Faculty of Natural and Applied Sciences Journal of Mathematics and Science Education
Print ISSN: 2814-0885 e-ISSN: 2814-0931
www.fnasjournals.com
Volume 4; Issue 1; March 2023; Page No. 48-63.

IMPROVING SENIOR HIGH SCHOOL STUDENT ACADEMIC ACHIEVEMENT AND ATTITUDE TOWARDS LOGARITHMIC FUNCTION

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Abstract
This study sought to examine whether the use of an integrated approach reinforces senior high school students' conceptual understanding and procedural knowledge in logarithmic function with the view to improving their academic achievement. A multistage sampling procedure was used to select 107 students to participate in the study. The study followed a quasi-experimental design in which both quantitative and qualitative methods were used. Achievement tests and structured interview schedules were used to collect data from the 107 students. The data obtained were analysed using means, standard deviations, percentages, independent-sample t-tests, and themes. The results from the study found that students find it difficult to apply rules and properties of logarithms. However, the use of an integrated approach helped make the learning of these rules and properties simpler and less difficult for students. It is, therefore, recommended that mathematics educators and researchers adopt the use of an integrated approach to large-scale research to its positive effect. We further advocate for use of design-based research.

Keywords: Logarithmic functions, conceptual understanding, procedural knowledge, integrated approach

Introduction

The ability to solve problems using thought and reasoning is indispensable to every area of life. Developing an understanding of logarithmic functions is crucial for senior high school students learning trajectory. This is because logarithmic functions are a mathematical concept with varied applications in other related areas of study. According to Backhouse et al.(1985), a logarithm is an index. The logarithm of q to base a is the power to which p must be raised to equal q. Consequently, if $a^p = q$, then $\log_a q = p$. These two mathematical statements are equivalent and in simple terms are the alternative ways of stating the relationship between the variables a, p and q. That is, the inverse of the exponential function is a logarithmic function (Blitzer, 1998).

Chua and Wood (2005) observed that logarithms are tremendously important to the field of Mathematics and Science. For example, the study of logarithms can enable one to study population growth and the determination of pH of a solution. Logarithms also arise in problems of exponential growth and decay because they are inverses of exponential functions (Stewart et al., 1996). Logarithm turns out to be useful in the measurement of the loudness of sound, intensity of the earthquake, and many other human phenomena (Blitzer, 1998). A good understanding of logarithms will help with the determination of how the temperature of an object changes when placed in an environment held at a constant temperature. Furthermore, logarithms help in the determination of population growth, the spread of epidemics, and the growth of investment funds (Stewart et al., 1996). While students understanding remains crucial in learning logarithmic functions, there appears to be an agreement in mathematics education that, the concept remains problematic to many students (Chua & Wood, 2005; Ganesan & Dindyal 2014; Kenney & Kastberg, 2013; Weber, 2002; WAEC, 2011; 2013; 2017). In Ghana, the Chief Examiner for West African Examinations Council [WAEC] noted that the majority of the students who responded to the test items relating to logarithms were unable to apply the laws of logarithms. For example, in 2013, students were

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required to solve items; $\log(x-2)+lo2=2\log y$ and $\log(x-3y+3)=0$ in solving both items, the theory of logarithm and its applications were the problems for the students who attempted them. Students could not derive two linear equations in two variables as they failed to apply the laws of logarithms.

Also in 2014, Ghanaian candidates were to evaluate $\log\left(\frac{75}{100}\right)-2\log\left(\frac{5}{9}\right)+\log\left(\frac{100}{243}\right)$ without using tables or calculators. The report, however, noted that students were unable to write the given expression as a single logarithm using the power, product, and quotient laws of logarithms. In 2017, students were required to find $\log_{10}\sqrt{\frac{x}{y}}$, given that $\log_{10} x=\bar{1}.3010$ $\log_{10} y=1.6021$ and (WAEC, 2017). According to the report, students left their answer $\frac{1}{2}\left[\log_{10} x-\log_{10} y\right]$s as, and went on to substitute the given values and added. This indicates that the students lack conceptual understanding because they could not differentiate between Mantissa and Characteristics, and so they added the terms together to obtain wrong responses.

Lach and Sakshaug (2005) attributed the challenges that students face in the study of logarithms to the emphasis placed on memorization or rules and the sequential nature of the topic. In furtherance, students are told the rules and sequences without actively engaging them to discover the rules themselves. Zazkis asserted that students have difficulty understanding the meaning of logarithms, misinterpretation of the operations and the inverse relations of exponential and logarithmic functions (Kenney & Kastberg, 2013); students' difficulty with the concept is linked to their inability to relate exponential function to logarithms and connection between additive and multiplicative structure and symbolism (Genesan & Dindyal, 2014); and the unverified error was the difficulty and could be attributed to the lack of depth in the understanding of logarithms when solving items on logarithmic equations (Chua & Wood, 2005). This study emerged from the challenges confronting SHS students as reported in the literature on the conceptual challenges in learning logarithmic functions. Firstly, students are unable to interpret the meaning of logarithms and also could not relate exponentials and logarithms (Chua & Wood, 2005). Secondly, students have difficulty in using properties or laws of logarithms to express logarithm expressions as a single logarithm and also solving logarithmic equations (Ganesan & Dindyal, 2014; Weber, 2002).

While issues relating to the teaching and learning of logarithms persist and seem to assume a wide and worrying proportion (Berezovski & Zazkis, 2006), a shift from teacher to student-centred pedagogy is, therefore, important in the teaching and learning of mathematics. The philosophy underpinning the teaching and learning of mathematics in Ghana sought to empower students to collaborate and communicate with others in supporting their learning. In so doing the curriculum has adopted a balanced programme to incorporate conceptual learning and the application of skills (Ministry of Education [MOE], 2010). The planners of the Ghanaian curriculum suggested teaching strategies for adoption by mathematics teachers including an integrated approach (MOE, 2010). However, it has been observed that the instructional strategy used in many of the classroom practices in mathematics lessons is predominantly a conventional approach where the 'expert' (that is, teacher) transmits knowledge to learners who are quietly seated trying to make sense of the expert (Masingila et al., 2011). In the conventional teaching approach, the teacher controls the entire teaching and learning process and renders the student's passive recipient of knowledge on mathematical facts and concepts (…). Any content taught to students through conventional means emphasizes procedures, which do not fulfil students' aspirations and mathematical needs. It stands to reason that teaching through an integrated approach is rarely seen in Mathematics classroom practices though, the SHS curriculum has suggested its adoption in the teaching and learning of Mathematics (MOE, 2010). There has, then, been a call for an approach that would place the student at the centre stage in the learning process to enable the student to construct knowledge and understanding under the guidance of others.

Weber (2002) proposed alternative techniques to supplement or replace traditional instruction whereas Ganesan and Dindyal (2014) recommend symbolic and graphical representations, which will allow students to have a better understanding and appreciation of the concept. The integrated approach to teaching is a constructivist teaching

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pedagogy which seeks to engage students through cooperative learning and is student-centred (Benek-Rivera, & Mathews, 2004; Bursal & Paznokas, 2006; Marbina, 2012). The integrated approach of teaching and learning addresses students' weaknesses, and take into account all abilities and interest of students (Marbina, 2012). Integrated teaching strategy builds on students' conceptual understanding, develops and maintains their positive disposition towards Mathematics and offers them the opportunity to brainstorm and come out with responses, communicate their ideas with each other, and work to solve problems together (Ahuja & Jahangiri, 2003; An et al., 2012; Bursal &Paznokas, 2006).

Building on the challenges faced by SHS students in responding to items relating to logarithmic functions, a variant integrated approach is adopted as a teaching strategy with the view to improving students' performance. In this integrated approach, students are paired to explore a logarithmic task using their relevant knowledge. After individual discussions, the pair are regrouped into groups of four or five each to share their ideas. At this level, students learn from one another because they discuss with other students as they compare their ideas or plans for getting solutions to the problem. The students are encouraged to employ various mathematical situations in small groups and communicate their ideas to others in a clear manner and offer explanations for steps being taken to conclude their task. A whole class discussion is held to examine and collate the views of students as a result of which any errors and alternate conceptions that are likely to be formed by the students are dealt with. In all these, the teacher then serves as a facilitator or guide to fill in any gap in the teaching and learning process (Rubenstein et al., 1995). The overarching benefit of the integrated approach is to enable students' challenges and difficulties to be remedied through group collaborations (Caniglia et al., 2017), which plausibly may improve their critical thinking and problem-solving skills. Subsequently, the purpose of this was to examine whether the use of this integrated approach could reinforce students' conceptual understanding and procedural knowledge with the view to improving students' academic achievement on logarithmic functions. To this end, the following research questions were formulated.

1. How effective is the integrated approach as an instructional strategy that improves students' achievement on logarithmic function compared to the conventional method of teaching?
2. What are the attitudes of students about the use of an integrated approach to learning logarithmic functions?

Methodology

The design for the study was a two-group pretest and posttest experimental design which employed quantitative and qualitative methods to examine the effects of an integrated approach to that of the conventional approach on students' academic achievements on logarithmic functions in a three-phase procedure. This design allowed for the comparison of two groups – the experimental and the control groups. The first phase of the study was the design of the intervention and test items, as well as a pilot test of the test items in a non-sample school. The second stage was characterized by the conduct of a pre-test among SHS2 students in two schools. After the pretest, the school with the least mean score has tagged the experimental whilst the highest mean score school became the control group. In the third phase of the experimental design, the students from the experimental group were taught the concept of logarithmic functions using the integrated approach and their counterparts in the control group were subjected to the same concept using the conventional approach. Subsequently, a posttest was conducted to examine the extent of the effects of the interventions on students' performance in logarithmic functions.

The study was conducted among SHS students in schools in one of the 18 Municipalities in the Ashanti Region of Ghana. Specifically, the study involved all year two students [SHS2] from all five schools in the municipality. The focus was on second-year students because the concept of the logarithm is taught and learned at this level of the mathematics curriculum. In year two, the curriculum required that students can find the relations between exponents and logarithms; explore the relationship between exponential function and logarithmic function; apply properties of logarithms to evaluate expressions; solve exponential and logarithmic equations; and use logarithm tables and calculators to find antilogarithms (MOE, 2010; p. 26). The multi-stage sampling procedure was followed in selecting the study sample. Ashanti Region is stratified into Metropolitan, Municipal, and District Assemblies. In the first stage, municipal assemblies were purposively sampled because they share similar economic and social characteristics which support education in the Ashanti Region. However, in soliciting permission for the study among the municipalities, only one educational directorate oblige to the request. This municipal education directorate has five SHS. In stage two of the sampling process, two of the five schools in the

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municipality were simply randomly selected. From those two schools, SHS2 students were purposively chosen. In stage three, a computer random number generator was used to select 72 SHS2 students from each of the two schools. Onwuegbuzie et al. (2004) have submitted that 21 participants per group were sufficient for an experimental study. Thus, the sample size for the study was 144 SHS2 students.

A logarithmic achievement test [LAT] was designed by the researchers to examine the effectiveness of the integrated approach to teaching SHS logarithmic functions. LAT is composed of 10 items and it was used for both the pretest and posttest. Each of the 10 items had two parts – the main statement, and a provision to explain the solution. The explanation given by the students to each mathematical response was subsequently used to ascertain students' conceptual understanding of logarithms. Each test item scored two marks; one score for correct mathematical response and the other score, for the correct explanation given. The total score for LAT was 20 marks. Expert analysis of LAT from experience mathematics teachers ensured content validity. An initial 15-item LAT was pilot tested for item screening. Based on item difficulty analysis (Backhoff et al., 2000), five items were eliminated because they were too difficult. The remaining 10-item LAT had a very good KR20 reliability coefficient of 0.80 (Zaintz, 2013). Another instrument, the logarithmic structured interview guide [LSIG] was constructed to examine the views of students towards learning logarithmic functions with an integrated approach. LSIG was constructed based on the literature and experiences of the researchers. All students responded to the nine items on LSIG and sufficient students' explanations will be reported in this report to support the themes for readers to make their meanings.

Day collection took 9 weeks. This involved pre-testing, teaching and learning logarithmic functions, and post-testing and interviews. The teaching and learning took 7 weeks for four areas of logarithmic functions. A summary of each interaction session in this study is presented in Table 1.

Table 1: Stages involved in the Logarithm Lessons Presentations

Day	Activity
1	Administering pretest
2 – 3	Exploring logarithmic functions through number pattern
4 – 5	Drawing graphs of exponential and logarithmic functions
6 – 7	Exploring transformational approaches to the logarithm
8	Exploring properties of logarithms and using the properties to solve problems on logarithms
9	Administration of post-test and interviews

Data analysis

Prelude to the test of significant differences, the data from the pretest and posttest were adequately screened for missing values, normality and equality of variance tests using the guidelines by Tabachnick and Fidell (2013). Students who for one reason or other could not participate in either of the tests were eliminated from the final analysis from experimental and control groups. The test of normality of both the pretest and posttest scores was met. Additionally, the test of equality of variance was not violated. Hence, the means, standard deviations and independent-sample t-test were used to answer the research questions. The explanations of students from the interviews were open-coded and constantly compared. Thereafter, we made meaning out of them to form themes and subthemes.

Results

Effectiveness of Integrated Approach on Students' Academic Achievement

In the pretest, both the experimental group ($M = 4.6, SD = 3.7$) and the control group ($M = 5.5, SD = 3.4$) generally had weak scores. The experimental group's score ranged from 0 to 12, whereas the control group had a minimum score of 0 and a maximum score of 14 out of a possible 20 marks. The low pretest mean scores gave credence to the implementation of an intervention so as resolve the presumed conceptual and procedural difficulties students had in learning logarithms. Additionally, the low performance of the experimental group was fertile ground to investigate the influence of the integrated approach on students' learning of logarithms. The difference in the mean scores between the control and experimental group did not, however, reach a statistically significant level ($t(105) = 1.3, p = 0.189$).

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After seven weeks of treatment using the integrated approach on the students from the experimental group and the conventional teaching approach on the students from the control, the posttest was administered. The percentage performances of the students from the two groups in the posttest are presented in Figure 1.

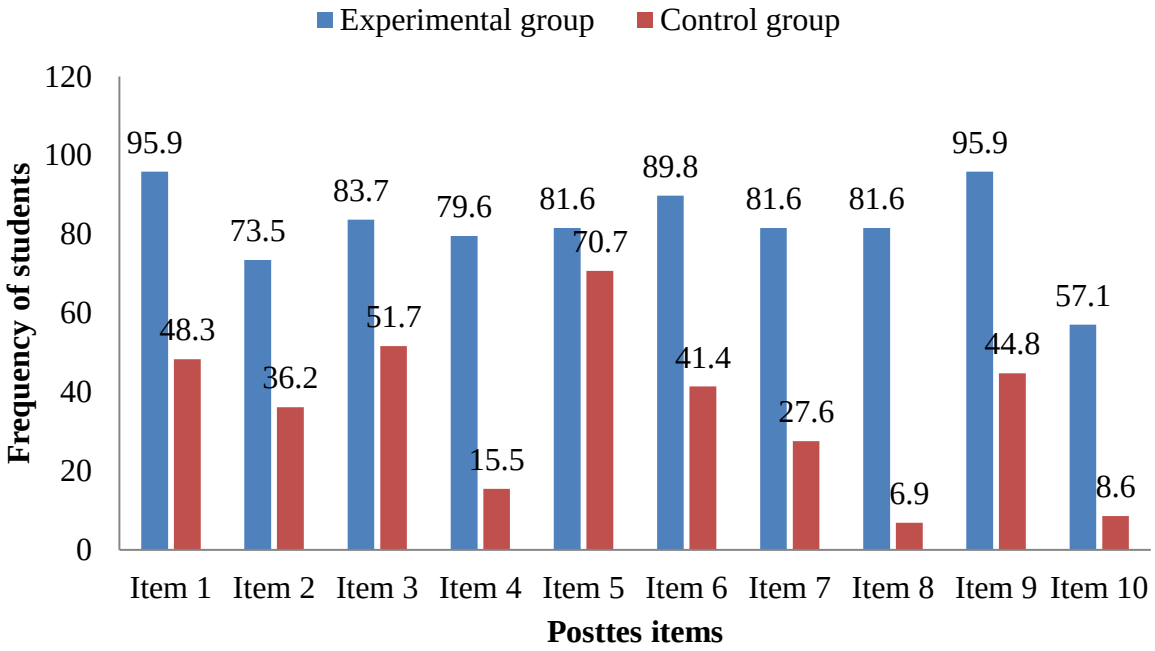

Figure 1: Percentage of students' performance in the posttest.

The results from Figure 1 show the percentage performances of students who provided correct mathematical responses and explanations to the 10 items on LAT in the posttest from the experimental and the control groups. It could be seen that the percentage performances of the students from the experimental group were encouraging as the minimum performance was 57.1% on Item 10 and the maximum performance of 95.9% on Items 1 and 9. The students from the control group showed low percentage performance in those items as only 8.6% for Item 10 and 48.3% and 44.8% respectively for Items 1 and 9. Though there was some above 50.0% performance of students from the control group on items 3 and 5 however, there were others below 10.0% on items 8 and 10. Nonetheless, in those instances, the percentage performance of students from the experimental group was higher than that of the students from the control group.

The results from Figure 1 show that graphically, the performance of the students from the experimental group has improved compared to the performance of the students from the control group. This could be attributed to the effect of the integrated approach used in teaching the logarithmic function to the students from the experimental group or could be by chance. To further examine the effect of the integrated approach on students' learning of logarithms, the mean and standard deviation scores of the students from the experimental group ($M = 17.7, SD = 1.7$) and the control group ($10.1, SD = 3.2$) in the posttest were calculated. Respectively, the minimum scores in the posttest for the experimental and control groups were 14 and 2 out of 20 marks. Also, the maximum score in the posttest for the experimental and control groups were 20 and 15 respectively. Additionally, the experimental group's performance was within 1.7 deviations from the mean as compared to the 3.2 deviations from a mean score of 10.1 for the control group. An independent-sample t-test calculated on the post-test scores showed that the mean score difference between the experimental and the control groups was statistically significant, $t(105) = 14.7, p = 0.000$. The difference in the mean scores of the two groups was found to be strong (eta squared = 0.67) (Cohen, 1988).

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Students Attitudes Towards Learning of Logarithms

Research Question 2 sought to examine the attitudes of students towards learning logarithmic functions before and after their experiences with the integrated approach. To be able to achieve this, students responded to the 9-item structured interview schedule. The results from the interviews are presented under the themes:

Students' Perception and Expectations

Item 1 sought to find out students' perception towards learning logarithms before learning the concept with an integrated approach and students' expectation of learning logarithmic function using the integrated approach. Students' perception towards the learning of logarithms before experiencing the integrated approach was attracted by a mixed reaction. This is because different students had positive, neutral or negative attitudes towards learning logarithms before their experience with the integrated approach. Most of the students (55.1%) mentioned that they had no negative nor positive attitude towards learning logarithms with only an individual student (2.0%) with a positive attitude and 42.9% with a negative attitude towards learning logarithms. It appears that the students were simply neutral in their attitude to learning logarithms. However, after learning logarithmic function with an integrated approach the perceptions changed as they met their expectations. Five subthemes were generated:

Improved confidence level: some of the students (22.2%) expressed that their expectations were fulfilled in learning logarithms with the integrated approach. This is because the confidence level of learning and demonstrating an understanding of logarithms improved after the experience with the integrated approach. The excerpts are: "*I didn't like the topic at all but am confident now in using the rules of the topic*" (E/PO/006); and "*with this approach, I understand the properties. I now have more confidence in solving log*" (E/PO/032).

Teacher's way of teaching: some of the students (15.2%) expressed that their expectations were met as the way the teacher taught the concept of logarithms with the integrated approach enhances understanding. The excerpts are: "*Yes, my expectations are met because of the way the teacher taught. Also the way the teacher responds to our questions and problems*" (E/PO/007); and "*positive; Yes because I have been taught well how to use the properties so I can now use it*" (E/PO/019).

Conversant with logarithms: some of the students (12.5%) expressed that their expectations were met as they are conversant with the properties of logarithms. The excerpts are: "*By and large they are being fulfilled. I am now conversant with the properties of log*" (E/PO/021); and "*I am now conversant with the rules and that made me understand what to do appropriately*" (E/PO/034).

Students developing interest: some of the students (15.2%) expressed that they expected learning logarithms with the integrated approach to be interesting and this has been met. The excerpts are: "*Yes because I wanted to enjoy the lesson and I am enjoying it*" (E/PO/011); and "*Somehow I was not all that punctual in class. But I enjoyed the few hours I spent with the tutor*" (E/PO/017).

Application of properties of logarithms: most of the students' responses (34.8%) under Item 1 on the interview schedule were in this domain. The students mentioned that the integrated approach has helped in the application of properties of logarithms, and hence, their expectations were met. The excerpts are: "*This is because I now can use the rules in other examples which in the past I couldn't. Though I still have some challenges but when I sit and look at it I will overcome it*" (E/PO/005); and "*yes, my expectations were fulfilled. I can conveniently apply the properties of log to solve problems on it*" (E/PO/027).

Students' Goals for Learning Logarithms with Integrated Approach

Item 2 sought to measure the expected goals of the students before participating in the lessons on an integrated approach and also examine whether the goals were met. Six sub-themes emerged after open coding and constant comparison of students' explanations. The results show that the students went into learning logarithms with an integrated approach with some goals expected to be achieved at the end of the intervention period. Most (53.1%) of the goals of the students at the beginning of their learning of logarithms with the integrated approach were centred on understanding the concept of logarithms. Only two (4.1%) of the students aimed at overcoming their learning challenges in logarithms. The goals of the students and whether such goals were fulfilled are categorised as:

Understanding logarithms: to a large extent some of the students (53.1%) aimed at understanding the concept of logarithms through the use of the integrated approach. To them, this goal was met at the end of their experiences with the integrated approach to learning logarithms. The excerpts are: "*My goal was to understand. Yes, it has met my expectation well*" (E/PO/002); and "*to get understanding and it has been fulfilled*" (E/PO/012).

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In another instance, the students aimed at understanding the concept of logarithms using the integrated approach. This goal was achieved as the students expressed that they can apply the properties of logarithms in any given situation. The excerpts are: "*My goal was to understand, yes because as I said in the first question applying the properties has not been difficult*" (E/PO/001); and "*the goals are: 1) to understand the topic and 2) to answer or apply the rules of log very well. Yes, they are met. I can now use the rules to answer questions on the log*" (E/PO/009).

Mastering logarithms: some of the students (8.2%) aimed at mastering logarithms using the integrated approach. This goal was met as the students can apply the properties of logarithms in any given situation. The excerpts are: "*to master in learning logarithm; thus I can apply it not all but most of the properties in answering logarithm questions*" (E/PO/024); and "*yes to be able to master all the properties or rules of logarithm and apply them where necessary*" (E/PO/031).

Confidence level: some of the students (12.2%) aimed at becoming confident in using the properties of logarithms as they learn the concept with the integrated approach. The excerpts are: "*to become confident. Yes, my goals are met because I can now tackle logarithm questions with confidence because I now know the concept of logarithm*" (E/PO/015); and "*my goal was to have confidence by the end of the lesson on logarithm. Yes; now I have some level of confidence in solving logarithm*" (E/PO/023).

Being conversant: some of the students (16.3%) aimed at becoming conversant with the properties of logarithms by learning through the integrated approach. The students mentioned that this goal was met as they are conversant in using the properties of logarithms in any given situation. The excerpts are: "*to be conversant. The extent of the fact that I am now conversant with the properties or rules of logarithms*" (E/PO/035); and "*to be conversant with logarithms. The extent that I am conversant with the properties and rules of logarithm*" (E/PO/037).

Overcoming challenges: some of the students (4.1%) aimed at overcoming their learning challenges in logarithms using the integrated approach. This goal was met as students can handle test items on logarithms with less or no difficulty. The excerpts are: "*to overcome my challenges in mathematics. I can now work logarithm question due to the properties and how I have learnt them*" (E/PO/026); and "*I was having challenges as far as this logarithm is a concern so I took this opportunity to overcome and to be able to handle questions on it. I have understood it and the rules can be used well too*" (E/PO/038).

Solving logarithms: some of the students (6.1%) aimed at solving problems on logarithms as they learn the concept using the integrated approach. This student goal was met as the students mentioned that they can solve problems on logarithms by applying the properties. The excerpts are: "*My goal was to solve questions on it by using the laws. Yes, they are met because I can use the rules well and appropriately*" (E/PO/025); and "*My goal of learning logarithm was to know how to solve problems on logarithm. Yes, they have been fulfilled. This is because I can now apply the rules of the logarithm to solve logarithm questions*" (E/PO/028).

Students' Involvement in Integrated Approach Lessons

Item 3 sought to find out the extent of students' involvement in the teaching and learning process on logarithms using the integrated approach. The extent of students' involvement in the integrated approach lessons on logarithms is categorised into five subthemes as group discussion, teacher-led discussion, student participation, question and answer session, and discussion and question and answer session. The results show the integrated approach to teaching and learning logarithms which provided students with much room to be involved in the learning process. This is because the integrated approach is student-centred with the majority (77.5%) of the students involved in group discussion, question and answer, and both group discussion and question and answer.

Group discussion: some of the students (24.5%) expressed that the extent of their involvement in the integrated approach lessons was concerning the discussion in small groups. The small group discussion provides members with feedback and further explanations on logarithms. The excerpts are: "*Through group discussion, feedback is given. At group level we discussed among us and asked for further explanations to things that were not clear*" (E/PO/008); and "*I participated through discussion and group work and this gave us feedback. I have the chance to further explain myself*" (E/PO/013).

In another instance, the students expressed that the extent of their involvement in the integrated approach lessons is concerning the discussion in groups where ideas are freely shared and accepted by group members. The excerpts are: "*During group discussion in class I contribute freely and my ideas are taken on board …*" (E/PO/004); and "*through group discussion I shared my views freely and my opinion was also considered ...*" (E/PO/024).

Teacher-led discussion: some of the students (10.2%) mentioned that the extent of their involvement in the integrated approach lessons was concerning open class discussion. Students discuss their solutions to a given

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problem on logarithms and the teacher provides them with feedback. The excerpts are: "*We discuss our solutions together and our doubts are explained. We get feedback from the teacher. I asked questions in class; I also answer some of the questions in class*" (E/PO/010); and "*I participated during class discussion. Feedbacks are provided by the teacher*" (E/PO/032).

Students' participation: some of the students (12.3%) expressed that the extent of their involvement in the integrated lessons was concerning class engagement and participation. Students' engagement and participation are achieved through questions and answers. The excerpts are: "*Through class engagement and participation. I ask questions in class and also answered some of them*" (E/PO/003); and "*Through class engagement and participation, I also ask a question for clarify in class and also answer questions in class. Feedbacks are provided*" (E/PO/036).

Question and answer session: some of the students (16.3%) mentioned that the extent of their involvement in the integrated approach lessons was concerning participation in asking questions and responding to questions from colleagues or the teacher. "I asked questions and answer some of them in class and at group levels" (E/PO005); and "*at group level, I contribute and answer questions in class. I also asked questions which the answers are provided by my friends and sometimes the teacher*" (E/PO/018).

Group discussion and question and answer: some of the students (36.7%) expressed that the extent of their involvement in the integrated approach lessons was concerning group discussion and question and answer sessions. Students meet at a group level to discuss and find the solution to questions and meet also in class for 'general' discussion where questions are asked by the teacher or colleague for clarification. The excerpts are: "*Through discussion among ourselves and trying asking questions and answering: I solved a question*" (E/PO/014); and "*I participated at the group levels where we solved question on logs and we provided our solutions in whole class discussion. Prompt feedback is given to correct us. I also asked questions in class and answered as well*" (E/PO/030).

Nature of the Integrated Approach to Learning Logarithms

Item 4 sought to find out the views of students on the nature of learning logarithms using the integrated approach as an instructional strategy. Five subthemes were deduced after open coding and constant comparison of the views of students. The five subthemes were interactive, interesting, participatory, stress-free, interactive and friendly. The results show that a little above half (51.0%) of the students viewed the integrated approach to learning logarithms as interactive. Of the 51.0%, 16.3% of the students described the integrated approach as simply interactive and 34.7% of the students described the integrated approach as both interactive and friendly. The views of the students concerning the five subthemes are:

Interactive: some of the students (16.3%) expressed that learning logarithms with the integrated approach as the instructional strategy was interactive. This is because the integrated approach provides students with the opportunity to interact among themselves to share ideas on a solution to a given problem on logarithms. The excerpts are: "*To me, it is very good because it is more on the interaction among ourselves. We could see our mistakes and we corrected it*" (E/PO/009); and "*it was interactive. We could interact among ourselves, correct ourselves, we have the opportunity to discuss our answers*" (E/PO/033).

Interesting: some of the students (12.4%) mentioned that learning logarithms using the integrated approach as an instructional strategy was interesting. This is because the approach provides students with the freedom of expressing their ideas with the teacher as a guide. The excerpts are: "*very interesting. The classroom environment was interesting as we were free to interact among ourselves for explanations. I could ask questions and feedback is given*" (E/PO/002); and "*very good and the reason is that I speak my mind and the way the classroom situation is lively we could contribute freely. In fact, it is interesting. The teacher guides us*" (E/PO/029).

Participatory: some of the students (18.3%) expressed that learning logarithms using an integrated approach as an instructional strategy was participatory. This is because the students are deeply involved in the teaching and learning process responding to questions and asking questions. The excerpts are: "*It was good. I am involved in the class. I asked questions and also answer some of them when I had the opportunity. Other students also correct me when am wrong or not getting something well*" (E/PO/007); and "*very good and this is because am deeply involved in the teaching and learning process*" (E/PO/023).

Stress-free: some of the students (18.3%) mentioned that learning logarithms using the integrated approach as an instructional method was stress-free. This is because there is no pressure on students to accept or reject any explanation for an issue but they do so freely. The excerpts are: "*I like this method because it is good for me. There is no pressure on me. I can also make a suggestion which is accepted by the class. I like the various means*

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to get the answers" (E/PO/006); and "*I didn't feel any pressure. Our class was more of a free class where we all contribute to the discussion. And the teacher provide feedback*" (E/PO/025).

Interactive and friendly: some of the students (34.7%) expressed that learning logarithms using the integrated approach as an instruction method was interactive and friendly. This is because a conducive learning environment is created where the teacher provides students with feedback and students are free to raise and respond to issues in class discussion. The excerpts are: "*The method used was interactive and friendly. It was expressed in a way that logarithm questions became easier. The environment was also conducive. The feedback of the teacher was provided and was understandable for corrections to be made*" (E/PO/011); and "*the method of teaching was interactive, friendly classroom environment where learners freely share their ideas. Also, the feedback is given and I was free to contribute in class*" (E/PO/021).

Positive or Interesting Aspects of Learning Logarithms with the Integrated Approach

Item 5 sought to find out the positive or interesting aspects of using the integrated approach in learning logarithms. From the explanations given by the students, six subthemes were deduced to justify the positive or interesting nature of the lessons from the integrated approach. The results show that there were a lot of positive or interesting aspects of using the integrated approach as an instructional strategy. The most positive or interesting aspect of the integrated approach lessons was the interactive nature and rest as varying approaches and applying rules. This is because 24.6% of the students identified interactive nature as the positive or interesting aspect of integrated approach lessons and an equal proportion of 20.4% of the students identified varying approaches and applying as a positive or interesting aspect of integrated approach lessons. Students' views on the positive or interesting aspects of integrated approach lessons are categorised as:

Encouraging nature: some of the students (12.2%) expressed that the positive or interesting aspect of the integrated approach lessons on logarithms was that it encourages students to learn. This is because the approach gives students the confidence to share their views during lessons. The excerpts are: "*It is positive because it encourages us to talk. It made me confident; my views are taken on board. My weakness is treated*" (E/PO/016); and "*the most interesting thing of this lesson is that it gives me encouragement by way of contribution and that made me confident in your lessons*" (E/PO/034).

Changing logarithms to indices: some of the students (10.2%) mentioned that the positive or interesting aspect of the integrated approach lessons on logarithms was changing a given logarithm to indices. The excerpts are: "*The aspect that was very interesting to me was changing the logarithm method to indices. And when the questions are in the division form you thereby subtract the approach*" (E/PO/020); and "*How to change logarithm to number base and how to solve the quadrilateral equation in the logarithm was very interesting to me*" (E/PO/030).

Working together: Some of the students (12.2%) expressed that the interesting aspect of the integrated approach lessons on logarithms was that students work together in groups. This provides students with the opportunity to share ideas on logarithms. The excerpts are: "*It is interesting because we work together, free to talk on issues. Quick feedback is given*" (E/PO/010); and "*my participation at group work, my involvement in teaching and learning. I answer questions and those that I got wrong are explained to me. It is interesting and friendly*" (E/PO/031).

Interactive nature: some of the students (24.6%) expressed that the positive or interesting aspect of the integrated approach lessons on logarithms was the interactive nature. This is because students actively work among themselves sharing ideas as they look for a solution to a given problem. The excerpts are: "*It is interactive since we were able to interact among ourselves. I participated actively in the lesson. I ask questions and was free to ask and answer questions*" (E/PO/023); and "*It is interactive and we are free to contribute. We share our views as we interact to get the solution the questions*" (E/PO/027).

Varied approaches: some of the students (20.4%) mentioned that the positive or interesting aspect of the integrated approach lessons on logarithms was the use of different approaches in the lessons. The excerpts are: "*various ways of solving that same question. The way we could interact among ourselves in class. We were made to think on our own*" (E/PO/003); and "*different approaches to arrive at the same answer. It is very accommodating. We could freely express our ideas in class*" (E/PO/022).

Applying rules: some of the students (20.4%) expressed that the positive or interesting aspect of the integrated approach lessons on logarithms was the opportunity to apply the rules underpinning logarithms. This shows that the integrated approach makes room for students to apply concepts learnt. The excerpts are: "*My perception about logarithm has now vanished. I can solve any question after I've learned well by applying the rules. This is interesting to me*" (E/PO/017); and "*the positive aspects I experienced can solve logarithms by applying the rules*

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and properties, change indices into logarithm and vice versa. This is because I now know that the logarithm of a number is the index or power" (E/PO/028).

Nature of Learning Logarithms Before Experiencing the Integrated Approach

Item 6 sought to find out the views of students on learning logarithms before their encounter with the integrated approach lessons. After open coding and constant comparison of the views of students, four subthemes were deduced as rote learning, copying of formulas and rules, solving questions, and teacher-dominated lesson. The results show that among the four subthemes on learning logarithms before students experienced the learning of logarithms with the integrated approach, rote learning was the main approach adopted by teachers in teaching logarithms. This is because 55.1% of the students mentioned the rote nature of learning logarithms. The other three subthemes; copying formulas and rules, solving questions, and teacher-dominated lessons were expressed by less than 20.0% of the students in each case. The views of students on the nature of learning logarithms before the experience of the integrated approach lessons are categorised as:

Rote learning: some of the students (55.1%) mentioned that before learning logarithms with the integrated approach, learning of logarithms was purely by rote learning. This is because students just commit the concept into memory to recall it another time. The excerpts are: "*rote learning*" (E/PO/005); "*studying logarithms before this approach was quite memorizing. Teacher writes the properties of logarithms on the board for us to memorize*" (E/PO/013); and "*through rote learning. Teacher write formulas on the chalkboard without explaining them but just to say it is a formula*" (E/PO/035).

In another instance, the students expressed that before learning logarithms with the integrated approach, learning logarithms was by rote learning. However, the integrated approach has helped students to conceptualise the principles and properties of logarithms and that students can apply the properties of logarithms. The excerpts are: "*through rote learning of chew, past, and forget. Yes, it has, because I can now apply the rule and properties of log because I understand it now*" (E/PO/004); and "*through the rote approach. I memorized it so I didn't like it at all. Yes, it has changed and I understand it now. I can now apply the rules not only that but when to apply it*" (E/PO/024).

Some of the students also expressed that before learning logarithms with the integrated approach, learning was by rote learning with no confidence. However, with the use of the integrated approach, students have developed confidence as they now understand logarithms. The excerpts were: "*through memorization. Yes because I now have confidence when it comes to solving logarithm*" (E/PO/001); and "*I use to memorize the properties with no confidence since the teacher was not explaining. Indeed, this method has changed my perception and learning of logarithms. Due to the friendly interaction and discussion being made, I am now confident as it is simple as A B C* (E/PO/011).

Copying of formulas and rules: some of the students (16.3%) mentioned that before learning logarithms with the integrated approach, they were used to copying formulas and rules from the teacher. However, with the use of the integrated approach, students can confidently solve problems on logarithms and apply the laws as well. The excerpts are: "*I was introduced to the topic in abstract form so I didn't like the topic. The teacher wrote the laws on the board for us to copy. Yes, this method has impacted me because I can now apply the laws well*" (E/PO/014); and "*before this approach, I studied it by copying and reading the notes given by the teacher. Yes, because I can now confidently solve all given logarithm questions given to me*" (E/PO/021).

Solving questions: some of the students (10.2%) mentioned that before learning logarithms with the integrated approach, learning was just solving questions given by the teacher without understanding. However, with the integrated approach, there is an understanding of learning logarithms. The excerpts are: "*I studied logarithm by solving when I see the questions there, but no properties were given. This method has changed my studying somehow and I understand*" (E/PO/018); and "*by solving it on my own. I was told the properties. Yes, I now understand the formulas* (E/PO/019).

Teacher-dominated lessons: some of the students (18.4%) mentioned that before learning logarithms with the integrated approach, students were told everything by the teacher. That is the teacher explains and works examples for students to follow. However, with the integrated approach, students understand logarithms and can apply the rules. The excerpts are: "*very poor because everything was said and done by the teacher alone. Yes, this method has helped me to apply the rule how and when to apply them*" (E/PO/022); and "*I was told to apply the indices to logarithms and how to change from logarithm to indices by our teacher. Yes, it improved my understanding such that the knowledge I got now about logarithm, it is no more difficult for me*" (E/PO/029).

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Areas Discouraging Students' Learning of Logarithms

Item 7 sought to find out some of the areas of logarithms that discourage student learning. Four subthemes were deduced upon open coding and constant comparison of the explanations given by the students. The four subthemes were properties, rules, properties and rules, and roots. The results show that the area of logarithms that discourages students most times from learning it was the rules of logarithms. This is because the majority (63.3%) of the students expressed that learning logarithms becomes a difficult and discouraging task to do as a result of the rules. The views of students on areas of logarithms that discourage learning are categorised as:

Properties: some of the students (14.3%) expressed that the area of logarithms that discourages learning was the properties. This is because students find it difficult to conceptualise the usage of the properties. The properties are identified as large in number. The excerpts are: "*the properties of logarithm were as many as the leaves of plants and could not get the understanding because it was memorised*" (E/PO/031); and "*the applications of the properties. I didn't know how and when to use them*" (E/PO/042).

Rules: some of the students (63.3%) mentioned that the area of logarithms that discourages learning the concept was the rules. This is because the rules are large in number and, the usage of the rules is difficult and confusing. The excerpts are: "*using the rules of the log was difficult. I didn't know how to approach a question and which rule to apply first or next*" (E/PO/025); and "*there were many rules which I did not have an idea when to use them. Sometimes you can get confuse*" (E/PO/044).

In another instance, the students expressed that though the rules are large in number the way teachers handle them discourages students from learning logarithms. The excerpts are: "*The use of the rules scared me. The teacher does not take his time to explain the rule instead wrote them on the board, he would continue with examples and gave us exercises to do. The teacher told us the rules if I may say so*" (E/PO/027); and "*the nature of the rules. I couldn't apply them because I didn't understand anything. The teacher writes the rules on the board and asks us to copy them into our books*" (E/PO/046).

Properties and rules: some of the students (12.2%) mentioned that the areas of logarithms that discourage learning are both the properties and rules. This is because both the properties and the rules are large in number to apply. The excerpts are: "*the properties and rules. Because they are many and I didn't know when to use which of them*" (E/PO/012); and "*the rules and properties discouraged me a lot. This is because I didn't know where to apply them*" (E/PO/047).

Concept of root: some of the students (10.2%) expressed that the area of logarithms that is discouraging to student learning was the concept of the root. This is because it often confuses students. The excerpts are: "*the root in the logarithm. I was often confused about how to handle the root when I get there*" (E/PO/018); and "*working with roots under logarithms is confusing. So that what discourages me*" (E/PO/048).

Students' Attitude towards Logarithms without the Integrated Approach

Item 8 sought to find out students' attitudes towards learning logarithms before experiencing learning the concept with the integrated approach. After open coding and constant comparison, six subthemes were deduced. The results show that students' attitudes towards logarithms before learning the concept with the integrated approach were generally negative. This is because 34.7% of the students had a negative attitude towards logarithms without the integrated approach. Students' attitudes towards learning logarithms without the integrated approach are therefore categorised as:

Negative: some of the students (34.7%) mentioned that they simply had a negative attitude towards learning logarithms without the integrated approach. The excerpts are: "*negative*" (E/PO023); "*negative* (E/PO/032); and "*in the past it was negative*" (E/PO/037).

Dislike some of the students (14.3%) expressed that they had a dislike towards the learning of logarithms without the integrated approach. The excerpts are: "*I even dislike logarithms since from day one*" (E/PO/020); and "*I didn't like it at all. Teacher always told us the rules or formula which I did not understand*" (E/PO/034).

Not enjoyable: some of the students (8.2%) mentioned that they did not enjoy learning logarithms before their experience with the integrated approach. The excerpts are: "*I didn't enjoy logarithms*" (E/PO/006); and "*It was not enjoyable; therefore, hardly will I be seen in a mathematics classroom*" (E/PO/016).

Fear: some of the students (10.2%) had an attitude of fear towards learning logarithms without the integrated approach. This attitude of fear is linked to the way teachers handle mathematics concepts. The excerpts are: "*In the past, I fear mathematics*" (E/PO/007); and "*I like mathematics but the way some of the teachers taught logarithms made me fear it*" (E/PO/026).

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Difficult: some of the students (12.2%) considered mathematics a difficult subject. This led students to distance themselves from learning mathematics. The excerpts are: "*I saw it as a very difficult subject and I blocked my mind on it*" (E/PO/012); and "*was not all that well and you don't want to learn it and that is a bad attitude. That is mathematics is difficult*" (E/PO/014).
Not encouraging: some of the students (20.4%) mentioned that it was not encouraging to learn mathematics previously. The excerpts were: "*I was not even showing interest in it. It did not encourage me to learn mathematics*" (E/PO/002); and "*There wasn't no encouraging for me when going for mathematics class"* (E/PO/015).

Students' Attitude towards Logarithms with the Integrated Approach

Item 9 sought to find out students' attitudes towards learning logarithms with the integrated approach. After open coding and constant comparison, three subthemes on students' attitudes towards learning logarithms with the integrated approach were deduced. The results show that the negative attitude of students towards learning logarithms changed to the positive end of the continuum. This, the majority (40.8%) of the students did not just describe it as just positive change but as encouraging. Students' attitudes towards learning logarithms with the integrated approach are categorised as:
Positive: some of the students (34.7%) simply developed positive attitudes towards learning logarithms with the integrated approach. The excerpts are: "*It was far more positive than before*" (E/PO/003); and "*It is now positive. I like it*" (E/PO/009).
In another instance, the students expressed that they have developed a positive attitude towards mathematics with the integrated approach. This is because they are developing an interest in learning logarithms. The excerpts are: "*It is positive as it is a buildup which involves a lot of work. It has made me sit down and I am loving it*" (E/PO/008); and "*It is now positive. I am gradually developing so much interest in the subject*" (E/PO/032).
Improving: some of the students (24.5%) mentioned that their attitude towards learning logarithms has changed and the change is an improvement as compared to the previous attitude. The excerpts are: "*My attitude towards logarithm is now improving*" (E/PO/030); and "*better than before. There is a lot of improvement over the past*" (E/PO/038).
Encouraging: some of the students (40.8%) mentioned that their attitude towards learning logarithms with the integrated approach is now encouraging. The excerpts are: "*It is simply encouraging*" (E/PO/010); and "*My attitude towards logarithms now is very encouraging*" (E/PO/020).
In another instance, the students expressed that their attitude towards learning mathematics with the integrated approach is encouraging. This is because they can confidently apply the rules and properties of logarithms. The excerpts are: "*It is encouraging. I want to be a good mathematics student apply the properties confidently*" (E/PO/017); and "*My attitude towards mathematics is now encouraging because I can now solve logarithms questions with confidence. Am happy the way the teacher taught and I like it*" (E/PO/028).

Discussion

The results from the pretest have shown that the students have difficulties in learning logarithms as reported elsewhere (Chua & Wood, 2005; Gramble, 2005; Kastberg, 2002; Sello & Percy, 2013; Weber, 2002). Indeed, the study has shown that SHS students have difficulties in responding to test items on logarithms before their experience with the integrated approach and this confirms the WAEC Chief Examiner's reports on Core Mathematics (WAEC, 2008; 2009; 2010; 2011; 2012; 2013; 2014; 2017). In some instances, where the students have less difficulty in responding to the logarithmic functions in the pretest, the students seem to be doing routine mathematical computations (Chua & Wood, 2005). Their difficulties could be attributed to a lack of conceptual and procedural knowledge of logarithms. It could also be that the students have difficulties in the pretest because the items were those that demanded from them higher levels of cognitive thinking (Chua & Wood, 2005). Students' difficulties in learning logarithms can be overcome by the use of the integrated approach. This is because there is an improvement in students' achievement in logarithms as a result of the use of an integrated approach and this supports other research works (Benek-Rivera, & Mathews, 2004; Bursal & Paznokas, 2006; Geist, 2010; Marbina, 2012) where students' performance in mathematical concepts were improved by such an intervention. The students from the experimental group overcome their learning difficulties in logarithms having experienced seven weeks of learning through the integrated approach as compared to learning logarithms through the conventional approach. This is because there is an increase in the mean achievement of the students from the experimental group and the majority of the students' scores are relatively close to each other from the distribution

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of the scores. This implies that the integrated approach can help improve the achievement of students in logarithms (Benek-Rivera, & Mathews, 2004; Bursal & Paznokas, 2006; Geist, 2010; Marbina, 2012). This difference in the achievement of students from the experimental group compared to the students from the control is not by chance but by the impact of the integrated approach. And the improvement could be attributed to the varied approaches in-built into the integrated approach as an instructional strategy (Holliday et al., 2005).

The results show that generally students show a neutral attitude towards learning logarithms (mathematics) without the integrated approach. However, in other instances, students showed either positive or negative towards the learning of mathematics. It is noted that after students' experiences with the integrated approach, they show a positive attitude towards the concept. This positive attitude of students towards learning logarithms is expressed in their expectations of learning logarithms with the integrated approach. The expectations are met and the positive attitudes are expressed in terms of student confidence level, the teacher's way of teaching, being conversant with properties of logarithms, interesting lessons, and applying properties of logarithms. The integrated approach changes the neutral attitude of students towards logarithms (mathematics) to a positive attitude which is underpinned mainly by the student's ability to apply properties of logarithms in new situations. Students can apply properties of logarithms in new situations as the integrated approach provides students with opportunities of becoming conversant and develop confidence and interest in learning logarithms (mathematics). It could be that the integrated approach is participatory as participatory instruction develops learning interest (Pain et al., 2011) and confidence in students (Adu-Gyamfi., 2020). As integrated approaches improve students' confidence and interest, teachers should use them more often to help improve students' attitudes towards mathematics. Students enter into lessons with some goals and learning logarithms are indifferent. The goals of students in learning logarithms with the integrated approach are to understand logarithms, master logarithms, confidence level, be conversant, overcome challenges, and solve logarithms. These goals are not isolated but interwoven. This is because a good mastery or understanding of logarithms would make students conversant with the concept and hence, develop the needed confidence in solving logarithmic expressions. And if students can solve logarithms, then they could be considered as having overcome their learning challenges. The integrated approach that uses varied approaches helps students to meet their learning goals (Lynch & Star, 2014). To attain a good confidence level in learning mathematical concepts learning through varied approaches (Lynch & Star, 2014) is important and the results show that the integrated approach offers students the opportunity to achieve their learning goals.

Also, students' involvement in integrated approach lessons is seen as group discussion, teacher-led discussion, student participation, question and answer session, and combined discussion and question and answer sessions. These are indeed approaches in an instructional strategy that provide students with opportunities to participate in lessons (Adu-Gyamfi et al., 2020). Approaches like discussion offer students opportunities to make meaning of concepts by learning to agree or disagree and to have mutual respect (UNESCO, 2001). The discussion approach makes the integrated approach participatory as the discussion is an essential element of participatory instruction (UNESCO, 2001). The integrated approach ensures students' participation and engagement in lessons (Lynch & Star, 2014). This is an indication that the integrated approach engages students in group work, sharing ideas to solve a given problem, which is key to students' meaning-making (Cooperstein & Kocevar, 2004) in logarithms. The approaches seen under the integrated approach further offer students feedback both from colleagues and the teacher. This feedback, which is an important aspect of student participation in the integrated approach further ensures mastery or conceptual understanding in students. The act of sharing ideas during group discussion fosters cooperation among students (Panicker, 2014) and hence, possible development of procedural knowledge and conceptual understanding. Students appreciate that the integrated approach is an instructional strategy which is characterised by its interactive, interesting, participatory, stress-free, and both interactive and friendly nature. Though the integrated approach is more of both interactive and friendly nature its nature as interesting, participatory, and stress-free cannot be ignored. This is because, in a participatory lesson, students are deeply involved, interacting among themselves (Adu-Gyamfi et al., 2020; Landcare Research, 2002) to develop a conceptual understanding of materials through sharing of ideas. As students acquire a conceptual understanding of materials in a conducive learning environment, they develop an interest in the lesson and hence, reduce the anxieties and uncertainties (stress-free) of meaning-making (Maija, 1991). These attributes students believe the integrated approach offers them as an instructional strategy.

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In addition, the results show that the integrated approach is positive or interesting. This is because the usage of an integrated approach to teaching and learning logarithms is characterised by students' interactions, students' encouragement, working together, varied approaches, and application of concepts learnt. This implies that the usage of the integrated approach offers students the opportunity to learn mathematical concepts through different instructional strategies and have the opportunity to apply the new concept taught. Using different instructional strategies allowed the teacher to match the instruction with content helping students to make meaning. Students learn under an integrated approach as the varied approaches take into consideration the learning needs of students (Fong, 1996). Students tend to interact more among themselves sharing ideas to develop conceptual understanding. And this interaction encourages students to make meaning of mathematical concepts. Learning logarithms without the integrated approach is characterised by rote learning, copying formulas and rules, solving questions, and teacher-dominated lessons. Of these attributes of learning logarithms (mathematics) without the integrated approach, students' development of conceptual understanding and procedural knowledge is purely rote learning. This implies that students would find it difficult to make meaning of materials and to apply the acquired knowledge in new situations (Hiebert & Carpenter, 1992) but reproduced without conceptual understanding. It must be noted that learning which is dominated by the teacher, only solving questions, and copying formulas and rules without conscious effort from the teacher to use appropriate instructional methods rooted in constructivist learning theories would result in rote learning (Jones & Brader-Araje, 2002).

The results show that the areas of discouragement of learning logarithms are properties, rules, combined properties and rules, and roots. Of these areas of discouragement, the rules stand out as the main area in learning logarithms. There are a lot of rules under logarithms and all these rules are very important to the concept. The rules are learnt by students through rote learning in most cases (Lach & Sakshaug, 2005) which may not enhance conceptual understanding when teacher-dominated approaches are used as an instructional strategy. Not only are the rules of logarithms many to learn the properties are also a lot and teacher-dominated instructions may not eliminate rote learning of the properties of logarithms. Aside from the rules and properties of logarithms, solving logarithmic expressions involving roots discourage students as well. The roots more often than not confuse students in solving logarithmic expressions involving roots. Before students' experiences with the integrated approach, students have negative, dislike, not enjoyable, fearful, difficult, and not encouraging attitudes towards logarithms. The negative attitude of students towards learning mathematics could be attributed to the instructional strategies adopted by teachers in mathematics lessons (Felder, 1993). This is because such instructions are teacher-dominated, which encourages rote learning and discourages deep student involvement in lessons. Students develop a 'positive' attitude towards learning logarithms (mathematics) with the integrated approach. This attitude was expressed by students as positive, improving, and encouraging. This implies that using the integrated approach as an instructional strategy develops in students a much more positive attitude towards learning mathematics. The integrated approach encourages students to learn logarithms. This is because it makes students confident in themselves (Lynch & Star, 2014). The integrated approach with its attributes of varied approaches and interactivity could be considered as an instructional strategy that positions students to develop conceptual understanding as well as procedural knowledge and its application in the new situation. The unit in charge of mathematics curriculum development should suggest integrated approaches as instructional strategies for teaching mathematics in senior high schools. This is because when an instruction offers students the opportunity of retention and applications, the students show a positive attitude towards learning (Felder, 1993).

Conclusion

The study aimed at examining whether the use of the integrated approach as an instructional strategy had a remarkable potential to improve students' academic achievements in logarithmic functions. To achieve this aim, the study adopted a quasi-experimental design to collect and compare the quantitative data of student achievement based on researchers' designed LAT items between the experimental and control groups. The findings on students' achievement on logarithms show difficulties in logarithms at the pretesting stage of the study. However, the performance of students from the experimental group in the posttest is encouraging as compared to those from the control group. The integrated approach is effective in inducing students from the experimental group to overcome their learning difficulties and negative attitude towards logarithms as compared to students from the control group. It is, therefore, recommended that mathematics educators and researchers should adopt using integrated approaches in further research on teaching and learning mathematics to encourage teachers to integrated approaches in teaching.

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Recommendation

1. The implementation of the integrated approach and the conventional approach to teaching logarithmic functions were carried out by the researchers, and the suspicion of deliberate bias cannot be completely overruled even though frantic efforts were made to eradicate it.
2. Additionally, the scale of this study was found to be relatively small to the extent that making inferences about the general population may be defective.
3. Furthermore, we the researchers hold the view that even though this pretest-posttest quasi-experimental study has affirmed the positive effect of the integrated approach to teaching logarithms, this design is not very robust enough compared to other designs. We, therefore, advocate for use of design-based research and factorial designs.

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Cite this article as:
Ndamenenu, D.K., Agyei, D.D., Kenneth, A., & Taley, I.B. (2023). Improving senior high school student academic achievement and attitude towards logarithmic function. *FNAS Journal of Mathematics and Science Education, 4*(1), 48-63.
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