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Comparing the effectiveness of differentiated instruction versus conventional (traditional) instruction on the performance of grade 8 integrated science students at a secondary school in region 6, Guyana: A preliminary study

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Abstract
This study compares students' performance using two different instructional methods, the old-fashioned conventional method and the differentiated method in the classroom. The aim was to compare the performance level using the two instructional methods at a particular secondary school in Region 6, Guyana, and to determine whether there was a significant difference between the two methods of teaching and the student's performance. A total of 40 students were selected from two Grade 8 classes. Twenty students were selected from one Grade 8 class as the control group and were taught via the traditional instructional method. Another group of twenty students was selected from another Grade 8 class to be the experimental group and were taught using differentiated instructional methods. Students from both groups were being taught three Integrated science lessons, after which a test containing 30 items on all three domains of Bloom's taxonomy was given to both groups of students. A T-test was used to compare the means of student performance between the two groups, and a P-value of less than 0.05 was considered significant. The results from this study showed that an average of 9.8 students passed the test, representing an average percent of 49.0 for the control group, and an average of 10.7 students passed the test, representing an average percent of 53.5 for the experimental group. The experimental group performed better than the control group, but the difference was not significant in the current sample size.

Keywords: Differentiated instruction, conventional instruction, integrated science, secondary school, performance, Guyana

Introductions

Traditional and Differentiated Instructions in the Classroom

Every classroom has a variety of learners, who differ in learning styles, personal experiences, readiness levels, motivators, interests, and prior educational experiences. Over the years, teachers near and far have continued to rely on conventional teaching, often called traditional teaching, whereby each student is expected to learn at the same pace and time given the same materials.

The researchers and relatively new teachers, who taught Integrated Science in the Grade 8 level at Secondary School A, noticed that students' performance in the subject area was very poor. In the past, teachers tried to remedy this situation by providing more hands-on activities and assessments, but results have not changed regardless of this. This could be a result of many issues, one of which could be the teaching method employed by the teacher since individualized attention was not granted to a student. Thus, they were treated as an entire body. To combat this problem (poor performance), a new method (differentiated instructions) was employed by the teacher to investigate the area that needed to be enhanced to increase students' performance. It was expected that this method would not only benefit the students but also aid teachers in planning a curriculum that allowed them to cater to the needs of all students in their classroom.

Traditional teaching methods were based on a model in which the teacher delivered instruction, typically through lectures, and then models the skill, often on a blackboard.

When the teacher stops modelling the lesson, she gave the student practice work, usually in the workbook and later reviewed the student's work and provided feedback of the class performance in the form of a grade [24].

It was apparent that, in a traditional classroom a relatively narrow sense of intelligence prevailed and coverage of curriculum guides drove the instructions while in a differentiated classroom, student readiness, interest, and learning profile shaped instruction and so, many instructional arrangements were used [44].

Udovic *et al.* (n.d.) stated "Traditional teaching approaches are generally teacher-directed and follow a cookbook of steps of activities and demonstrations. This approach may not provide students with valuable skills or even with a body of knowledge that lasts much beyond the term". Differentiated instructions will not only meet the needs of each student but will give students a sense of assurance that they are learning equally to their peers in their classroom who are considered the high flyers.

Huebner defined differentiated instruction as "a process to approach teaching and learning for students of differing abilities in the same class. The intent she said, "Is to maximize each student's growth and individual success by meeting each student where he or she is, rather than expecting students to modify themselves for the curriculum" [19].

"The biggest mistake of past centuries in teaching has been to treat all children as if they were variants of the same individual and thus feel justified in teaching them all the same subjects in the same way" Gardner [36]. In Gardner's view, the dominant formal IQ test only measures one type of intelligence, yet humans can excel in multiple areas of intelligence.

Each student is distinct, they have different needs. Presently conformity rather than addressing diversity is the norm in many classrooms since very few teachers are willing to make accommodations for these variances in their teaching style [39]. A pattern of failure is created for certain students by the traditional methods that teachers employ, which frequently center on identifying and correcting deficiencies. It follows that the usage of lessons that are taught at a set pace using a single teaching strategy ignores the various learning interests and styles that are present in every classroom [39].

Tomlinson (2005), defines differentiation instruction as a "philosophy of teaching that is based on the premise that students learn best when their teachers accommodate the differences in their readiness levels, interests and learning profiles".

Students' improvement from a pre-test to a post-test in an experiment group was compared. It was found that the largest percentage of students that was instructed with mathematics using differentiation performed better in the post-test than pre-test than those taught using a conventional instructional approach. From this, they concluded that "differentiated instruction is a promising approach for supporting the diverse needs of all students for it consistently had positively affected student achievement" [29].

Similarly, Stavroula *et al.* (2011) [38], did a quantitative data analysis, which indicated a statistically significant difference between students' achievement taught by differentiated instruction and students who did not received differentiated instruction. Although the effect size for both tests was fairly small, she said "these results were to some extent expected".

In addition, Gamble (2011) [13], conducted a study to determine whether differentiated instruction via Mathematics out of Box (MOOT) had a significant effect on mathematics achievement. While there were no significant differences in MAP post-test results for instructional type, it was found that there was growth in each group, however, there was a significant difference in students' attitude toward mathematics relative to enjoyment. Thus, the differentiated group enjoyed mathematics more than the traditional group because students were allowed to interact with each other, becoming active participants while being able to retain ideas and concepts.

Based on the reviews and results obtained, it was evident that differentiated instruction played a pivotal role in meeting each student in a classroom, both academically and socially. As science teachers who had a keen interest in this mode of teaching, the researchers were becoming more convinced that this method may be what is necessary to foster growth in the classroom setting. The research question that guided this study was: Is there a significant difference between the performances of Grade 8 students who are taught using differentiated instruction as against conventional classroom teaching?

In summary, differentiated instruction is considered the best mode of teaching and this was outlined by numerous sources whose class performance along with student's attitudes towards the subject area improved. This was not only the case for science but also mathematics, thus differentiated instruction can be a substitute teaching method in all subject areas.

Science is and may continue to be a difficult area to study in school, and since everyone does not learn the same way, and teachers continue to teach based on tradition, the failure rate will continue to rise yearly. A change in teaching method may be the only hope for teachers and hence students. This study looked at differentiated instruction as a means of savior for many students and teachers who have an added interest in functioning to the best of their ability.

Tomlinson (2005), defines differentiated instruction as a "philosophy of teaching that is based on the premise that students learn best when their teachers accommodate the differences in their readiness levels, interests and learning profiles". It is hypothesized that "there is a statically significant relationship between students who are taught Integrated Science using differentiated instructions and conventional classroom instruction". This hypothesis will be retained or rejected depending on the mean difference obtained. The study presented in this article is mainly an effort to put differentiation in practice, thus meeting the needs of all students and gaining better results in the subject area under study.

Science has continued to be the weakest and by far, the most challenging area of academics. Students who can cope will continue to do so while others might become frustrated and continue to flunk the subject area. To alleviate this problem, differentiated instructions might be the only hope. Differentiated instruction was not only applicable to the teaching of Integrated Science but across the board, whereby students would be challenged academically to meet their educational needs. It was also feasible since the needs of each student could be catered for, thus rather than setting the curriculum to meet the standards of the class, it was set in such a way, to meet the academic demands of each student. Thus, although differentiated instruction might take extra time and effort, it would have a positive impact on student learning.

The general aim of this study was to compare the performance of Grade 8 students who were taught Integrated Science using traditional methods against differentiated learning methods. The specific objectives of this research are: (1) to determine whether there was a significant difference between the methods (conventional vs differentiated) taught and the student's performance outcome. (2) To compare the performance level using the conventional and differentiated methods. (3) To identify the best teaching method (conventional or differentiated) to apply in the classroom.

The hypotheses that guide this study are

Null Hypothesis

(H_0): There is no statistically significant difference between the performance of Grade 8 students who are taught Integrated Science using differentiated instruction and conventional classroom instruction.

Alternative Hypothesis

(H_1): There is a statistically significant difference between the performance of Grade 8 students who are taught Integrated Science using differentiated instruction and conventional classroom instruction.

Methodology

Research Design

The research design chosen for this study was the Quasi-experimental pretest and posttest design. This was the preferred method because it allowed a comparison to be made between participant groups, and it also measured the degree of change that occurred as a result of the treatments (differentiated teaching methods). Two groups were assessed, one group was taught via differentiated instruction and the results were gathered at the end while the control group received teaching via the conventional (traditional) methods over the same period but participated in the same test.

This strategy had the benefit of enabling the researcher to compare the two groups' final post-test results, which allowed them to gauge the treatment's overall efficacy. The researcher was also able to observe how the two groups developed from the pre-test to the post-test and determine if one, both, or neither group became better over time. The primary issue with the design, however, was that it sacrificed external validity to increase internal validity. As a result, there was no baseline measurement to compare the results to groups that received no treatment at all, making it impossible to determine whether the pre-testing procedure had any real impact on the outcomes.

Description of Sample

The sample for this research consisted of 40 students from 2 Grade 8 classes at Secondary School A. Each class contained 20 students who performed poorly in Integrated Science over the years. The Grade 8 level contained 4 classes. The classes utilized in this study were randomly selected. The name of each class was written on a piece of paper, folded, and inserted into a bag. Two papers were identified and placed on a table, face down. Without opening the papers, the researcher identified the control and experimental group. When this was completed, the papers were opened to identify the classes that would undergo treatment along with the type of treatment that would have been issued to them. The classes chosen were also heterogeneous and had mixed abilities and a variety of ethnicities and cultural backgrounds.

Instrumentation

Tests were the instruments used in this study. Three sub-topics were identified under the general topic from the Grade 8 termly scheme which was guided by the Grade 8 consolidated curriculum guide. A table of specifications was drawn up with the topics to be tested along with the skills to be assessed. The skills that were assessed were identified from the cognitive domain of Bloom's Taxonomy, this included knowledge, comprehension, and application. It was projected that a total of 10 questions were to be selected from each topic. The 10 questions included; 3 knowledge, 4 comprehensions, and 3 application types. Thus, each topic had an equal weight of 33.3%., totaling up to 99.9%. With the use of this plan, a total of 30 multiple-choice items were constructed, in order from simple to complex (application knowledge). This ensured the accuracy, balance, and reliability of the test. This pre and post-test were further administered to the students before and after the treatment (teaching method used) to assess their performance.

Reliability of Instrument

A multiple choice or objective type test was compiled containing 30 questions that tested three skills of the cognitive domain of Bloom's taxonomy. These skills were knowledge, comprehension, and application. 30 questions were chosen because a longer test is more reliable than a shorter test, as whatever random fluctuations in the performance occurred throughout the test would have canceled itself out across many items. Reliability was also ensured by choosing 3 different topics rather than just having one.

In addition, an objective type of test catered for fewer random errors in the scoring as the researcher would have objectively scored the test. This type of test was chosen to maintain consistency in the grading of students; thus, a standard mark sheet was prepared and so, regardless of the amount of time the test was taken, there would not have been a change in the student's performance as a stem was prepared along with four options so students had to identify the answer of their choice by simply circling the letter attached to the option.

Description of procedures for data collection

A pilot test was conducted with students of the Grade 9 level since they would have covered these contents when they were Grade 8 students. The Grade 9 level consists of a population of 107 students distributed across 6 classes (Grades 9 A-F). A total of 80 Grade 9 students were selected at random to answer the test items on Parallel Papers A and B. 40 students were given Parallel Paper A to answer and 40 students were given Parallel Paper B to answer. The responses on the papers were marked and the results were tabulated using Microsoft Excel and the total scores attained by each student were recorded. The number of students who scored the correct responses on the test items was also totaled using Microsoft Excel. A total of 32 papers were selected from the pilot student; 16 from paper A and 16 from paper B (8 students who scored the highest and 8 students who scored the lowest for both papers A and B). The reliability and Kuder-Richardson Reliability Coefficients (KR21) of the test items were subjected to an item analysis and calculated using Microsoft Excel. The effective items were then selected by comparing the values of the facility (F) and discrimination (D) indices to compose the paper C which was utilized for the pre-test and post-test for the Grade 8 students. According to Hulin *et al.* (2001) [21] and Ursachi *et al.* (2015) [46], a value of 0.6-0.7 indicates an acceptable level of reliability and 0.8 or greater, a very good level.'

Two Grade 8 classes that the teacher taught were randomly selected, each class contained 20 students. One class was chosen as the control and so was taught by the researcher using conventional (traditional) instructions while the other class was the experimental group and was also taught by the researcher using differentiated instructions guided by lesson plans. Both classes were given a pre-test prior to teaching three lessons**.** Each class was taught 3 lessons; this was enough time (not too short or long) to avoid a simple recall of the test items or a change in the student's behavior which would have been biased to the study. The students were taught by their teacher so they were unaware of the experimentation.

Based on the results from the pre-test, the students in the differentiated classroom were grouped. This was done to foster group thinking; thus, students were grouped based on the range they scored in. Grouping was also done so that students who showed a readiness level could be placed to work together, while those who had an interest in a particular area were also grouped and the final grouping was those students that had a specific learning profile, i.e. how the students processed information. Activities such as cubing, exit cards, menus, worksheets, and flashcards were used. Each material contained commands that were allotted to each group of students in the class. The students were allowed to carry out the command allotted to them in the time frame as the students that were taught using conventional methods.

After administering the pre-test, the results were recorded. Both groups were taught 3 lessons each; the conventional group was taught 3 lessons using conventional teaching methods while the experimental group was taught 3 lessons using differentiated instructions. Following this, a post-test was administered to both classes to compare the differences in performance. The same test was administered to both classes on the same day and they were required to work within the time frame of 45 minutes. Furthermore, the pre-test and post-test were treated as a normal test that is administered to students.

All data analysis will be done using Microsoft Excel software and IBM SPSS (Statistical Package for the Social Sciences) version 23.0 software.

Results & Discussion

Presentation of Data and Analysis

Table 1: Students performance for the experimental and control groups.

Item #	Experiment Group - No. of students passed	Control Group - No. of students passed	Experiment Group- % Passed	Control Group- % Passed
1	16	10	80	50
2	19	10	95	50
3	03	12	15	60
4	09	08	45	40
5	05	03	25	15
6	19	12	95	60
7	12	14	60	70
8	10	05	50	25
9	02	04	10	20
10	13	12	65	60
11	12	13	60	65
12	15	18	75	90
13	01	04	05	20
14	14	11	70	55
15	02	03	10	15
16	05	00	25	00
17	08	11	40	55
18	07	04	35	20
19	02	03	10	15
20	10	11	50	55
21	20	15	100	75
22	17	14	85	70
23	08	08	40	40
24	16	11	80	55
25	11	10	55	50
26	10	11	50	55
27	08	08	40	40
28	10	16	50	80
29	19	17	95	85
30	18	16	90	80
Mean	10.7	9.8	53.5	49

Three (3) skills belonging to the cognitive domain of Bloom's taxonomy were assessed in this study namely knowledge, comprehension, and application. Overall, it was evident that the students from the experimental group outperformed those from the control group in all the skills that were tested (Table 1). The skill that received the most attention was application; this was highlighted for both groups as the percentage passed was at its highest, between questions 22-30. This was in contrast to the knowledge that required simple recall; however, students barely performed in this area- questions 1-9; this was also highlighted for both groups. Comprehension which included questions 10-21 was placed in the middle of knowledge and application and thus it received the second highest pass rate in both the experimental and control group. In the experimental group, the highest percentage pass (100%) pass was at question 21, a comprehension question while the smallest percentage (10%) pass was at question 9, which tested the skill of knowledge. The control group had the largest percentage (80%) pass at question 12 while the smallest percentage (0%) was at question 16, both of which were comprehension questions. The results from Table 1 further showed that an average of 9.8 students passed the test, representing an average percent of 49.0 for the control group, and an average of 10.7 students passed the test, representing an average percent of 53.5 for the experimental group.

Table 2: Mean scores and mean learning gains from the pre and post-test for the experimental and control groups.

Pre-Test	No. of Students	Mean Score	Mean Gain
Experimental Group	20	12.6	
Control Group	20	12.4	0.2
Post Test			
Experimental Group	20	16.1	
Control Group	20	14.5	1.6

The results of Table 2 indicated that the students who were subjected to teaching by the differentiated method performed better than those who were taught using conventional teaching methods. This was outlined in the difference of mean as; the experiment group succeeded that of the control group. However, the difference in performance was not very large for both the pre and post-test of both groups. Thus, the mean gain from the pre-test was 0.2 while that of the post-test was 1.6; this highlighted a mean increase of 1.2 from the pre- to post-test.

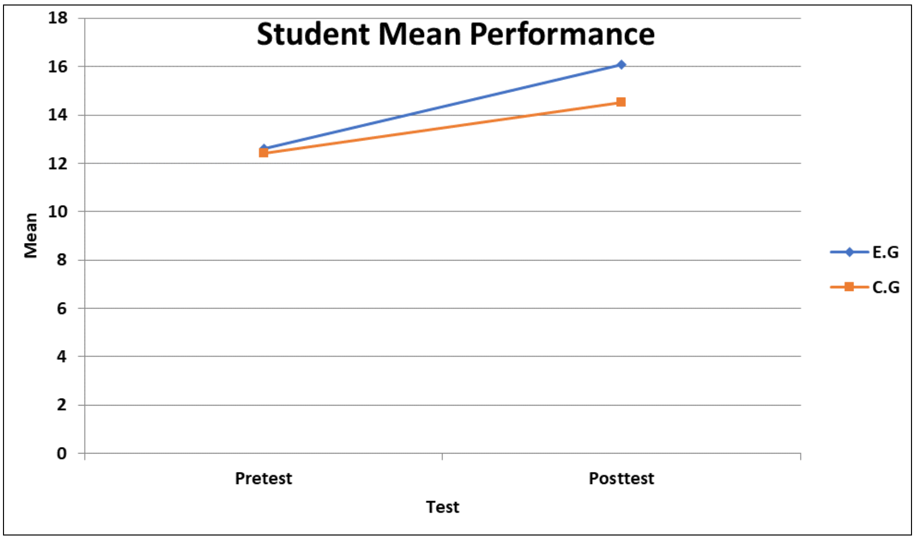

Fig 1: Student mean performance in the control and experimental group

E.G- Experimental group C.G - Control group

Figure 1. outlined the comparison of the mean performance of students in the experimental and control groups. It is observed that in the pre-test the means of the two are relatively close indicating equivalence between the two groups. However, in the post-test, the experimental group succeeded that of the control group but the difference was not large.

Table 3: T-test of Post-test results from Exposure of Students to Differentiated Instructions and Conventional Classroom Teaching

Group	Number of Students	Mean	Standard Deviation (SD)	t-value	Degrees of freedom (d.f)	p-value
Experimental Group	20	16.1	3.059	1.520	38	0.05
Control Group	20	14.5	3.576			

Table 3 highlights the t-test results obtained from the post-test of the experimental and control group. In the experimental group, it was evident that the scores obtained by the students were closer to the mean than those of the control group. This was accounted for by the small standard deviation figure obtained; the experimental group had a standard deviation of 3.059 while the control group had a of 3.576. Although the difference between the figures was relatively small, the scores of the control group were more scattered than those of the experimental group. A t-value of 1.520 was obtained and d.f of 38 was calculated both manually and using Microsoft Excel and SPSS Version 23 software. The alpha level (value) taken was 0.05 and since the t-value was less than the critical value identified for the t-test, it was said to be not significant.

Table 1 highlighted the number of students along with the percentage pass for each item. It was observed that students from both the control and experimental groups performed better in questions 22-30. These were all application-type questions and so required the students to apply necessary skills in deducing the answer. This was in contrast to questions 1-9 which received little attention from students, as they failed to pinpoint the correct answers for most of the questions. All of these questions were knowledge questions that required the students to simply recall what was taught to them.

This difference in response to identifying the correct answer in the lower order domain may be a result of many factors which may include students' inability to recall content taught since they are at the stage where abstract thinking played a key role in their development and so they were more equipped to handle such questions. Another important factor that was taken into consideration was item difficulty, where application-type questions had a low difficulty value as compared to the knowledge questions. This may have been due to numerous reasons such as the knowledge item probably being too challenging relative to the overall ability of the class or the item may have not been written correctly.

Questions 10-21, were in between the results obtained and they were all comprehension questions. The number of responses along with the percentage pass was somewhat spread out, thus there was no consistency in the responses gathered for each question. Furthermore, in this domain, the highest and lowest percentage for particular test items was identified. Question 16 in the control group received the lowest percentage (0%) which indicated no student got the correct answer. On the other hand, for question 21, all the students (100%) for the experimental group obtained the correct answer. This indicated an item difficulty of one (1) along with a discrimination index of zero (0).

In Table 2, the mean scores along with the mean gains were identified. For both the pre-test and post-test the experimental group received a larger mean. The mean obtained for the pre-test of the experimental group was 12. 6 while that of the control group was 12.4. This accounted for a mean gain of 0.2 between the groups. The post-test of the experimental group later received a mean of 16.1 while that of the control was 14.5, a mean gain of 1.6. Overall, this increase was attributable to the increase in performance shown by the students of the experimental group. It was expected that the students who took part in the differentiated instruction would have performed better than those from the conventional classroom, based on the results of the mean; it was evident that this was through even though the performance difference was not large.

In addition, in Table 3, the post-test means along with the standard deviation of both the experimental and control group were taken into consideration. As was pointed out in Table 4.2, the experimental group had a larger mean than the control group; however, it had a smaller standard deviation. This smaller standard deviation indicated that the scores obtained by the students were closer to the mean; this is in contrast to the control group which had a larger standard deviation. This suggested that the scores obtained here were more scattered around the mean, some were high while others were low, and thus there was no consistency.

An alpha value of 0.05 was calculated both manually and using Microsoft Excel and SPSS Version 23 and chosen and a t-test was generated, the t-value (1.520) obtained was smaller than the critical value (1.6871) identified on the table of significance for the degree of freedom. When comparing the calculated values an equal variance is assumed; there is no difference between the groups. Utilizing the 95% confidence interval and comparing the values of the lower bound (-0.530 & -0.532) to the alpha value (0.05), the null hypothesis was retained. Additionally, since the t-value was smaller than the critical value identified, it was concluded that the difference between the means was not significant. This result agreed with that of the null hypothesis which stated that "there is no statistically significant relationship between Grade 8 students who are taught Integrated Science using differentiated instruction and conventional classroom instructions". Thus, the null hypothesis was retained rather than rejected. This indicated that there was no relationship in the population and that the relationship in the sample may have been due to sampling error or the difference observed: "occurred by chance". Although the calculated mean of the post-test showed that the experimental group performed better than the control group, statistical analysis by the T-test showed that there was no statistical difference between the two groups.

A Canadian study by Bennett and Rolheiser in 2001 [8] compared the use of differentiated instruction and traditional methods in high school classrooms. The results indicated that differentiated instruction not only improved academic performance but also fostered a more positive classroom environment, with students expressing higher satisfaction. This study concluded that differentiated instruction improves both academic performance and classroom climate, making it a more effective approach than traditional methods. In 2001 [41], a study by Tomlinson, a pioneer of differentiated instruction, emphasized the importance of tailoring instruction to meet the diverse needs of learners in the classroom. Tomlinson suggests that differentiated instruction can improve student performance by providing multiple pathways for learning. The study revealed that students in differentiated classrooms showed higher levels of engagement and achievement, particularly in reading and mathematics. The study concluded that differentiated instruction leads to improved student performance by addressing individual needs and promoting engagement.

In 2002 [3], a study in the United Kingdom by Ainscow and Miles explored how differentiated instruction supports inclusive education. The findings indicated that differentiated instruction was highly effective in promoting academic success among students with a wide range of abilities, including those with special educational needs. This study concluded that differentiated instruction promotes inclusivity and academic success among students with diverse learning needs. Hall and Strangman (2003) [16] investigated the effects of differentiated instruction on students with learning disabilities in a middle school setting. The authors found that differentiated instruction strategies, such as flexible grouping and scaffolding, allowed students to better access the curriculum and perform at higher levels compared to traditional methods. This study concluded that differentiated instruction improves the academic performance of students with learning disabilities, particularly when instructional methods are adapted to their needs. Nell and McArthur's study in 2004 [30] investigated the effect of differentiated instruction in reading instruction for elementary students. They found that differentiated instruction led to improved reading fluency and comprehension scores when compared to students who received traditional instruction. This study further concluded that differentiated instruction enhances reading performance by improving fluency and comprehension in elementary students.

McCarthy's study in 2005 [26] focuses on the impact of differentiated instruction on high school students in the United States. The findings show that differentiated instruction significantly improved student performance in both standardized tests and classroom assessments, especially for low-achieving students. The study concluded that differentiated instruction is particularly effective in boosting the performance of low-achieving students in secondary education. Sullivan's study in 2005 [40] focused on the impact of differentiated instruction on the motivation of secondary students in English language arts classrooms. The findings indicated that students in differentiated instruction classrooms were more engaged and motivated, which positively impacted their performance on assignments and tests. This study concluded that differentiated instruction increases student motivation and engagement, leading to improved academic performance. In 2005 [35], Roehler and Dugger's research analyzed the impact of differentiated instruction in the context of science education. Their study found that differentiated instruction allowed for greater differentiation of content and learning activities, leading to improved student outcomes in both knowledge retention and problem-solving tasks. The study concluded that differentiated instruction enhances students' understanding of scientific concepts and their ability to apply knowledge to problem-solving tasks.

A study by Lopes and Rodrigues in 2007 [25] compared the effectiveness of differentiated instruction and traditional instruction in teaching mathematics to middle school students in Portugal. The results suggest that differentiated instruction led to higher student achievement and increased motivation, while traditional methods did not show significant improvements. The conclusions of this study revealed that differentiated instruction enhances student achievement and motivation in mathematics education. In 2008[7], Bender explored the use of differentiated instruction in inclusive classrooms, particularly for students with learning disabilities. The study concluded that differentiated instruction was highly effective in improving the performance of students with disabilities, particularly in reading and mathematics. Miller and Hickman (2008) [27] conducted a study to explore how differentiated instruction affects student performance in reading comprehension. The study revealed that students who received differentiated reading instruction performed better in comprehension tests compared to those who received conventional instruction. This study concluded that differentiated instruction improves reading comprehension and student performance, particularly in reading-intensive subjects. Murphy and McKinnon in 2008 [28] evaluated the effects of differentiated instruction on student achievement in high school social studies classrooms. The authors found that students in differentiated instruction classrooms performed significantly better on both unit tests and final exams compared to those in traditional classrooms. The study concluded that differentiated instruction leads to better performance in social studies classrooms, particularly in assessments.

A study by Deunk and Elbers in 2010 [11] compared the outcomes of differentiated instruction versus traditional teaching methods in science classrooms. The results demonstrated that differentiated instruction contributed to better understanding and retention of scientific concepts, with students in differentiated instruction classrooms scoring higher on post-tests than those in traditional settings. The conclusion of this study revealed that differentiated instruction results in better comprehension and retention of scientific concepts, thus improving student performance. Guskey and Bailey (2010) [15] examined the effectiveness of differentiated instruction in social studies classrooms. The findings revealed that differentiated instruction led to better performance, particularly for students who were previously underperforming in traditional settings. The authors concluded that differentiated instruction improves performance in social studies, especially for students who struggle in traditional classrooms. Ware and White's study in 2010 [50] focused on the long-term impact of differentiated instruction on student achievement in middle schools. The authors concluded that differentiated instruction had a lasting effect on students' performance, particularly in writing and mathematics, and that the benefits were sustained over multiple years.

Research by Hockett and Udall (2011) [18] compared student outcomes in elementary classrooms using differentiated instruction versus traditional methods. The findings revealed that differentiated instruction students performed better in writing and mathematics assessments, demonstrating the positive impact of differentiated teaching on academic achievement. The conclusion of this study showed improved student performance in core subjects such as writing and mathematics. In 2011 [20], a study by Hughes and Bailey focused on the effect of differentiated instruction on students' critical thinking skills. The study concluded that students exposed to differentiated instruction were better able to analyze and evaluate information, demonstrating improved performance in critical thinking tasks compared to students who received traditional instruction. This study concluded that differentiated instruction enhances students' critical thinking abilities and overall academic performance. Research by VanTassel-Baska and Brown (2011) [49] focused on the application of differentiated instruction in gifted education. The study concluded that differentiated instruction strategies effectively support the academic growth of gifted students, enabling them to perform at higher levels in both individual and group tasks.

Jordan and Piattoeva, (2012) [22] in Finland evaluated the effectiveness of differentiated instruction in early childhood education. The findings showed that children who received differentiated instruction demonstrated greater social and cognitive development compared to their peers who received traditional, undifferentiated instruction. This study concluded that early childhood education significantly improves cognitive and social development, leading to better student performance. A comprehensive study was conducted by Tomlinson and Imbeau in 2013 on differentiated instruction in diverse classrooms highlighting its positive impact on student performance across various subjects. It was found that differentiated instruction, when implemented effectively, allowed students from diverse backgrounds and ability levels to achieve at higher levels than in traditional classrooms. This study concluded that differentiated instruction is particularly effective in diverse classrooms, improving overall student achievement.

A study by Altintas and Özdemir (2015) [32] evaluated a newly developed differentiation approach and found that it positively impacted student achievement, demonstrating the potential benefits of innovative differentiated instruction strategies. Consequently, Özdemir and Altintas (2015) [32] investigated teachers' opinions on a new differentiation approach. The study found that teachers perceived differentiated instruction positively, and its implementation led to improved student outcomes, emphasizing the importance of teacher perspectives in differentiated instruction effectiveness. Goddard *et al.* (2015) [14] explored the effects of differentiated instruction-related school norms and teaching practices on students' academic achievement in mathematics and reading. The results showed that differentiated instruction practices had significantly positive effects on student achievement, underscoring the importance of school culture in implementing effective differentiated instruction. A study by Valiandes (2015) [47] assessed the impact of differentiated instruction on student progress and found that differentiated teaching approaches positively affected students' academic development, emphasizing the effectiveness of differentiated instruction in promoting student learning. In 2017 [5], Altemueller and Lindquist explored flipped classroom instruction for inclusive learning and found that it facilitated differentiated learning experiences, leading to improved student outcomes, and emphasizing the adaptability of differentiated instruction strategies.

Adeniji *et al.* (2018) [1] examined the effect of mastery learning, a form of differentiated instruction, on students' performance and retention in geometry. The findings indicated that mastery learning positively affected student achievement and retention, supporting the efficacy of differentiated instruction strategies in mathematics education. A review by Akçayir and Akçayir (2018) [2] analyzed the advantages and challenges of the flipped classroom model, a differentiated instruction strategy, and found that it positively impacted student engagement and learning outcomes, highlighting the potential of innovative differentiated instruction methods. In 2018 [12], Deunk *et al.* conducted a meta-analysis of 21 studies, this research identified a small positive effect of differentiated instruction on primary students' academic achievement. However, when differentiated instruction was operationalized solely through grouping strategies, no significant effect was observed, indicating the importance of comprehensive differentiated instruction approaches.

Smale-Jacobse *et al.* (2019) [37] conducted a systematic review that analyzed 12 empirical studies on differentiated instruction in secondary education. The findings indicated small to moderate positive effects of differentiated instruction on student achievement, with effect sizes ranging from d = +0.509 to +0.741. The study highlighted the variability in differentiated instruction implementation and the need for more rigorous research. A study by van Munster *et al.* (2019) [48] investigated how differentiated instruction affected students' motivation and engagement in science education. The researchers found that students exposed to differentiated instruction demonstrated higher motivation levels and increased engagement in learning tasks compared to those in conventional instruction settings. The study emphasized the role of differentiated instruction in fostering student-centered learning and suggested that differentiated instruction could be an effective tool in science education when properly implemented.

In 2020 [23], a study by Kulakow compared the competency-based differentiated instruction learning approaches to traditional methods. The study revealed that students engaged in differentiated instruction reported higher levels of academic self-concept, highlighting the benefits of differentiated instruction on students' perceptions of their academic abilities. A longitudinal study was conducted by Nusser and Gehrer (2020) [31] where the researchers examined the impact of differentiated instruction on secondary students' German competence development. The findings indicated a positive development in students' competencies; however, this could not be directly attributed to teachers' use of differentiated instruction, suggesting that other factors may also play a role. Puzio *et al.* (2020) [34] examined the impact of differentiated literacy instruction and found that differentiated instruction positively influenced students' literacy outcomes, supporting the effectiveness of differentiated instruction in enhancing specific academic skills. Alnahdi *et al.* in 2021 [4] investigated the impact of differentiated instruction on students' well-being, social inclusion, and academic self-concept. This study found that differentiated instruction positively influenced these non-academic outcomes, suggesting that differentiated instruction supports holistic student development beyond academic achievement. A study by Tomlinson and Murphy (2021) [28] provided an extensive review of differentiated instruction strategies and their implementation in K-12 classrooms. The researchers found that differentiated instruction significantly improved student learning outcomes, particularly for students with diverse learning needs. The study concluded that successful differentiated instruction implementation depended on teachers' professional development, access to resources, and institutional support.

In 2022 [10], Chen and Hsu conducted a case study examining the effects of flipped learning and adaptive instruction on student learning outcomes in a computer programming course. The findings indicated that these differentiated instruction strategies improved student performance, suggesting the effectiveness of differentiated instruction in technical subjects. Peters *et al.* (2022) [33] investigated the effects of providing teachers with tools for implementing assessment-based differentiated reading instruction in second grade. The study found that such support led to improved student reading outcomes, highlighting the role of teacher resources in effective differentiated instruction implementation. In 2023, Bi *et al.* investigated variables influencing teachers' practice of differentiated instruction in Chinese classrooms. The study found that teacher beliefs and knowledge significantly affected differentiated instruction implementation, which in turn impacted student learning outcomes, highlighting the role of teacher factors in differentiated instruction effectiveness. Colbert *et al.* (2023) explored differentiated instruction as a framework for meeting the needs of diverse adult learners in health professions education. The findings suggested that differentiated instruction strategies enhanced learner engagement and performance, indicating the applicability of differentiated instruction across educational contexts. Rahman *et al.* in 2024 conducted a quasi-experimental study comparing differentiated instruction and conventional instruction in secondary mathematics education. The findings revealed that students who received differentiated instruction performed significantly better in problem-solving and critical-thinking tasks than those taught using traditional methods. The study highlighted the importance of tailoring instruction to individual student needs to enhance academic performance.

Conclusion

The research question of this study asked "Is there a significant difference between the performances of Grade 8 students who are taught using differentiated instruction as against conventional classroom instruction?". Results obtained indicated that there was a difference between students' performance in both groups; this was outlined by the mean obtained for both groups. For the experimental group, the students' scores were closer to the mean as compared to the control group where the scores were more scattered. However, although this difference was evident, it was not significant and thus the null hypothesis was retained because there was no significant relationship between the performances of each group tested and the difference obtained could have been by chance or sampling error.

Limitations

The results and conclusions of this study would have been limited depending on the following:

1. Resources available: differentiated instructions required teacher-made activities and materials that are very costly to attain and so what was available had to be utilized.
2. Time was too short to do the research and so the effectiveness of the instruction was not completely guaranteed.
3. The curriculum does not cater for this type of instruction and so as a teacher, it could be very frustrating to teach using the method when it was expected for you to finish the content in a specified time.
4. Students may have taken a while to get accustomed to the new concept as they were in that state where conventional (traditional) teaching was the only method they could relate to.
5. A small sample size was used and may have contributed to the result achieved in this study.

Recommendations

It has been recommended that differentiated instruction be used for science and all other disciplined instruction based on the results and conclusions of this study. A thorough reorganization of the curriculum and an assessment of the scientific education goals are necessary to provide differentiated instruction across a range of subject areas. This resulted from the differentiated education approach's beneficial effects on students' science achievement.

Differentiated instruction should be incorporated into science curriculum development and taught by science teachers during their training. This means that teacher education institutes should create and offer pre-service and in-service programs that incorporate differentiated instruction. It is also necessary to conduct professional development and training programs for differentiated education, which call for a coordinated effort from all parties involved, including teachers, administrators, and school authorities.

The learning process and student achievement can be improved by implementing differentiated instruction based on the key element of successful differentiated teaching, as demonstrated by the current study. Although we know that differentiation is a proposal for attaining effectiveness for all children, it is not a simple solution to ineffectiveness. Based on the evidence of the research presented, differentiation is practical, efficient, and required to promote the quality and equality dimensions of effectiveness. Subsequently, more study is needed to ascertain the efficacy of differentiation over time, for all students, in various educational levels (primary and secondary), and across subjects through longitudinal studies (Stavroula *et al.*, 2011) [38]. This study should be repeated utilizing a larger sample size, incorporating more lessons over a longer period.

Compliance with ethical standards

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Statement of ethical approval: Prior to piloting of the parallel papers A and B, a permission letter of request to conduct research was sent to the Deputy Dean of the Faculty of the Faculty of Education and Humanities at the University of Guyana. Permission was then granted by the Chief Education Officer (CEO) of the Ministry of Education (MOE) in a formal letter of permission which was taken to the Regional Educational Officer (REO) of Region 6 to be endorsed. The letter was then taken to the school selected for this study before the research process was conducted.

Student participants were not required to state any identifying information such as their names, signatures, contact numbers, or any information that can be used to trace back to the student who participated in the pilot study and answered questions from the parallel papers A and B as well as the paper C that was answered for the pre-test and post-test. The school that was used to conduct this research were not identified but were designated as Secondary School A throughout this research.

Disclosure of conflict of interest

The authors hereby declare that this manuscript does not have any conflict of interest.

Statement of informed consent

All authors declare that informed consent was obtained from all individual participants included in the study.

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