algebraic geometry, trigonometry, and logical reasoning skills students face multiple obstacles throughout their studies. For any student struggling to make sense of calculus there are practical steps they can take to overcome these challenges; collaborating with teachers or tutors is just one option among many. Another approach is through utilizing digital resources such as Kognity in order to cement an understanding of this subject matter.

Digital textbooks carry numerous benefits specifically tailored towards helping students improve their performance; interactive features like simulations, animations, along with practice problems are particularly noteworthy in this regard as they provide an immersive way for them to visualize complex ideas which leads towards greater comprehension. Moreover by using this platform, learners are able to remain engaged throughout the process which furthers retention capacity effectively over time. The platform itself is easily accessible via smartphones, tablets, and laptops allowing learners constant access even when away from traditional textbooks.

Customizable features add yet another dimension beyond reading students' ability so highlight important areas while taking notes makes the experience more personalized. By personalizing studying methods according to individual learning style and needs using digital textbooks, students can improve their comprehension and retention abilities [14]. The textbook's chapters include written explanations that introduce new concepts. Illustrations and charts often accompany these texts.

Exercises follow that cater towards different levels of student understanding [14]. Although teachers may use other materials like digital web resources or worksheets alongside digital textbooks for reinforcement purposes [9] digital textbooks remain a primary teaching tool.

The potential of digital textbooks is particularly significant concerning scientific and mathematical learning. They facilitate skills like visualizing complicated relationships or practicing interactive activities for better comprehension results [11], [17]. Moreover, using computer simulations facilitates model-based learning wherein students can manipulate representations and better understand direct consequences for improving mathematics learning performance. Digital textbooks hold promise in helping students overcome cognitive barriers caused by misunderstandings [10]. During the pandemic, [1] and [12] created digital textbooks for math education, still there's a scarcity on information about factors influencing Indonesian teachers' usage towards digital math textbooks. Clear-cut evidence regarding these factors will aid school officials and local government decision-makers in increasing instructors' propensity towards using them.

This research aims to evaluate whether digital textbook resources such as Kognity can improve student performance in calculus exploring their impact on comprehension levels as well as engagement and retention abilities related to calculus concepts. Taking into account their advantages as well as disadvantages via valid data analysis will pave way for understanding how efficient digital textbooks can be in supporting effective calculus learning.

Through this investigation, educators, students and policymakers can gain valuable insights into how digital textbooks can enhance learning outcomes in the realm of mathematics.

The purpose of this research is to assess if using Kognity as a digital textbook improves student learning outcomes for Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) in comparison to traditional instruction methods.

In do so the researcher argue by comparing the performance of students who use the digital textbook (Kognity) against those who receive traditional way of instruction only as part of the control group. Implications from these comparisons will enable us to determine whether incorporating such technology benefits instruction practices in the field of calculus education and subsequently allow teachers or curriculum developers' at large meaningful data-driven feedback.

A. Objectives of the Study

This study aimed to investigate the effectiveness of using digital textbook (Kognity) on the 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. describe the performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) of the subjects under the control and treatment groups before and after receiving the traditional way of instruction and instructions utilizing digital textbook (Kognity);

2. examine the difference in the performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) of the subjects under the control and treatment groups before and after receiving the traditional way of instruction and instructions utilizing digital textbook (Kognity);

3. find out the difference in the performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) of the subjects under the control group and the treatment groups after receiving the traditional way of instruction and instructions utilizing digital textbook (Kognity);

B. Hypotheses of the Study

1. There is no significant difference in the performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) of the subjects under the control and treatment groups before and after receiving the traditional way of instruction and instructions utilizing digital textbook (Kognity).

2. There is no significant difference in the performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) of the subjects under the control and treatment groups after receiving the traditional way of instruction and instructions utilizing digital textbook (Kognity).

METHODOLOGY

A. Research Design

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 necessitate subject randomization procedures quasi experimental studies allow researchers flexibility in controlling treatment condition assignments using alternative criteria [6]. Quasi experiments are appropriate for investigations when there are impracticalities or ethical concerns surrounding random assignment.

This also offers validity advantages since they can be conducted in natural settings thereby improving generalizability of findings to a wider population and situations [6].

This study adopted the Pretest-Posttest design among other quasi experimental options available. To assess the impact of digital textbook (Kognity) instruction on subject performance in Calculus, conducted a comparative analysis between traditional way of instruction and instruction utilizing digital textbook (Kognity)

The Pretest-Posttest design was used in finding the difference in the performance of the control and treatment group before and after receiving traditional way of instruction and instruction using the digital textbook (Kognity).

B. Study Sites

The study took place during the winter (2nd) semester of the 2022 – 2023 academic year at Shanghai United International Schools Gubei Campus at Hongsong East Road, Minhang District, and Shanghai, China.

C. Respondents and Data Collections

Data was collected from 44 students through an online survey. The two groups were selected based on their enrollment from Grade 11 for participation in the IBDP Curriculums two year course (up to Grade 12 class)

The researcher chose a heterogeneous class composition to avoid biases when evaluating their performance in Calculus. In order to conduct a study, two groups were created: the treatment group, consisting of 23 students and the control group which had 21 students.

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. The researchers provided their email address for any questions about the study. After six weeks of intervention, both the control and treatment groups took a posttest to measure their performance in Calculus using traditional instruction and digital textbooks (Kognity) in terms of Definite Integral, Kinematics, Mclaurin Series, and Differential Equations.

D. 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.

E. Instrument Used

The Pretest and Posttest Mathematical Performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) was used to compare subjects' performance before and after receiving traditional way of instruction and instruction utilizing digital textbook (Kognity).

Test questions were sourced from the Kognity question bank while ensuring that they aligned with International Baccalaureate Diploma Program (IBDP) course syllabi for validity purposes.

Test items for pretest and posttest was adapted by the researcher from the Kognity on the topics found in the International Baccalaureate Diploma Program course syllabus Mathematics: Analysis and Approaches – Higher Level used in teaching (CALCULUS) Unit 1: Definite Integral, Unit 2: Kinematics, Unit 3: Maclaurin series, and Unit 4: Differential Equations. Pretest and posttest Mathematical performance in Calculus was developed with respect to the selected unit (measurement), the test was consisted of thirty (30) items.

A measure of a student's mathematical performance in Calculus depends on how well they understand fundamental concepts like theory and technique as these are crucial determinants of success in the subject matter. The evaluation is done using grading scales varying from Grade 1 (the least proficient) through Grade 7(the most proficient).

Students scoring at the top end earn a Grade 7 level, demonstrates a comprehensive theoretical knowledge that extends beyond routine application, displaying insightful ability in analyzing problems and solving them creatively. At Grade 6 level, one notch below demonstrates good conceptual understanding that occasionally may not be without errors or minor omissions. At less proficient levels students who earn Grade 5 or 4, displays some knowledge of the subject matter but may experience mistakes in their calculations. The pattern becomes more noticeable among those who perform below them with Grade 3 indicating a struggling proficiency level and Grade 2 showing minimal understanding of basic mathematical concepts. Grade 1 help teachers to identify areas where support is needed best preparing students for challenging problems requiring accurate mathematical comprehension skills.

Consequently, students answered all the pre-test and posttest questions via Kognity's digital platform as part of this study.

Data Analysis

Employing a quantitative research approach through pretests and posttests provided insight into performance in Calculus before and after receiving traditional way of instruction or digital textbook instruction via Kognity.

To analyze information collected during pretests/post-tests intervention objectively, statistics software like MS Excel/SPSS aid helped in processing this data accurately.

To get concise summaries from raw data acquired from intervention, the researcher turned towards Microsoft Excel's help before seeking more elaborate interpretations by getting assistance from expert statistician.

Based on the study, Calculus was recognized as a focal subject due to its complexity and technicality, hence evaluating students' performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series, and Differential Equations) before and after traditional way of instruction and instruction utilizing digital textbooks (Kognity) yielded the most desirable results.

To compare the effectiveness of traditional way of instruction versus instruction utilizing digital textbook (Kognity), the researcher utilized the mean, standard deviation, and independent t-test methods to compare the performance of the subjects in the control and treatment groups. Furthermore, the researcher evaluated using the mean, standard deviation, and independent t-test methods to assess performance of subjects in the treatment group solely after receiving the instruction utilizing digital (Kognity)

The scores were then converted into qualitative labels based on IBDP Grade Descriptor which offers grades between 1 to 7 and considers grade 4 as a passing score. These grades are allotted by external assessments held during the 12th grade, determined by the Grade Boundaries/Descriptors.

RESULTS AND DISCUSSION

The data collected were analyzed and explained using statistical methods, in line with the research objectives.

This section consists of five parts between the control group and treatment group, namely, description of the subjects performance in Calculus under the Control Group before and after traditional way of instructions, description of the subjects performance in Calculus under the Treatment Group before and after instructions utilizing digital textbook (Kognity), difference in the performance of the subjects under the Control Group before and after traditional way of instruction, the difference in the performance of the subjects under the Treatment Group before and after instruction utilizing digital textbook (Kognity), and the difference in performance of the control and treatment groups after receiving the traditional way of instruction and instruction utilizing digital textbook (Kognity).

A. Subjects' Performance in Calculus under the Control Group Before and After Receiving Traditional Way of Instruction

The performance of the subjects in Calculus under the Control Group was assessed in a pretest and posttest which is summarized in Table 1. The International Baccalaureate Degree Program (IBDP) grades each subject on a scale of grade 1 to 7, with a grade of 4 being considered a "pass." This score is based on external assessments conducted during the 11th and 12th grades, as indicated by the recent Grade Boundaries/Descriptors from the November 2022 External Examination, which are detailed in Appendix VIII page 108.

From the table, it is evident that the control group had 11(52.38%) attained a grade 7, 6(28.57%) attained a grade 4, 2(9.52%) achieved a grade 5, 1(4.76%) attained a grade 6, and 1(4.76%) attained a grade 3, which is below the passing score, before receiving traditional way of Instruction. Only one subject (grade 3) in the control group demonstrated partial knowledge of the learning competencies and a limited understanding of mathematical arguments in calculus. However, prior to receiving traditional way of instruction, the control group, subjects displayed only a satisfactory knowledge of the syllabus and the ability to apply mathematical arguments to complete routine tasks.

Table 1 Subjects' Performance in Calculus under the Control Group Before and After Receiving Traditional Way of Instruction

GRADE	INTERVAL	PRE TEST Control Group (n = 21)		POST TEST Control Group (n = 21)	
		f	%	f	%
Grade 1	0 – 9	0	0	0	0
Grade 2	10 – 15	0	0	0	0
Grade 3	16 – 26	1	4.76	0	0
Grade 4	27 – 43	6	28.57	3	14.286
Grade 5	44 – 58	2	9.52	1	4.7619
Grade 6	59 – 72	1	4.76	2	9.5238
Grade 7	73 – 100	11	52.38	15	71.429

From the table, it is evident that the control group had 11(52.38%) attained a grade 7, 6(28.57%) attained a grade 4, 2(9.52%) achieved a grade 5, 1(4.76%) attained a grade 6, and 1(4.76%) attained a grade 3, which is below the passing score, before receiving traditional way of Instruction. Only one subject (grade 3) in the control group demonstrated partial knowledge of the learning competencies and a limited understanding of mathematical arguments in calculus. However, prior to receiving traditional way of instruction, the control group, subjects displayed only a satisfactory knowledge of the syllabus and the ability to apply mathematical arguments to complete routine tasks.

As a result, the subjects in this class could only recollect some rudimentary concepts from their Calculus classes in Grade 10 and achieved only minimal scores on the IBDP syllabus. However, if they aspire to take up courses like Mathematics, Engineering or Physics at University level, then achieving at least a grade of 6 is essential on account of university regulations.

Therefore, subjects under the control group are presently enrolled for Analysis and Approaches - Higher Level (AAHL) mathematics classes within the IBDP framework that targets learners with robust mathematical basics

and an aptitude for speedy and accurate mental calculations. This learning track ideally suits those seeking incredibly numerical university courses such as Mathematics, Engineering or Physics. The outcome of pre-tests revealed that nine pupils among those belonging to the control group could not secure admission into their desired colleges/universities.

Grade	Interval	Pre test Treatment group (n = 23)		Post test Treatment group (n = 23)	
		f	**%**	**f**	**%**
Grade 1	0 – 9	0	0	0	0
Grade 2	10 – 15	0	0	0	0
Grade 3	16 – 26	0	0	0	0
Grade 4	27 – 43	4	17.39	0	0
Grade 5	44 – 58	7	30.43	0	0
Grade 6	59 – 72	6	26.09	2	8.70
Grade 7	73 – 100	6	26.09	21	91.30

Meanwhile, the researcher also had access to post-test scores received by these subjects under traditional way instruction. In terms of grades earned by subjects who received traditional instruction in the control group, most achieved a grade 7 (71.43%). Interestingly enough there were fewer instances of other grades achieved, namely grade 4 (14.29%), grade 6(.52%), and grade 5(4.76%) respectively.

All subjects in this group including pretest scores indicating scores as low as grade 3 passed their posttest demonstrating improvement during their study period. It is important to note that teacher-led activities played an integral role allowing learners to actively participate throughout instructional sessions leading to increased engagement resulting in improved academic outcomes which was observed particularly amongst those individuals exposed to traditional instructional methods.

Supporting these results were related studies such as [16] exploration of lectures, note-taking and textbook reading as effective teaching methods. Furthermore, students in the study preferred hard copies over digital material as in [20] assertion that traditional instruction typically focuses on knowledge transfer that is delivered via instructional demonstration through instruction which was ultimately absorbed by the students.

Building on previous investigations by [24] this inquiry supports their contention that established teaching techniques can lead to superior academic performance. Employing quasi-experimental quantitative measures utilizing pretest and posttests designed for comparing cooperative learning approaches against traditional teaching strategies within classroom contexts.

Noteworthy is that the benefits of improved subjects performance were found in both replicating tried-and-true conventions as well as integrating digital materials like Kognity into lesson plans. It allows mentioning that even control groups relying on traditional way of instructions exhibited statistically significant improvements between testing intervals.

B. Subjects' Performance in Calculus under the Treatment Group Before and After Receiving Instruction Utilizing Digital Textbook (Kognity)

Table 2 displays the pretest and posttest scores of the subjects in the treatment group who were given instructions using a digital textbook (Kognity). These test scores were used to evaluate their performance in

Calculus.

The table show that the treatment group had 7(30.43%) attained a grade 5, 6(26.09%) attained a grade 7, 6(26.09%) attained a grade 6 and 4(17.39 attained a grade 4, which achieved the minimum passing grade of 4 in the IBDP Syllabus requirement. It's important to note that the Treatment group is also studying Analysis and Approaches - Higher Level (AAHL) mathematics, and even if they do achieve a Grade 4, it doesn't necessarily mean that they will be offered a place at their desired top university in the world. Based on the pretest results, it's estimated that only about 12 students will definitely receive an offer at the end of their course.

Table 2 Subjects Performance in Calculus under the Treatment Group Before and After Receiving Instruction Utilizing Digital Textbook (Kognity)

Grade	Interval	Pre test Treatment group (n = 23)		Post test Treatment group (n = 23)	
		f	**%**	**f**	**%**
Grade 1	0 – 9	0	0	0	0
Grade 2	10 – 15	0	0	0	0
Grade 3	16 – 26	0	0	0	0
Grade 4	27 – 43	4	17.39	0	0
Grade 5	44 – 58	7	30.43	0	0
Grade 6	59 – 72	6	26.09	2	8.70
Grade 7	73 – 100	6	26.09	21	91.30

Prior to being instructed through digital textbooks (Kognity), subjects in the treatment group displayed a limited grasp of the syllabus and possessed only rudimentary skills in applying mathematical arguments to solve routine problems. As a result, these students retained a meager level of fundamental concepts in Calculus, which they had previously learned in lower year, and only managed to achieve the minimum scores stipulated by the International Baccalaureate Diploma Programme (IBDP) syllabus. However, it is imperative for those students who wish to pursue higher education in Mathematics, Engineering, or Physics at the University level to secure a minimum of Grade 6, as it is a mandatory requirement for admission to university programs in these fields.

Meanwhile, Table 2 shows that all subjects in the treatment group achieved good scores in the posttest, with 21(91.30%) scoring Grade 7 and 2(8.70%) scoring Grade 6 and. Their successful performance can be attributed to the use of a digital textbook (Kognity) for instruction, which provided various interactive media experiences such as videos, online activities, key concepts, terms, and past paper examinations to help them master the concepts and meet the expected standards of the lesson content.

The results of the research are consistent with [8] study, which demonstrated that digital textbooks can facilitate active and engaged learning in suitable educational environments. The use of multimedia-based teaching, such as digital textbooks, has been shown to enhance learning and academic performance in subjects like math. This is because it encourages active participation, problem-solving, and mathematical thinking, which are often absent in modern-day math students. To put it differently, students who utilized the Kognity digital textbook as part of their instruction will feel assured about receiving an offer from the university they desire.

Also according to [2] there is a need to improve digital textbooks to cater to the diverse needs of students in

general education classrooms. The advancement in technology has introduced various new learning opportunities for students, as e-books have several advantages over printed textbooks. E-books often include multimedia features that are not present in traditional textbooks, as noted by [4].

This claimed also supported by [23] in the study examines the effects of a digital textbook on students' mathematics performance in a Chinese university, including calculus. The researchers found that the digital textbook significantly improved students' math performance outcomes compared to a traditional paper textbook, and students reported a high level of satisfaction with the digital textbook.

C. Difference in the Performance of the Subjects under the Control Group Before and After Receiving the Traditional Way of Instruction

Table 3 displays an investigative comparison of the performance of the control group before and after receiving traditional way of instruction prior and post study involvement demonstrating any resulting effects of traditional teaching methods on subject-performance levels. To analyze the data, the researcher used independent sample t–test to evaluate the Mean Pretest scores and Posttest of control group to establish any significant contrasts between the subjects' test results.

Table 3 Difference in the Performance of the Subjects under the Control Group before and After Receiving Traditional Way of Instruction

Control group	n	Mean	SD	$t_{(42)}$	P value	Interpretation
Pretest	21	62.86	26.13	–4.17	0.00	Difference is Significant
Posttest		75.40	18.42			

The table illustrates the pretest scores were 62.86 with a standard deviation score of 26.13; while posttest performance levels increased dramatically, as shown with an average number of points achieved at 75.40 and a lower standard deviation score of only18.42. These statistics suggest that traditional teaching methods had a considerable effect on academic performance levels for subjects involved in Calculus classes. The t–value illustrated a negative at –4.17, additionally, p-values were less than .001 indicating significance in favor of traditional way of instruction.

These findings are also supported by [18] a comprehensive analysis was conducted investigating the effects of conventional teaching strategies on student achievement in calculus. The research team discovered that pupils who received traditional instruction consisting of lectures and problem sets significantly outperformed those taught through alternative methods like online learning or flipped classrooms.

The study also disclosed that individuals taught using classical pedagogical techniques had a better grasp of calculus concepts making them more comfortable with tackling advanced mathematical coursework. However these findings diverge from those presented by [3] whose research reported negative effects associated with orthodox teaching styles including reduced acquisition by learners of foundational knowledge about the subject material leading to poorer scores on standardized evaluations. Lecturing alone coupled with worksheet assignments appeared ineffective at engaging students' interest.

From this analysis it can be inferred the rejection of the null hypotheses, therefore is indeed that there is a significant difference pointing towards varying levels of proficiency amongst the subjects completing Calculus (specifically in Definite Integral, Kinematics, Mclaurin Series, and Differential Equations) under the control group before and after receiving traditional way of instruction.

D. Difference in the Performance of the Subjects under the Treatment Group Before and After the Instruction Utilizing Digital Textbook (Kognity)

Table 4 presents the comparison between subjects' performance in Calculus before and after receiving the instruction through digital textbooks (Kognity) under the treatment group.

Table 4 Difference in the Performance of the Subjects under the Treatment Group before and After Instruction Utilizing Digital Textbook (Kognity)

Treatment group	n	Mean	SD	$t_{(42)}$	p value	Interpretation
Pretest	23	61.59	15.63	-9.19	0.00	Difference is Significant
Posttest		86.23	10.84			

As shown in the table, prior to incorporating digital textbooks through Kognity's approach for instruction purposes, the subjects had a mean pretest score of approximately 61.59 with a standard deviation 15.63, on the other hand the mean posttest score was 86.23 with a standard deviation of 10.84. This indicates that these digitized learning experiences led to significant improvements in subject test performances.

Furthermore, table 4 provides further analysis on how significant this improvement is by providing us with a t–value (–9.19) accompanied by p–value of 0.000 that is below 0.001 indicating a significant difference between those who receive instruction through Kognity's digitized approach. Thus, this study suggests that through digitization, there was an increase in personalized learning experiences for students with improved efficiency and a better connection with their educational materials.

According to [7], students found that utilizing digital technology instruction was an effective and enjoyable method of learning. They were motivated by visuals that enhanced their understanding of content. Moreover, employing digital textbooks led to a marked improvement in academic performance among students; these findings are supported by this study's results.

As [22] suggests in his work on digital textbooks' effectiveness, they should involve problems challenging learners' analytical skills yet conform to study programs assigned by teachers or schools while being accessible through numerous platforms. Therefore, virtual textbooks available nowadays do have three different types: minimum platform ones; hybrid platform ones; exclusively electronic ones. For this study, "digital textbooks" refers solely to comprehensive e-curricula covering multiple mathematical aspects designed for prolonged usage. These materials feature coherent content based on the national curriculum, enabling students to progress through material over an entire year.

From the findings above, the null hypothesis that suggests no significant difference in the performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) of the subjects under the treatment groups before and after instruction utilizing textbook (Kognity) is rejected.

E. Difference in the Performance of the Control and the Treatment Group After Receiving Traditional Way of Instruction and Instruction Utilizing Digital Textbook (Kognity)

Table 5 exposes the differences in the performance between the control and the treatment group after receiving traditional way of instructions and an instruction utilizing the digital textbook (Kognity) respectively.

Their mean scores were carefully measured resulting in revealing statistics. The control group scored an overall mean grade of 75.40 (SD=18.42), but those taught with Kognity's technology improved their average grade by almost ten points to reach an impressive mean score of 86.23 (SD=10.84). This variation is statistically significant according to Table's t-test results (t–2.40; p = 0.02 <.05).

Table 5 Difference in the Performance of the Control and the Treatment Groups After   Receiving Traditional Way of Instruction and Utilizing Digital Textbook (Kognity)

Groups	n	Mean	SD	MDiff	$t_{(42)}$	p value	Interpretation
Control	21	75.4	18.42	-10.84	-2.4	0.02	Difference is Significant
Experimental	23	86.23	10.84				

According to recent research on teaching strategies for Calculus classes shows that incorporating a digital textbook into lesson plans can lead to better results than traditional modes of education. One possible explanation is that students are able to customize their learning experience by choosing which topics they want to study first with greater flexibility for pacing themselves through material at their own speed. Furthermore including multimedia elements like videos or interactive online activities allow for an immersive educational experience that holds learners' attention span longer than just text alone.

In particular implementing Kognity as a digital textbook has shown significantly positive outcomes in terms of increasing subject knowledge retention scores compared with non-digital materials methods used traditionally. These findings suggest that using this method could have advantages over other instructional techniques when it comes down specifically toward enhancing subject performance in Calculus. Digital tools with adaptive features have carved out an important niche within contemporary education by facilitating content delivery that is tailored to a student's specific learning style.

This is especially useful when grappling with unfamiliar or abstract mathematical theories. Additionally, these tools provide ample opportunities for consolidating existing knowledge on fundamental mathematical principles an indispensable step towards gaining true mastery [10], [21]

Perhaps one of the most impressive features of these digital tools revolves around their ability to provide instant feedback to learners. This feedback is designed to tackle the issues that typically lead to misconceptions lingering in the minds of students [15].

Another compelling reason for utilizing digital textbooks is found in their potential to develop key skills integral in scientific and mathematical fields, such as the ability to visualize complex relationships [11]. Research has shown that technology can greatly enhance learning by providing interactive and scaffold activities. Computer simulations that allow students to manipulate representations have also been found to promote model based learning and improve mathematical performance.

Digital textbooks can even help students overcome common misconceptions associated with cognitive limitations [9] In fact recent studies by [1] and [12] have developed digital textbooks specifically designed for mathematics education during the COVID 19 pandemic. However despite these benefits there is still a lack of information on the adoption of digital math textbooks among teachers in Indonesia. Understanding the factors that affect utilization patterns could help decision makers promote their use at school and government levels.

From the results presented above the null hypothesis that there is no significant difference in performance in Calculus (in terms of Definite Integral, Kinematics, Mclaurin Series and Differential Equations) between the control group and treatment group after receiving the traditional way of instruction and instructions utilizing digital textbook (Kognity) is rejected.

CONCLUSION

Both control and treatment groups demonstrated satisfactory comprehension of Calculus before being exposed to traditional way instruction or instruction utilizing digital textbook (Kognity). As a result, both groups retained fundamental principles from prior years and met minimal requirements outlined by IBDP syllabi. The control group's performance improved after receiving traditional way of instruction that could be attributed

that the teacher's ability to encourage active participation among students, granting them autonomy over constructing knowledge during lessons. In contrast, subjects in the treatment group who used Kognity digital textbooks achieved high post-test scores due to access interactive media resources like videos, online activities, key concepts & terminology definitions as well as past paper exams. Accessing these resources was crucial towards enabling the subjects attain mastery levels through complete comprehension on Calculus. For those under traditional way instruction methods as observed among the subjects within control group, a meaningful increase marked by notable progress had occurred given noticeable surge in posttest evaluations relative to corresponding pretests thus serving as evidence that such methods can enhance student performance remarkably when learning calculus.

On another note, treatment group protocol which hinged on Kognity's digital textbook proved effective at raising productivity levels while providing customized instructional services thus resulting into noticeable improvements across mean posttest evaluations compared to pretest. This was premised upon its ability to differentiated learning experiences and accentuates interactive sessions between instructional materials and the subjects.

Comparing both sets of results, it became evident that treatment arms recorded considerably higher mean posttest scores averaging at 86.23 with a corresponding standard deviation of 10.84. Meanwhile those in the control group recorded a mean score of approximately 75.40 with a corresponding standard deviation of about 18.42 after adopting traditional modes of instruction. As per observations, the mean score of subjects that received treatment is notably higher than those who did not. The study has found both traditional methods of instruction and digital textbook (Kognity) helpful in improving Calculus scores for both groups of students. Nevertheless, subjects who received treatment showed substantially better growth compared to the control group indicating better performance. Digital textbooks seemed more effective in raising student's scores because it could be customized as per student requirements related to lesson sequence or any other additional features available on Kognity. Furthermore, incorporating various media resources like images and interactive online exercises within Kognity helped students focus and comprehend lessons thoroughly resulting in improved grades overall.

Utilizing digital textbooks proves to be an efficacious approach in enhancing academic success in calculus. This strategy could potentially elevate the performance of students attending Shanghai United International School - Gubei Campus and aid them in achieving a grade 6 or higher, thereby instilling confidence for admission to esteemed universities worldwide.

ACKNOWLEDGMENT

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