African Journal of Mathematics and Statistics Studies
ISSN: 2689-5323
Volume 4, Issue 3, 2021 (pp. 64-78)
www.abjournals.org

EFFECTIVE APPLICATION OF MAPLE SOFTWARE TO REDUCE STUDENT TEACHERS' ERRORS IN INTEGRAL CALCULUS

Emmanuel Kwadzo Sallah[1], Joshua Kofi Sogli[2], Alex Owusu[3] and Leonard Kwame Edekor[4]

[1]Department of Mathematics, Evangelical Presbyterian College of Education, Amedzofe.

[2]Department of Mathematics, Tarkwa Senior High School, Tarkwa

[3]Department of Mathematics, Evangelical Presbyterian College of Education, Amedzofe

[4]Department of Mathematics, St Francis College of Education, Hohoe

Cite this article:

Emmanuel K.S., Joshua K.S., Alex O., Leonard K.E. (2021), Effective Application of Maple Software to Reduce Student Teachers' Errors In Integral Calculus. African Journal of Mathematics and Statistics Studies 4(3), 64-78. DOI: 10.52589/AJMSS-WRFGFPIH.

Manuscript History

Received: 13 Sept 2021

Accepted: 30 Sept 2021

Published: 19 Oct 2021

ABSTRACT: *This study explored the effective application of Maple software to reduce student teachers' errors in Integral Calculus at Evangelical Presbyterian College of Education, Volta Region – Ghana. The study employed the quasi-experimental non-equivalent group design. Convenience and simple random sampling techniques were employed to obtain a sample of 80 students, which consisted of 40 students in the control group and 40 in the experimental group. Teacher-made Pre, -Post-Calculus Achievement Tests (CAT), and questionnaires were used to collect quantitative and qualitative data respectively. Descriptive, Independent samples t-test and paired samples t-test were used in analyzing the data. Descriptive error analysis revealed that students committed many conceptual, procedural and technical errors when solving Integral Calculus tasks. The results also indicated that there was a statistically significant difference between students of the experimental group exposed to the use of Maple software in learning integral calculus to the control group exposed to traditional methods. The researchers recommend Maple assisted instruction in the teaching and learning of Integral Calculus and also the need to employ a blended teaching approach, in which Maple software is used simultaneously with traditional teaching strategy.*

KEYWORDS: Maple software, Errors, Mathematics, Effective Application, and Integral Calculus

Article DOI: 10.52589/AJMSS-WRFGFPIH
DOI URL: https://doi.org/10.52589/AJMSS-WRFGFPIH

INTRODUCTION

In educational contexts, educational technology is utilized to improve the efficiency of education (Aldiab, Chowdhury, Kootsookos, Alam, & Allhibi, 2019). Computers and related technology are seen as the future of teaching and learning, as well as a strong technical machine that may help students learn more effectively. Computers have the ability to make a learning environment more appealing and effective (De Barba, Malekian, Oliveira, Bailey, Ryan, & Kennedy, 2020). In today's market, there are many different sorts of educational software. Drill and practice, tutorials, simulations, supplemental exercises, programming, database development, and other applications are all included in this category.

Technology has a variety of implications on education, particularly in terms of improving student instruction (Ratheeswari, 2018). When technology and proper teaching approaches are integrated into teaching and learning of mathematics, both the cognitive and affective domains can be enhanced to benefit students (Buckley, Seery, Canty, & Gumaelius, 2018). In mathematics education, the various potential that technology provides for improving classroom learning have been clearly demonstrated.

The National Council of Teachers of Mathematics (NCTM) encourages mathematics teachers or educators to incorporate technology into their classrooms (National Council of Teachers of Mathematics (NCTM), 2014; National Council of Teachers of Mathematics (NCTM), 2019). The NCTM, on the other hand, emphasizes that technology should not take the role of a mathematics teacher. In a typical technology-rich classroom, the teacher performs multiple key responsibilities, making decisions that impact students' learning in a variety of ways (NCTM, 2019). The application of technology as a tool or support for connecting with others allows students to take an active role in their learning rather than being passive recipients of knowledge from an instructor, textbook or broadcast.

Many mathematics educators believe that computer technology has the ability to demonstrate concepts and provide enrichment beyond what teachers can provide. Computer technology also encourages students to actively consider material, make decisions, and perform skills that are often taught in teacher-led classes (Das, 2019). Many studies have been undertaken on the use of computer technology in mathematics teaching and learning. The majority of these studies used mathematical software like Maple, Mathematica, Geometer's Sketchpad, Matlab, Derive, and handheld devices like graphic calculators.

Moreover, the use of technology in education is still relatively rare in Ghana, as few mathematics teachers today are unaware of the growth in recent years of computer technologies for teaching, learning and research in mathematics. Notwithstanding, there is a growing body of research that suggests its extended use is imminent (usumah, Kustiawati, & Herman, 2020; Kovács, Recio, & Vélez, 2020).

In furtherance, calculus is a branch of mathematics concerned with the calculation of instantaneous rates of change, known as Differential Calculus, and the summation of infinitely many small factors to determine some whole, known as Integral Calculus (Berggren, 2016). Calculus is an important concept for the mathematics students in the Colleges of Education across Ghana, as it is the gateway to the study of the following advanced disciplines such as Engineering, Business, Differential Equations, Vector Analysis and Complex Analysis. The dwindling student teachers' performance in calculus is a concern

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to mathematics educators and policy makers, however, it still remains challenging and problematic concepts, despite its wide application in our daily lives and many other fields (Kusumah, Kustiawati, & Herman, 2020; Kovács, Recio, & Vélez, 2020; Berggren, 2016; Zakaria & Salleh, 2015;). For this reason, mathematics tutors of Colleges of Education ought to focus on the development of students' understanding in calculus concepts and provide a better teaching and learning experience.

Notwithstanding, poor understanding of prerequisite concepts which comes as result of the use of inappropriate teaching methods, poor attitudes and perceptions towards the study of calculus were some of the contributing factors to low performance in calculus (Odell, Cutumisu, & Gierl, 2020; Wang, Hofkens, & Ye, 2020; Mazana, Montero, & Casmir, 2020).

However, irrespective of the measures put in place by stakeholders to promote paradigm shift in the mode of teaching from teacher centered to learner centered method of teaching mathematical concepts to enhanced students' academic gains, our classrooms are still dominated with the traditional method of teaching (Lee, 2021). Very little has been done to investigate student teachers' errors in integral calculus to boost their performance in integral calculus.

Considering the importance of this subject in academic undertaking, the researchers were prompted to enhance the teaching methodology with the integration of technology by exploring integral calculus using Maple software to reduce students' errors in integral calculus. Maple software was chosen because it is suitable for a variety of uses including solving very difficult calculus problems. Furthermore, it requires minimal programming as compared to other mathematical software's.

Maple software can be used to solve general-purpose mathematical problems (Purnomo, Winaryati, Hidayah, Utami, Ifadah, & Prasetyo, 2020). Problems in the area of mathematics, science, and engineering can be investigated using Maple software and it is well suited to aid students learn mathematics through verifying, calculating, manipulating of mathematical expressions and graphical visualization of 2D, 3D complicated graphs (Tanjung & Ihsan, 2019). Maple system uses only a procedural language of 4th generation (4GL), similar to the C language, FORTRAN, BASIC and Pascal. Tedious computations are performed by Maple software by featuring systematic solutions of the problem as obtained when done manually (Dronyuk, Fedevych, Stolyarchuk, & Auzinger, 2019).

Theoretical Framework

Addressing student teachers' errors in Integral Calculus through the integration of Maple software in teaching and learning drew its theoretical framework from constructivism. Constructivism advocates learner-centered, activity-centered interactive pedagogical approach thus emphasize the importance of the learner being actively involved in the learning process, Studies have shown that the constructivism theory is effective in a computer-technology-integrated environment (Kumar, Pandey, & Sharma, 2019; Bali, Kumar, & Nandi, 2016; Salleh & Zakaria, 2015). With technology, students are flexible in adjusting their learning strategy based on their learning style. The researchers based the development of the study on a constructivism theory of Action, Process, Object and Schema - Activities using Maple software on the computer, Classroom discussion based on Maple outputs, and Exercises done outside the class hour known in short as APOS - ACE theory

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Conceptual Framework

Considering the type of research that was undertaken, research questions, and category of data collected. The study was modeled by a conceptual framework, which depicted a representation of dependent and independent variables and the relationships between them.

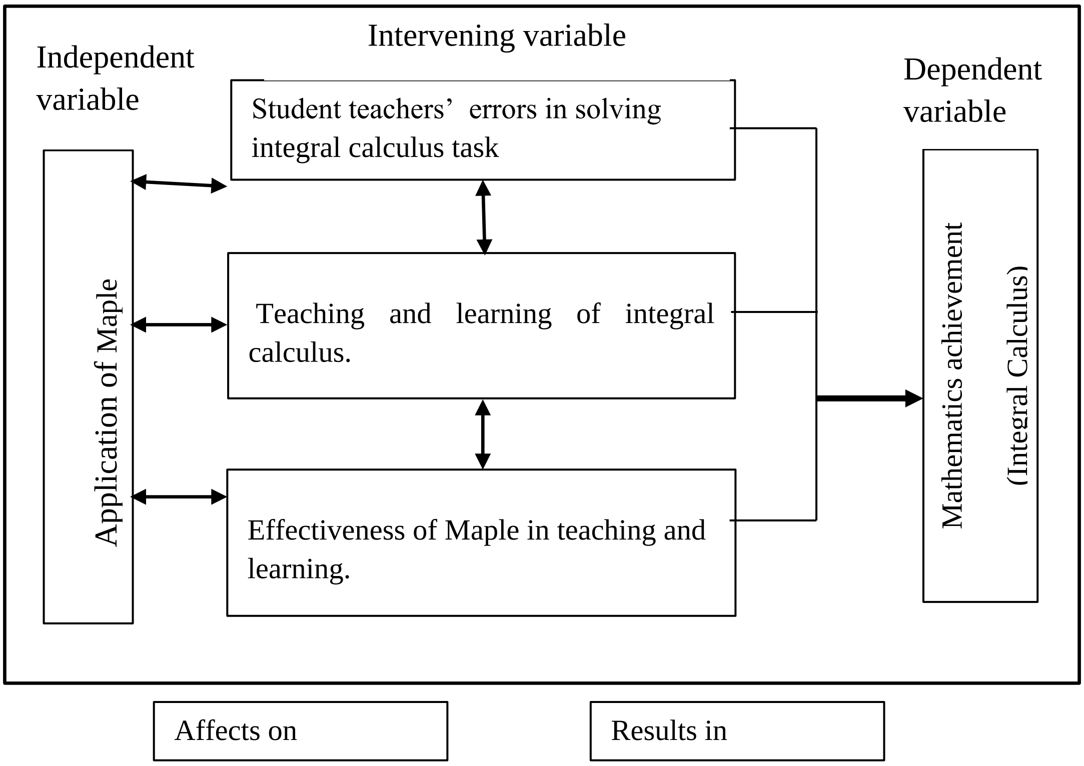

Figure 1: Conceptual Framework Model of the Study

From figure 1, the effective application of the independent variable (Maple software) will affect student teachers' common errors in solving Integral Calculus tasks. Effective application of Maple software will also affect the teaching and learning of Integral Calculus, as well as effectiveness of Maple in teaching and learning Integral Calculus. The expected outcome will be a change (positive or negative) in the dependent variable (Integral Calculus) depending on the outcome of the study.

Purpose of the Study

The purpose of this research was to analyze students' errors in integral calculus and the impact of Maple integration in teaching and learning.

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Research Questions

The following research questions were formulated to guide the study:

1. What errors emerge from students' responses when solving integral calculus tasks?
2. What is the impact of Maple software on students' understanding of integral calculus?

   H_o: There is no statistically significant difference between the mean scores of the control and experimental group in the post-test.

3. How do students perceive the effectiveness of Maple software in learning?

Methods

The study was carried out at Evangelical Presbyterian College of Education, Volta Region – Ghana during the first semester of the 2020 - 2021 academic year. The study was designed in line with Handley, Lyles, McCulloch, and Cattamanchi, (2018) description of non-equivalent quasi-experiment group design.

Types of groups	***pretest***	***treatment***	***posttest***
Experimental	O_1	X	O_2
Control	O_3	C	O_4

The pretests O_1 and O_3 were done to determine the initial entry points and compare differences between groups before treatment. The posttests O_2 and O_4 were administered to examine the treatment effect after the experimental group received integral calculus tuition through Maple instruction ***(X)*** and the control group received integral calculus tuition through the conventional instruction ***(C)***.

The study adopted quasi-experimental non-equivalent group design. An adopted quasi-experimental non-equivalent group design is one that looks similar to an experimental design but lacks the key ingredient which is random assignment (Handley, Lyles, McCulloch, & Cattamanchi, 2018). In other words, it is a design in which the responses of a treatment group and a control group are compared on measures collected at the beginning and end of the research. The sampling techniques used in the study were convenience and simple random sampling techniques. A convenience sampling is a type of non-probability sampling that involves the sample being drawn from that part of the population that is close to hand (Stratton, 2021). Moreover, simple random sampling is a type of probability sampling in which the researcher randomly selects a subset of participants from a population (Latpate, Kshirsagar, Gupta, & Chandra, 2021). Each member of the population has an equal chance of being selected.

The convenience sampling technique was used in selecting a sample of 80 students from an accessible population of all third year students (405) due to accessibility, geographical proximity, availability and willingness to participate in the study. Simple random sampling technique was also used in categorizing them into a control group of 40 students and an experimental group of 40 students respectively.

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www.abjournals.org

The instruments used to measure students' understanding in integral calculus are tests and questionnaires. The instruments were developed by the researchers and have been carefully piloted to ensure its reliability and validity. By using Cronbach Alpha, the reliability of the test instrument was proven high with item reliability of 0.90. The spearman- Brown reliability was also proven good for questionnaire, which is 0.81. The intervention was carried out for six weeks, where the experimental group was exposed to integral calculus learning using Maple instruction and the control group exposed to traditional methods of integral calculus instruction. Integral Calculus achievement posttest was administered to both groups after the intervention. A paired samples t-test was further used on pretest posttest of the groups.

A Likert-scale questionnaire was administered to students in the experimental group to find out their views or perceptions on effective application of Maple as computer software used in teaching and learning of integral calculus. The questionnaire comprised a four - point Likert scale of 11 items, which were scaled as 1-Strongly Disagree, 2-Disagree, 3-Agree and 4-Strongly agree. The data collected were analyzed qualitatively based on; views about whether Maple lessons had increased participation in class activities, improved concentration in class, enjoyment during learning times, self-confidence, content mastery and ultimately recommendation of this teaching and learning method.

RESULTS AND DISCUSSION

Descriptive error analyses under the following subtopics of integral calculus were investigated: (i) Indefinite integral (ii) Integration of powers; integration of trigonometric functions (iii) Definite integral (iv) Area under a curve, area bounded between two curves.

Errors in working with indefinite integral of $\int \frac{x-2x^2}{\sqrt{x}}dx$

Student teachers' difficulties with integral symbols and variables were identified as one of the errors in the test-item question 1. The integral sign $\int$ and dx were omitted in the solution presented by the student teachers. The integral sign $\int$ and dx are the symbol errors committed by some student teachers. The errors related to symbols and variables pertaining to integral calculus might seem trivial but not. Another problem was misunderstanding on the property of integral such as $\int \frac{x-2x^2}{\sqrt{x}}dx = \int (\frac{x}{x^{\frac{1}{2}}} - \frac{2x^2}{x^{\frac{1}{2}}})dx$. Many student teachers had mixed up the processes involved in integration with that of differentiation, which resulted from forgetting of the techniques in integrating functions, or lacked practice in this area.

Another error exhibited by the student teachers was not adding a constant of integration (c), after integrating an indefinite integral. Student teachers were not aware or had forgotten that they needed to add a constant, (c) after integrating an indefinite integral. Table 1 describes statistically the performance of each skill under finding indefinite integral of function

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Table 1: Students' Performance in Indefinite Integral of Function

Ability to:		N	Number of students with correct answers	Number of students with wrong answers	Number that failed to attempts
i.	Split the function into separate terms	80	32(40)	36(45)	12(15)
ii.	Integrate individual terms	80	24(30)	44(55)	12(15)
iii.	Find the correct integral with the constant attached	80	20(25)	48(60)	12(15)

Percentages in parentheses

The researchers therefore agrees with the common grounds identified in the related literature by (Kiat, 2005; Metaxas, 2007; Yee & Lam, 2008; Mahir, 2009; Souto & Gomez-Chacon, 2011; Usman, 2012; Salazar, 2014; Zakaria & Salleh, 2015). These researchers revealed in their reports that student teachers were not able to integrate individual terms of any integral function and forgot to put in a constant, $+C$ after the integration. Besides the error regarding the constant, $+C$ from the results, it seems that there were still student teachers who were not aware or have forgotten that they needed to add a constant of integration, $+C$ whenever they were doing indefinite integration. The researchers therefore agree with the common grounds identified in the related literature by Selden, (2005) and Haripersad, (2011) on the causes of students' errors in Integral Calculus. Thus, students learn through rote learning and memorization rather than fully understanding the concept. It is because of these causes that students sampled for this study could not remember the procedures for integrating indefinite integral.

Error in working with indefinite integral involving trigonometric of $\int (sin^4 x)dx$

The second type of errors identified was confusion with respect to trigonometry, differentiation and integration. This errors occurred in the question 2 involving integrating trigonometric function, as student teachers were not able to recall the trigonometric identity nor could they manipulate the trigonometric function of $\int (sin^4 x)dx = \int (sin^2 x)^2 dx$ and $\int (sin^2 x)^2 dx = \int (\frac{1}{2} - \frac{1}{2}cos2x)^2 dx$. Student teachers' inability to identify the appropriate integration techniques was another error identified. That is, student teachers' poor linkage between differentiation and integration as they were not able to integrate $\int (\frac{1}{2} - \frac{1}{2}cos2x)^2 = \frac{3}{8}x - \frac{1}{4}sin2x + \frac{1}{32}sin4x + c$ correctly. The table 2 describes statistically the performance of students under the skills required in finding indefinite integral of function involving trigonometric function.

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Table 2: Students' Performance in Indefinite Integral of Function involving Trigonometric Function

Ability to:		N	Number of students with correct answers	Number of students with wrong answers	Number that failed to attempts
i.	Split the function into separate terms- using correct trigonometric identities	80	5(6.25)	36(45)	39(48.75)
ii.	Apply the rules of integrating simple trigonometric functions	80	1(1.25)	40(50)	39(48.75)
iii.	Find the correct integral with the constant attached	80	0(0)	41(51.25)	39(48.75)

Percentages in parentheses

Generally, analysis shows that student teachers were in various views, neither able to split or manipulate trigonometric function into separable term using the correct trigonometric identity, identify and apply the applicable integration formulas and techniques, determine the derivatives of the function, nor simplify expressions to arrive at the answer with the constant, $+c$ attached to it. To understand more the nature of the difficulties of the student teachers in this area, the researchers highlighted the significant findings of other investigations that described similar cases in dealing with integration, such as (Kiat, 2005; Maharaj, 2008; Yee & Lam 2008; Lithner, 2011; Usman, 2012; Mikula & Heckler 2013; Siyepu 2015).

The poor showing of linkage between differentiation and integration by student teachers implied that they did not know whether they had used appropriate methods or whether they had used the correct formula in integration. Trigonometry served as an important precursor to Integral Calculus. Learning about trigonometric functions is initially fraught with difficulty. The researchers agree with Weber (2008), and Gur (2009), that trigonometric functions are typically among the first functions that students cannot evaluate directly by performing arithmetic operations. Trigonometry is an area of mathematics that students believe to be particularly difficult and abstract compared with the other subjects of mathematics and the most common errors that students make are the improper use of equations, order of operations, and technical or mechanical errors.

The researcher is not in doubt that many student teachers appeared to have little understanding of the underlying trigonometric principles and confirmed what was said by De Villiers and Jugmohan (2012) that students resort to memorizing and applying procedures and rules, while their procedural success masked underlying conceptual gaps or difficulties.

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Errors with definite integral of $\int_{-1}^{2} x(x-4x^2)dx$

The third question tested the student teachers on how to evaluate definite integral of $\int_{-1}^{2} x(x-4x^2)dx$. From the data analysis, some students evaluated the definite integral wrongly. They were not able to expand $\int_{-1}^{2} x(x-4x^2)dx$ to get $\int_{-1}^{2} (x^2-4x^3)dx$, before integrating, but rather integrated x and $(x-4x^2)$ separately, and ended up not obtaining the correct integrand $\frac{1}{3}x^3-x^4+c$, first. Even those students who evaluated the definite integral correctly ended up applying the limits wrongly. In addition, errors in basic mathematical skills such as additive, arithmetic operation and reducing by common factors errors were identified as common errors from the definite integral question. The table 3 describes statistically the performance of student teachers under definite integral of function.

Table 3: Students' Performance under Definite Integral of Function

Ability to:	N	Number of students with correct answers	Number of students with wrong answers	Number that failed to attempts
i. Expand and simplify the function	80	51(63.75)	23(28.75)	6(7.5)
ii. Integrate simple algebraic terms	80	46(57.5)	28(35)	6(7.5)
iii. Apply the limits	80	43(53.75)	31(38.75)	6(7.5)
iv. Find the correct answer for the definite integral	80	40(50)	34(42.50)	6(7.5)

Percentages in parentheses

This agrees with the findings of previous researchers: (Rasslan & Tall, 2002; Sealey, 2006; Grundmeier, Hansen & Sousa, 2006; Mahir, 2009) that students commit errors when solving problems involving the definite integral. The researcher agreed with Tall (2009) that miscellaneous technical errors were spanned from basic algebraic skills to functions. The students' massive errors were found in algebra and functions.

Error with area under curves of the function $y = x(x-4)$

Question four (4) tested the student teachers on how to evaluate definite integrals and apply integration to evaluate plane areas. The question did not provide any diagrams or sketches, required the student teachers to integrate the curve $y = x(x-4)$ from $x = 0 \text{ to } x = 5$. Because of this, many students failed to realize that the part of the curve $y = x(x-4)$ from $x = 0 \text{ to } x = 4$ was below the x −axis whereas the part from $x = 4 \text{ to } x = 5$ was above the x-axis. Many students had no idea that they needed to sketch out the curve to determine how they were going to integrate the function. Many simply integrated the function from $x = 0 \text{ to } x = 5$ directly. They integrated the function mechanically using the given limits. However, they had difficulty explaining their answers. Table 4 describes statistically the performance of each skill under finding the area under the curve.

Article DOI: 10.52589/AJMSS-WRFGFPIH
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Table 4: Students' Performance under Areas of Curves of Function

Ability to:		N	No of students with correct answers	No of students with wrong answers	Number that failed to attempt
i.	Sketch the curves	80	31(38.75)	17(21.25)	32(40)
ii.	Locate the required areas and find the respective differences	80	12(15)	36(45)	32(40)
iii.	Apply integration to find the area between the curves in the specific intervals	80	3(3.75)	45(56.25)	32(40)
iv.	Find the total area between the curve and the x-axis in the given interval	80	0(0)	48(60)	32(40)

Percentages in parentheses

From table 4, it shows student teachers' inability to sketch the curve in the given intervals. Many student teachers had no idea that they needed to sketch out the curve to determine how they were going to integrate the function. Another common ground established was their inability to locate the required areas and find the respective differences. Again, the table reveals that these students were unable to apply integration to find the area between the curves in the specific intervals.

Finally, from the table student teachers got the total area between the curve and the $x -$ axis and unit wrong. This means that students did not understand why the unit of an area is squared and must be measured in "square units". These findings agree with previous research studies (Kiat, 2005; Metaxas, 2007; Yee & Lam, 2008; Mahir, 2009; Souto & Gomez-Chacon, 2011; Usman, 2012; Salazar, 2014; Zakaria & Salleh, 2015), that students have these difficulties finding areas between curves.

Research Question 2, on impact of the Maple software on students' understanding of integral calculus. The mean scores of both groups in the pretest and posttest were compared using the paired sample t-test. The results of the analysis for the control and experimental groups were summarized in tables 5 and 6 respectively.

Table 5: Paired Samples T- test of Posttest and Pretest Scores of Experimental Group.

Group	Test	N	Mean	SD	df	t-value	p-value
Experimental	Post-test	40	25.75	3.46	39	-6.94	0.00
Experimental	Pre-test	40	4.18	5.42	39		

A paired sample t-test was carried out which compared the mean difference of posttest and pretest scores of the Experimental group as the data met all the assumptions of paired sample t-test. The result verify mean difference between the posttest and pretest scores indicated that

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there was a significant improvement in the achievement of posttest scores (M = 25.75, SD = 3.46) over pretest scores (M = 4.18, SD = 5.42) at [$\alpha < p \rightarrow 0.00 < 0.005$] at 0.05 level of significance, with conditions [t (39) = -6.94, P = 0.00]. It was therefore concluded that, there was a statistically significant difference between the posttest and pretest scores of students when taken through integral calculus after they have been taught with Maple software. The findings of this study agree with those of Noah (2019), Kusumah, Kustiawati, and Herman, (2020), Chen and Wu, (2020) and Septian and Prabawanto, (2020) that students taught with CAI packages in Chemistry, Physics, Mathematics and Education in general, perform better than those taught with normal classroom instruction. Table 6 showed paired sample t-test of posttest and pretest scores of the control group.

Table 6: Paired Samples T- test of Posttest and Pretest Scores of Control Group

Group	Test	N	Mean	SD	df	t-value	p-value
Control	Post-test	40	18.98	2.64	39	-4.01	0.00
Control	Pre-test	40	10.78	4.34	39		

The results on Table 6 showed that there was slightly statistically significant difference of the posttest scores (M = 18.98, S.D = 2.64) against pretest scores (M = 10.78, S.D = 4.34) at [t (39) = -4.01, P = 0.00], at [$\alpha < p \rightarrow 0.00 < 0.005$] at 0.05 level of significance, with conditions [t (39) = -4.01, P = 0.00]. This slightly marginal increase gives an indication that, to some extent, the traditional method and the teacher factor increased student teachers' understanding of Integral Calculus. It therefore follows that the traditional method seems not to be a significant difference in teaching as compared to Maple software approach of teaching integral calculus. This was because the mean difference of 8.2 showed that the control group exposed to the traditional method was not very good in the understanding of integral calculus concepts and its application to real life situations. The findings of this study agree with those of Noah (2019), Kusumah, Kustiawati, and Herman, (2020), Chen and Wu, (2020) and Septian and Prabawanto, (2020) that students taught with CAI packages in Chemistry, Physics, Mathematics and Education in general, perform better than those taught with normal classroom instruction.

To answer research question 2 further, hypothesis was formulated and independent samples t-test (Table 6) was conducted at 0.05 level of significance to establish if there was statistically significant difference in the post-test scores between the groups.

H_o: There is no statistically significant difference between the mean scores of the control and experimental group in the post-test.

Table 7 Independent Samples t-test Results on the Post-tests of both Groups

Group	Test	N	Mean	Std. Deviation	t-value	p-value (sig.)
Control	Post-test	40	18.98	2.636	-6.94	0.00
Experimental	Post-test	40	25.75	3.462		

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The independent samples t-test indicates that there was statistically significant difference between the post- test mean scores of the experimental group [M = 25.75, SD = 3.46] and the control group [M = 18.98, SD =2.64], t(78) = -6.94. In the analysis, the difference was significant at 5% with a p-value of 0.00 which is less than the significance level (0.00 < 0.05), indicating a significant difference between the mean scores of the control and the experimental groups. The mean of the experimental group [M = 25.75, SD = 3.46] is significantly higher than the mean of the control group [M = 18.98, SD =2.64] in the post-test. As a result, the null hypothesis, "there is no statistically significant difference between the mean scores of control and experimental groups in the post test" was rejected. In effect, the alternative hypothesis "there is a statistically significant difference between the mean scores of control and experimental groups in the post test" was retained. The integration of Maple activities in integral calculus tutorial classes was found to give positive effects on enhancing student teachers' understanding in this topic. These values show that the integration of Maple software in the learning of integral calculus has made a significant contribution to the effectiveness of integral calculus teaching for the student teachers. This better performance in Integral Calculus is because of the use of Maple software to teach the concept. The findings of this study agree with those of Noah (2019), Kusumah, Kustiawati, and Herman, (2020), Chen and Wu, (2020) and Septian and Prabawanto, (2020) that students taught with CAI packages in Chemistry, Physics, Mathematics and Education in general, perform better than those taught with normal classroom instruction.

Research Question 3: How do students perceive the effectiveness of Maple software in learning?

Furthermore, analysis of the students' rating on their perceptions of the use of Maple to learn integral calculus. The responses from the questionnaire revealed that the impact of the use of Maple software on students' understanding of Integral Calculus was very positive.

Table 8: Students' Questionnaire Ratings on their Perception of the Use of Maple Software to Learn

No	Statement	N	Mean	S.D.	Mode	Min.	Max.
1	Maple software is easy to learn	40	3.68	0.47	4	3	4
2	Maple software is easy to use in solving Integral Calculus problem	40	3.57	0.50	4	3	4
3	Maple software made me enjoy the Integral Calculus lessons.	40	3.50	0.55	4	2	4
4	Maple software made Integral Calculus easy to learn	40	3.48	0.51	3	3	4
5	Maple software has helped me to correct my errors in Integral Calculus.	40	3.38	0.49	3	3	4
6	Before the intervention, I had difficulty in understanding Integral Calculus.	40	3.05	0.78	3	3	4
7	After the intervention, I have gained better understanding of Integral Calculus	40	3.65	0.48	4	3	4
8	All student teachers should be exposed to Maple software to learn Integral Calculus	40	3.75	0.49	4	3	4
9	Mathematics tutors have to use Maple software to teach Integral Calculus	40	3.15	0.58	3	3	4

Article DOI: 10.52589/AJMSS-WRFGFPIH
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10	Maple software will help mathematics teachers to explain Integral Calculus concept better	40	3.40	0.55	3	3	4
11	Maple software will help mathematics tutors to make their lesson enjoyable	40	3.45	0.50	3	3	4

From Table 8, the modal score for each of the items was three (3) with only five having their mode to be four (4). That is, the majority of the students either agreed or strongly agreed to the items on their perception about the effective use of Maple software to learn Integral Calculus. That is to say, most students have a positive perception towards the effective use of the Maple software to learn Integral Calculus. In addition, the maximum score for the ratings on each item was four (4) and the minimum score was three (3) except for one (1) item whose minimum score was two (2). That is, "Maple software made me enjoy the Integral Calculus lessons" is the only item on the questionnaire that had very few students disagreeing with it. Findings from the questionnaire revealed that using Maple software in teaching and learning, not only increases achievement in general, but also motivates students. All the attributes in the questionnaire coined to be the six motivation attributes such as increased participation, improved concentration, enjoyment, self-confidence, content mastery and recommendation affirm that Maple software enhances student motivation to learn integral calculus. This finding was in consistency with the findings of (Tamur, Ksumah, Juandi, Kurnila, Jehadus, & Samura, 2021).

CONCLUSION AND RECOMMENDATION

Based on the findings of the study, the researchers recommend Maple assisted instruction in the teaching and learning of integral calculus and the need for teachers to employ blended teaching and learning methods, in which computer software such as Maple software are used simultaneously with traditional teaching strategy. The blended teaching and learning process is a system that combines face-to-face instruction with computer-mediated instruction. Fazal and Bryant (2019) argued that blended instruction offers more choices for content delivery and is more effective than teaching that is fully online or fully classroom based. Fitri and Zahari (2019) reported that students learn more in blended learning environments than they do in comparable traditional classes. Blended teaching offers advantages to both the school and the students. The method of instruction is not over-reliant on the physical presence in one room of both the tutors and the student, and it offers greater flexibility for student teachers to carry out their work independently (Fazal & Bryant, 2019).

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REFERENCES

Aldiab, A., Chowdhury, H., Kootsookos, A., Alam, F., & Allhibi, H. (2019). Utilization of Learning Management Systems (LMSs) in higher education systems: A case review for Saudi Arabia. *Energy Procedia*, 160, 731-737.

Berggren, J. L. (2016). Calculus: Mathematics. *Encyclopedia Britannica*, 2-15.

Buckley, J., Seery, N., Canty, D., & Gumaelius, L. (2018). Visualization, inductive reasoning, and memory span as components of fluid intelligence: Implications for technology education. *International Journal of Educational Research*, 90, 64-77 .

Chen, C. L., & Wu, C. C. (2020). Students' behavioral intention to use and achievements in ICT-Integrated mathematics remedial instruction: Case study of a calculus course. *Computers & Education*, 145, 103740.

Das, K. (2019). Role of ICT for Better Mathematics Teaching. *Shanlax International Journal of Education*, 7(4), 19-28.

De Barba, P. G., Malekian, D., Oliveira, E. A., Bailey, J., Ryan, T., & Kennedy, G. (2020). The importance and meaning of session behaviour in a MOOC. *Computers & Education*, 146, 103772.

Dronyuk, I., Fedevych, O., Stolyarchuk, R., & Auzinger, W. (2019). OMNET++ and Maple software environments for IT Bachelor studies. *Procedia Computer Science*, 155, 654-659.

Fazal, M., & Bryant, M. (2019). Blended learning in middle school math: The question of effectiveness. *Journal of Online Learning Research*, 5(1), 49-64.

Fitri, S., & Zahari, C. L. (2019). The implementation of blended learning to improve understanding of mathematics. *Journal of Physics*, 1188(1), 012109).

Handley, M. A., Lyles, C. R., McCulloch, C., & Cattamanchi, A. (2018). Selecting and improving quasi-experimental designs in effectiveness and implementation research. *Annual review of public health*, 39, 5-25.

Kovács, Z., Recio, T., & Vélez, M. P. (2020). Merging Maple and GeoGebra Automated Reasoning Tools. *Springer, Cham*, 252-267.

Kusumah, Y. S., Kustiawati, D., & Herman, T. (2020). The Effect of GeoGebra in Three-Dimensional Geometry Learning on Students' Mathematical Communication Ability. *International Journal of Instruction*, 13(2), 895-908.

Kusumah, Y. S., Kustiawati, D., & Herman, T. (2020). The Effect of GeoGebra in Three-Dimensional Geometry Learning on Students' Mathematical Communication Ability. *International Journal of Instruction*, 13(2), 895-908.

Latpate, R., Kshirsagar, J., Gupta, V. K., & Chandra, G. (2021). Simple Random Sampling. *Springer*, 11-35.

Lee, M. Y. (2021). Using a technology tool to help pre-service teachers notice students' reasoning and errors on a mathematics problem. *ZDM–Mathematics Education*, 53(1), 135-149.

Mazana, M. Y., Montero, C. S., & Casmir, R. O. (2020). Assessing students' performance in mathematics in Tanzania: the teacher's perspective. *International Electronic Journal of Mathematics Education*, 15(3).

National Council of Teachers of Mathematics (NCTM). (2014). *Principles to actions: Ensuring mathematical success for all.* Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (NCTM). (2019). *Calculation nation.* Roston VA: National Council of Teachers of Mathematics.

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DOI URL: https://doi.org/10.52589/AJMSS-WRFGFPIH

Noah, O. O. (2019). Effect of computer game-based instructional strategy on students' learning outcome in mathematics. *Journal of Education, Society and Behavioural Science*, 1-15.

Odell, B., Cutumisu, M., & Gierl, M. (2020). A scoping review of the relationship between students' ICT and performance in mathematics and science in the PISA data. *Social Psychology of Education*, 1-33.

Purnomo, E. A., Winaryati, E., Hidayah, F. F., Utami, T. W., Ifadah, M., & Prasetyo, M. T. (2020). The implementation of Maple software to enhance the ability of students' spaces in multivariable calculus courses. *Journal of Physics* , 1446(1), 012053.

Ratheeswari, K. (2018). Information communication technology in education. *Journal of Applied and Advanced research*, 3(1), 45-47.

Salazar, S. N. (2014). Performance/mathematics: A dramatisation of mathematical methods. *International Journal of Performance Arts and Digital Media*, 10(2), 143-158.

Septian, A., & Prabawanto, S. (2020). Mathematical representation ability through geogebra-assisted project-based learning models. *Journal of Physics*, 1657(1) 012019).

Stratton, S. J. (2021). Population Research: Convenience Sampling Strategies. *Prehospital and Disaster Medicine*, 36(4), 373-374.

Tamur, M., Ksumah, Y. S., Juandi, D., Kurnila, V. S., Jehadus, E., & Samura, A. O. (2021). A Meta-Analysis of the Past Decade of Mathematics Learning Based on the Computer Algebra System (CAS). *Journal of Physics*, 1882 (1), 012060.

Tanjung, S. D., & Ihsan, I. (2019). The Application of Quantum Teaching Learning Model on Derivative Function using Maple Software in Informatics Engineering of South Aceh Polytechnic. *Jurnal Inotera*, 4(2), 90-95.

Wang, M. T., Hofkens, T., & Ye, F. (2020). Classroom quality and adolescent student engagement and performance in mathematics: A multi-method and multi-informant approach. *Journal of youth and adolescence*, 49(10), 1987-2002.

Zakaria, E., & Salleh, T. S. (2015). Using technology in learning integral calculus. *Mediterranean Journal of Social Sciences*, 6(5), 144.

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