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Tailoring Learning: The Impact Of Differentiated Instruction Vs. Traditional Methods On Student Performance

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Abstract
Biology, as a core subject in secondary education, plays a pivotal role in understanding the natural world and contributing to advancements in various fields such as medicine, agriculture, and industry. However, poor performance in Biology remains a concern in many regions, including Guyana, where recent data reveals a significant decline in the number of students achieving high grades in the subject. This study investigates whether the application of Differentiated Instruction (DI), an instructional approach designed to cater to diverse learning needs, can improve student performance in Grade 10 Biology at a secondary school in Berbice, Guyana. The null hypothesis guiding the study posits that there is no significant difference between the performance of students exposed to Differentiated Instruction and those taught using traditional methods. The research incorporated a quasi-experimental, pre-test, post-test, non-equivalent control group design which involved using two intact Grade 10 classes. One class was randomly assigned to the experimental group and the other to the control group. The experimental group was taught using Differentiated instruction, while the control group received instruction on the same topics through traditional methods. To assess performance in the topic, a 20-item multiple-choice Biology achievement test was developed by the researcher and administered as both a pre-test and post-test. The data collected from the research were analysed using mean, standard deviation, and t-test. The findings of this research showed that there was a significant difference between the academic performance of students that were exposed to Differentiated Instruction as opposed to those who were exposed to Traditional Instruction. The findings are expected to provide valuable insights into the potential of innovative pedagogical strategies in enhancing Biology education in secondary schools.

Key Word: *Differentiated Instruction, Biology, K-12 Education, Teaching strategies*

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I. Introduction

Biology is one of the single science subjects that are taught in Secondary schools across the country. It can be defined as one of the branches of sciences that deal with the study of living organisms.Biology is an important discipline since it endeavours students to understand the biological processes and the relationship of organisms to each other; and to the environment. In addition, an understanding of biological concepts paves the way to the continual improvement of man's wellbeing as evidenced in the advancement of Medicine, Agriculture, Industry and other related fields. As such, Biology forms the basis for Natural Sciences, medicine, pharmacy and other related disciplines. Hence, students who plan to pursue studies in the disciplines are usually the ones that choose to write Biology at the Caribbean Secondary examination (CSEC examination).

Orodho (1996) emphasized that Biology plays a crucial role in the modernization, social, and economic development of not only individual countries but also the world at large. Therefore, it is essential to investigate the causes of poor performance in Biology to enhance educational outcomes in this subject. In the Caribbean, countries face challenges in improving Biology performance. Available statistics indicate that, despite achieving pass rates of over 50% in Biology between 2007 and 2011, there has been a decline in the number of students obtaining grades 1 and 2 (see Table 1). Guyana, in particular, has demonstrated an average pass rate of over 50% between 2007 and 2014; however, the number of students earning grades 1 and 2 has remained unsatisfactory (see Table 2). Although the Science and Technology Strategic Plan has encouraged more students to opt for the pure sciences, concerns persist regarding the decline in Biology pass rates.

Specifically, a secondary school in Berbice, Guyana has been experiencing a decline in performance in Biology. An analysis of the statistics for the year 2009 – 2015 shows a decline in the passes for grades 1-3. It is also evident that there are few instances of grade one passes as seen only for the years of 2011 and 2014. The data

from 2013 to 2015 indicated a significant decline in performance, with the pass rate decreasing from 57.3% in 2012 to 36.8% in 2013. This decline persisted in 2014, where the pass rate further dropped to 21.67%, and remained relatively low in 2015 at 22.10% (see Table 3).

Studies that have investigated the causes of poor performance in Biology have pointed out that the major cause that have accounted for students' inability to succeed in Biology is the type of methodology used by teachers (Ojogan&Oganwu 2006; Freidman 2000). Having taught Biology for more than six years, it has been noted that most teachers at the particular secondary school uses the whole group method of teaching. This method of teaching is heavily driven by 'teacher-talk' involves the transmission of knowledge by the teacher to passive listeners. As such, the aforesaid method does not cater for individual learning difficulties, needs, interests and learning styles of students as it is a one size fit all method that can only relate to some of the students. Vighnarajah and Abubakar (2008) affirms that in a science classroom where the traditional method which includes the whole group approach dominates, little learning takes place, as the learner's goal is to regurgitate the information or procedure as prearranged by the teacher. The teacher determines the outcome of the learning process and the learner is not challenged to create or critically contest teacher's results. The design in traditional approaches is such that learners spend more time in finding correct answers rather than critically thinking out how to construct their own meaning of scientific concepts.

Consequently, the need to improve student performance and provide appropriate learning experience in the area of Biology has propelled many researchers to investigated alternative methods of teaching. New theories such as Differentiated Instruction have emerged that seek to cater for learning needs of each student. Differentiated instruction is a type of pedagogy that advocates active planning of instruction to accommodate student differences in the classroom (Tomlinson and Allan, 2001). Rooted in the theories of Multiple Intelligence and Constructivism among other theories, this method caters for interest and learning styles of students. In addition, the method of Differentiated Instruction allows students to be actively engage in the classroom rather than being passive learners.

Hence, the proposed intent of this study is to establish whether the use of differentiated instruction would improve the performance of the Grade 10 Biology students at a secondary school.

Table 1: An analysis of the Biology (CSEC) results for 2007 -2011 in the Caribbean

Year	Grade 1	Grade II	Grade III	Grade IV	Grade V	Grade VI
2007	9.66	24.74	37.92	19.00	8.59	0.08
2008	15.78	26.96	34.35	15.65	6.97	0.06
2009	11.82	25.52	37.38	17.34	7.91	0.03
2010	11.04	26.13	37.97	17.48	7.34	0.04
2011	16.28	24.29	32.51	17.76	9.07	0.101

Source: Caribbean Examination Council Annual Report 2007-2011

Table 2: An analysis of the Biology (CSEC) results for 2009 – 2015 in Guyana

Year	Grade I	Grade II	Grade III	
2007	4.80	19.30	38.80	
2008	9.86	22.64	38.83	
2009	6.69	22.03	39.53	
2010	9.20	25.20	35.80	
2011	9.00	22.00	38.00	
2012	9.10	20.20	34.03	
2013	9.34	22.62	32.8	

Source: Garraway-Lashley, 2014

Table 3: An analysis of the Biology CSEC) results for 2009-2015 at a secondary school

Year	Grade I	Grade II	Grade III	Grade IV	Grade V	Grade VI
2009	0	0	66.7	33.3	0	0
2010	0	8.3	45.8	33.3	12.5	0
2011	9.5	23.8	23.8	33.3	9.5	0
2012	0	14.8	42.5	31.9	10.6	0
2013	0	0	36.8	47.3	15.7	0
2014	21.7	0	19.5	47.8	30.4	0
2015	0	4.4	17.7	71.1	6.7	0

Source: 'Secondary school' Analysis 2009-2015

Research Hypothesis

The study is guided by the following null hypothesis:

HO1- There is no significant difference between the performance of Biology students who are exposed to the method of differentiated instruction and those who are expose to the traditional method.

Theoretical framework

Differentiated instruction advocates that each student in a classroom is unique such that they are individuals in their learning styles, interest and readiness. Tomlinson and Alan (2001) stated that the use of differentiated instruction caters for the needs and differences of every student in the classroom thereby promoting effective learning. However, the idea of catering for students' differences such as learning styles, readiness and interest was researched by numerous psychologists. As such, differentiated instruction is embedded in the theories of Howard Gardner's Multiple Intelligences, Brain Based learning, Constructivism, Vygotsky's zone of proximal development, with each of them substantiating the need for catering for either the learning style of students, the interest of students or the readiness of students

One of the most well-known theories of variation in learning styles is Howard Gardner's theory of multiple intelligences, which posits that intelligence enables an individual to solve real-world problems or challenges (Bornstein, 1986). Gardner (2013) asserted, "The differences in intelligences of students challenge an education system that assumes that everyone can learn the same material the same way and that a uniform universal measure suffices to test students' learning." He further noted that the current educational system is heavily biased toward linguistic modes of instruction and assessment, with a somewhat lesser emphasis on logical-quantitative approaches. Gardner's critique of linguistic modes of instruction is particularly relevant in the context of schools in Guyana, where many teachers continue to rely on the lecture method or whole-group instruction. This traditional approach limits students' opportunities to acquire knowledge and reach their full potential. Gardner theory of Multiple Intelligences initially postulated that they are seven ways that individual exhibit intellectual ability: visually, verbally or linguistically, logically or mathematically, bodily or kinaesthetically, musically, interpersonally, or through self-reflection (Gardner, 2003). However, continuing research has established a naturalist and possibly an existentialist approach to learning. Howard Gardner theory of Multiple Intelligence identifies that individuals have many forms of intelligences and that they have varying strengths and combinations of these intelligences. Some may be linguistically intelligent but do not have a high level of musical intelligence while others may have the other way around.

Students learn in ways that are identifiably distinctive, according to Howard Gardner. Likewise the same has been echoed by studies on Brain based Learning. Brain based learning is defined as learning according to how the brain is naturally designed to learn. Brain based learning research affirms that although all students can learn, each brain is unique and each student have his or her own preferred learning style (Connell, 2009).Studies of cognition suggest that there exist many different ways of acquiring and representing knowledge, these individual differences need to be taken into account in our pedagogy as well as in our assessments (Gardner, 2013). As such, students who cannot master a concept can reveal significant understanding when these have been elicited in a different, more appropriate way. This differentiated view of the mind harbours hope that different students may be reached in different ways through educators implementing different strategies and manipulating different materials to suit the heterogeneous nature by which students learn.

Differentiated instruction also caters for the readiness of students. Readiness in learning is when students have mastered the prerequisite knowledge and they can move on to a new topic. Readiness is one of the factors that can be used to differentiate instruction in a classroom. This means that students can be grouped according to their level of prerequisite knowledge. Bruner's theory of constructivism also emphasized that learners construct new ideas or concepts based on existing knowledge and students should have the readiness to learn. Like Bruner, Vygotsky's theory of zone of proximal development supports that students need to work at different levels according to their readiness. According to Vygotsky as cited by Turville and Allen (2014), "zone is where learning occurs". As such in a classroom, there may be differences in zones; hence students would need to be working at different levels. Students with similar ZPDs can be grouped together to work on the same skill or objective; teachers can design tasks to suit the readiness of students thereby optimising learning (Vygotsky, Rieber& Carton, 1998 cited by Turville& Allen, 2014). However if students work outside of their ZPD, frustration occurs when students are not able to complete the task. Piaget's theory points out that students use existing mental patterns in new situations through the process of assimilation (Coon &Mitterer, 2008). As such, if the knowledge structure is not there, students cannot assimilate the new information.

Interest is also important since it explains a student's affinity for and engagement with a topic (Tomlinson &McTighe, 2006). When teachers tapped into students' interest, learning becomes more fun, the students become more autonomous in their learning and the outcome is more productive. Differentiated instruction counterparts constructivism since it is an individualised approach that caters for the prior knowledge, interests, cognitive levels and skills of students (Capella University, 2008). Bruner investigated motivation for learning. He felt that ideally, interest in the subject matter is the best stimulus for learning. Interest contributes to a sense of competence and self-determination in learners and to positive learning behaviors, such as willingness to accept challenge and persist in it (Csikszentmihalyi et al., 1993; Fulk& Montgomery-Grymes, 1994; Vallerand, Gagne, Senecal, & Pelletier, 1994; Zimmerman & Martinez-Pons, 1990 as cited by Tomlinson et al, 2003). Allowing students to do something they love is likely to help them develop both a positive attitude about leaming

and their creative potential (Amabile, 1996; Runco& Chand, 1995; Torrance, 1995 as cited by Tomlinson et al, 2003)

Based on the theoretical perspective reviewed, differentiation instruction can engage students in the classroom to be actively involved in their learning since it is an individualised approach that caters for the differences in students. It is vital to cater for the differences of students according to theories reviewed since it enables students to actively construct their knowledge rather than being passive receivers of knowledge, it motivates students to learn because it catered for their needs such as interest, readiness and learning styles. These conditions as stated by many theorists are essential to ensuring that effective learning occurs.

The use of Traditional Instruction in Biology

For decades, traditional instructional methods have been used to impart knowledge to students. This mode of instruction is teacher- centred and involves students sitting in traditional seating arrangements whereby the teacher employs one type of teaching strategies such as lecture or commonly called the 'chalk and talk' method. Traditional method can be defined as an approach that obliges students to submissively grasp and regurgitate information as and when conveyed by the teacher (Vighnarajah, Luan & Abubakar, 2008). The teacher is viewed as the gatekeeper of knowledge and is in controlled of the learning environment through which the teacher envisions that he or she solely influences learning to occur. As such, learning outcomes are objective and standardised; and instruction is solely concerned with the efficient movement of skills and knowledge from the teacher to students. Furthermore, in a traditional teaching environment, only little learning takes place even though there appears to be an active shift of information (Vighnarajah, Luan & Abubakar, 2008).

Consequently, the use of traditional method in Biology poorly addresses the learning needs of students. A method such as this is like a person throwing seeds randomly on soil, some will grow if the conditions are right while others that do not have the right conditions have no chance of growing. Likewise, using one type of pedagogy will only fit students that have the required level of prerequisite knowledge and will only be adequate for students with certain learning styles and interests. It does not cater for all students (Tomlinson, 2001). As such, only certain students who the 'one size fit all' method suits will be able to understand content and grasp concepts (Forsten, Grant & Hollas, 2002; McBride, 2004; McCoy & Ketterlin-Geller, 2004; Tomlinson, 2002; Tomlinson & Kalbfleisch, 1998 as cited by Subban, 2006). Gardner (2013) in his theory of multiple intelligences would have mentioned that the current traditional mode of instruction only lends itself to logical, quantitative modes of instruction which does not cater for the different ways that students learn. Moreover, Duch, Groh and Allen (2001) also mention that a traditional learning environment emphasizes abstract concepts over concrete examples; and application rarely challenges students to perform at higher cognitive levels of understanding.

Apart from traditional instruction restricting students from actively constructing knowledge and inadequately catering for the needs of each student, Traditional modes of instruction also use one method of assessment which is the paper and pencil test. Such assessments are 'one shot' and does not gauge students learning (Dikli, 2003). Traditional assessments usually test accumulative knowledge and cannot tell the progress of students. Apart from that, it does not test higher order skills and is centralised on testing students' knowledge on what they have recalled rather that what the students know and can do. It also restricts students from fully participating in their assessment (Dikli, 2003).

However, even though Traditional instructional methods have many disadvantages, it also has advantages such as it ensures that the curriculum is covered (Mattes, 2008). This is one of the aims of traditional instruction to ensure that curriculum objectives are achieved. The teacher speedily uses one method of instruction and systematically ensures that the syllabus is covered.

Hence, while traditional method of instruction may ensure that the curriculum is covered, it does not actively involve students in the classroom, it does not cater for the needs of students and it inadequately assesses students on what they know and can do. As such, it seems that the disadvantages have outweighed the advantages. Hence, there is a dire need to change this paradigm of teaching to a more student-centred method such as Differentiated Instruction which caters for the needs of students and assesses them based on what they can do.

The use of Differentiated Instruction in Biology

Today's teachers are still struggling with the task of reaching out to students who span the spectrum of learning readiness, personal interests, and culturally shaped ways of speaking about and experiencing the world. This is as a result of classrooms that are filled with students with similar ages; however, they exhibit a wide array of differences that challenges teachers to vary their teaching strategies. Differentiated instruction rises to this challenge by creating multiple pathways so that students of different abilities, interest or learning needs experiences equally appropriate ways to absorb, use, develop and present concepts as a part of the daily learning process (Tomlinson, 2014). As such, many teachers are adapting to the method of Differentiated instruction. In particularly, recent studies in Sciences such as Biology have shown that the use of Differentiated instruction can be used to improve the performance of students in Biology (McAdmins, 2001; Osuafor & Okigbo, 2013).

The idea of creating multiple paths for students to acquire information is based on the challenges experienced by teachers in which students have many differences; they vary in culture, socioeconomic status, language, gender, motivation, ability/disability, personal interests among others. As such, Differentiated instruction accept and act on the premise that teachers must use different approaches to learning, appeal to a wide range of interests and by using varied rates of instruction along with varied degrees of complexity and differing support systems to cater for the individual needs of students (Tomlinson, 2014). Osuafor and Okigbo (2013) pointed out that the use of a single paced lesson delivered through a singular methodological approach disregards the differences in learning styles and interests present in many classrooms. The researcher contends that, given the broad curriculum scope of Biology and the interconnected nature of its topics, the application of differentiated instruction in Biology can effectively stimulate student interest and place them at the centre of the learning process. By employing diverse learning materials and addressing students' varying levels of readiness, differentiated instruction ensures that students possess the necessary prerequisite knowledge to connect prior topics to new content.

Another advantage of differentiated instruction is the use of flexible grouping which accommodates students that are strong in some areas and weaker in others. The teacher that uses flexible grouping understands that some students may begin a task more slowly and then launch ahead at remarkable speed while others may learn more slowly (Tomlinson, 2014). This teacher also understands that sometimes some students prefer to work independently while others prefer to work in pairs or triads (Tomlinson, 2014; Tomlinson & Strickland, 2005). The use of flexible grouping can provide Biology students with the opportunity for self-competition, as it allows them to progress at their own pace rather than in comparison to their peers. This approach offers additional benefits, as it enables the teacher to provide targeted support to struggling students, thereby facilitating their advancement and helping them reach their full potential.

Moreover, teachers using differentiated approach proactively plan multiple ways to 'get at' and express learning (Tomlinson, 2001). Teachers plan varied ways such as use of technology, whole group, and small group and also plan to incorporate different materials to stimulate the interest of students. As such, students' interest and learning styles are tapped into such as some may be interested in technology, while others may be creative and interested in manipulation of objects. Catering for the interest and learning styles is vital to learning based on theories such as Howard Gardner, Jerome Bruner among others (Gardner, 2013). Teachers using differentiated instruction are like artists who use the tools of their craft to address students' needs. They do not aspire to standardized, mass produced lessons because they recognise that students are individuals and require a personal fit (Tomlinson, 2014). As such, the goal of this type of pedagogy is student learning and satisfaction, not curriculum coverage. However, teachers using traditional instruction plan a single approach with the aim of teaching a diverse population of students. Consequently, a single approach cannot cater for the different needs of students and as such, some students may become bored in the lesson, others may lose the concept before it begins. Yet, teachers expect that students would adjust to a single approach to learning when it is learning that should be adjusted to the learner (Gregory & Chapman, 2002). Hence, with he teacher proactively planning the lesson to suit the needs of students; it can be advantageous to a Biology classroom where students can be taught using varied materials so as to stimulate their interests and tap into the various ways that they learn.

Furthermore, in differentiated classrooms, assessment is diagnostic and ongoing. As such, teachers are provided with information on a daily basis on students' readiness for particular concepts, their interests and their approaches to learning (Tomlinson, 2014). In addition, teachers in differentiated classrooms do not envision assessment as an end to the lesson that informs on what students have learnt and did not but rather a tool of understanding for modification of the next day's lesson (Tomlinson, 2005). Formative assessment in this type of pedagogy is not standardised as in traditional classrooms which comprise of paper and pencil test that appeals heavily on the linguistic ability of students but rather spans a wide spectrum of alternative assessment entailing portfolio, interest surveys, journal entries, homework assignments and teachers' observation of students using checklist as well as a host of other mechanisms (Dikli, 2003). Such informal and formal assessment allows students to demonstrate what they know using their interest while at the same time providing information for teachers of who understands key ideas, who can perform targeted skills at what levels of proficiency. Hence the use of ongoing assessment may be advantageous in a Biology classroom since it can inform the teacher of the difficulties that students are encountering so that they can be addressed in a timely manner at the same time, teachers can be aware of students' readiness for the new topic.

However like everything else, Differentiated Instruction has its critics. Laura Pappano of the Harvard Education Letters says the primary criticism with this method is that it requires too much time of teachers in that they must individualise everything. Teachers may become frustrated of having to correlate many activities together in the classroom (Pappano, 2011). Additionally, Differentiated Instruction operates on assumptions about a students' readiness, skill level which may not always prove correct. Hence, inaccurate assumptions can lead to a derailing of the learning process and potentially creating chaos in the classroom. Furthermore, in Pappano (2011) article for the Harvard Education Letter, she exemplified a Mathematics teacher Sheryl Hauser who expressed

that when she tried to differentiate her lesson, students complain about having more Mathematics problems that their classmates.

While Educators are nowhere near perfecting Differentiated Instruction, the benefits of the approach seems to outweigh the drawbacks. Differentiated Instruction helps engage and motivate students in the classroom, thereby enhancing their learning. It meets the needs of each individual student in the classroom while at the same time consistently assessing them based on what they know and can do. Hence, as Tomlinson (2001) puts it "you could have an egg on toast every night for dinner, but to advance as a chef, you have to expand your ingredients." Shortcomings notwithstanding, that's exactly what Differentiated instruction an do for Educators.

The impact of Differentiated instruction in Biology

Several empirical research have stated that differentiated instruction have influenced academic achievement in practice. For example, the literature supports the effectiveness of DI as a method for students with learning disabilities. Tieso (2005) affirmed that students with learning issues who received DI displayed better achievement in mathematics than the students who received regular instruction. Baumgartner, Lipowski, and Rush (2003) noticed similar positive gains in reading among students with learning issues, in their study on an urban middle school's switch to DI methods. Furthermore, the effectiveness of differentiated instruction is also evident in the teaching of Biology. Researches showed that students taught using the differentiated approach performed significantly higher than their counterparts taught using the lecture method (Hodge , 1997; Osuafor&Okigbo, 2013).Evident in the investigations of researches, it shows that catering for the needs of students in the classroom can increase their academic performances as researchers. Osuafor and Okigbo (2013) pointed out that the use of a single paced lesson delivered through a singular methodological approach disregards the differences in learning styles and interests present in many classrooms.

Furthermore there is linkage between better results in Biology using differentiated instruction and forming observation. But before a linkage can be made, it is imperative to note all true biological knowledge must be based upon personal observation of living things (Agrawal, 2004). Such a proclamation is based on the fact that Biology is the study of living things and what better way to study living things than to make observations. As such, learners must observe, manipulate and experiment for themselves in order to have a full understanding of biological concepts. However, to make observations, one attention must be focussed and this can only occur if the interests of learners are aroused. As such, it is because of this determining quality in attracting attention that interest holds its importance place in education. However, two of the elements that influence the degree of pupil's attention is the level of previous knowledge and interest in the subject. True observation is the offspring of interest and knowledge (Agrawal, 2004). As such since the foundation of observation lies in the appealing to the interest of students and the extent of their readiness, then it is vital to note that students have varying interest and level of readiness, so what better way to cater for the many differences in students than to employ the method of differentiated instruction.

The Difference between Traditional and Differentiated Instruction
Comparing classrooms

Traditional classrooms	Differentiated Classroom
• Student differences are masked or acted upon when problematic • Assessment is most common at the end of learning to see "who got it" • A relatively narrow sense of intelligence prevails • A single definition of excellence exists • Student interest is frequently tapped • Relatively few learning profile options are taken into account • Whole-class instruction dominates • Coverage of texts and curriculum guides drives instruction • Mastery of facts and skills out-of-context are the focus of learning • Single option assignments are the norm • Time is relatively inflexible • A single text prevails • Single interpretations of ideas and events may be sought • The teacher directs student behavior • The teacher solves problems • The teacher provides whole-class standard for grading • A single form of assessment is often used	• Students differences are studied as a basis for planning • Assessment is ongoing and diagnostic to understand how to make instruction more responsive to learner need • Focus on multiple forms of intelligences is evident • Excellence is defined in large measure b individual growth from a starting point • Students are frequently guided in making interest-based learning choices. • Many learning profile options are provide for • Many instructional arrangements are used • Student readiness, interest and learning profile shape instruction • Use of essential skills to make sense and understand key concepts and principles is the focus of learning • Multi-option assignments are frequently used • Time is used flexibly in accordance with student need • Multiple materials are provided • Multiple perspectives on ideas and events are routinely sough • The teacher facilitates students' skills at becoming more self-reliant learners • Students help other students and the teacher solve problems • Students work with the teacher to establish both whole-class and individual learning goals • Students are assessed in multiple ways

Source: Tomlinson, 2014

II. Material And Methods

Methodology

The study incorporates the use of a Quasi-experimental non-equivalent control design. This design was chosen as the most appropriate since it is pertinent to the nature of the research by which the subjects of the study will not be randomly chosen. Often times in educational research, it is not feasible to perform true experimental design by which the participants are randomly assigned to a control and experimental group (Cohen, Manion& Morrison, 2011). As such, two whole groups: experimental group and controlled group, was used for the study. A pre-test was administered to both groups (control and experimental group) simultaneously; after which a post test was administered at the end of the eighth week.

However, since Quasi experimental non-equivalent control group design is not randomised as in true experimental design, it is susceptible to internal validity threats. The threats to internal validity includes: selection bias, maturation, instrumentation, statistical regression, testing, history, diffusion of treatment and mortality. The study therefore seek to control these threats since failure to do so can affect the outcome of the study.

Population

The target population of the study consisted of two intact grade 10 classes (Agricultural stream and Science stream) at a secondary school. Each of these classes consisted of twenty-five (25) students each; which adds to a total of seventy (50) students. Of the total population, 20 are boys and 30 are girls who are between the ages of 14-16 years and are of similar maturation levels. Furthermore, majority of the population are from African and East Indian descent, with minority being of mixed and Amerindian descent and are of similar economic, social and cultural levels.

Sample

The study incorporates convenience sampling – a type of non-probability sampling whereby available classes that are of easy access is used. As such, since the only classes in Grade 10 that does biology is the Agricultural and Science stream, the entire population will be used as the sample.

Instrumentation

An instrument can be defined as a measuring device that is used to provide information needed for research. An objective test is considered the best choice for the study since it has higher validity and reliability which is a result of it enabling the marker to be objective and unbiased. Apart from that, it is easier to score and facilitates testing in all areas of the cognitive domain. As such, a teacher made objective test was constructed which was employed for the pre-test and the post-test in both the experimental and control group. The objective test consisted of twenty multiple choice questions which is based on the topic: Genetics which is part of the Caribbean Secondary Examination Certificate (CSEC) syllabus. Two minutes per each question was allocated for the test which gives a total of forty (40) minutes to complete the entire test.

Validity of the instrument

In the process of validating the instrument that is constructed for the purpose of the study, assistance was sought from other grade 10 biology teachers as well as Measurement and Evaluation specialist from a university campus. Based on the corrections and suggestion from the teachers and specialist, steps were taken to improve the quality of the instrument.

Reliability of the instrument

A reliable test is one which when measured shows consistency. However, the reliability of a test can be affected by factors such as the range of the group being tested, the group's level of proficiency, the duration of the test (the longer the test, the greater the chances of error) and the manner in which the reliability is calculation (Best & Kahn, 2002).

In order to test for reliability, the test, re-test approach was employed whereby the teacher made test was administered to a grade 11 class who were exposed to the topic Genetics. The reliability coefficient was calculated, after which the PPMC was applied.

Procedures

To conduct the study, permission was sought from the Chief Education Officer and the principal of the secondary school, both of whom granted approval. In correspondence with the individuals, the aim, data needed and procedure among other details was clarified. Furthermore, permission to use the Grade ten (10) Biology students for the study was sought from the teacher that is responsible for the biology class, in which approval was granted. The Head of Department, as well as other teachers in the department were informed of the conduct of the study.

Before the treatment was applied to the experimental group, the pre-test was administered to both the control and experimental groups simultaneously. For that to be feasible, assistance was sought from a teacher in the school to invigilate the test. Following the test, scripts was marked, recorded and analysed using the t- test to ascertain the equivalence of both the control and experimental group.

Subsequently, treatment was applied to the experimental group. The biology teacher, assisting in the conduct of study was give lesson plans and briefed on the details of the study. The treatment consists of the experimental group being taught for eight weeks using the Differentiated method of Instruction while the Control group was taught for the same using the Traditional method of instruction (Whole class method) with the assistance of the biology teacher.

On the seventh week of the treatment, students were informed of the test in the following two weeks. They were given details about the test such as the time allocated, number of questions, marks allocated and the type of questions in order to ensure proper test administration. The post- test was administered one week after the treatment has ended. Assistance was sought from a teacher in the school to invigilate the test. At the end of the test, scripts were collected, marked and analysed.

Data Analysis

The data analysis describes how the data collected was analysed. Descriptive and Inferential statistics was used to analyse the data of the study. Descriptive statistics are numbers that are used to describe and summarise data while inferential statistics allows inferences to be drawn from the sample to the population. The Descriptive statistics that were used in the study are the mean, standard deviation and central tendency. This was used to highlight a general description of the data and the performance of both the experimental and control group.

The inferential statistics that were used is the t-test. The t- test was used to test the hypothesis to ascertain whether there is any significant difference between the mean of the two groups. The hypothesis was tested at Alpha 0.05 level of significance.

III. Results

Determining if data can be analyse using an independent sample t-test

To ensure that the data can be analysed using an independent t-test, six criteria were checked**.**

Criteria 1, the dependent variable should be measured on a continuous scale that is it is measured at the interval or ratio level). The test scores met this criterion because it is within this scale.

Criteria 2: The independent variable should consist of two categorical, independent groups. This criterion was met since the two groups used in were the control and experimental groups.

Criteria 3: There should be independence of observations, which means that there is no relationship between the observations in each group or between the groups themselves. For example, there must be different participants in each group with no participant being in more than one group. This was achieved by using two intact groups that consists of twenty-five students from each Biology class.

Fig.1 ***Control Group Pre-test Box Plot***

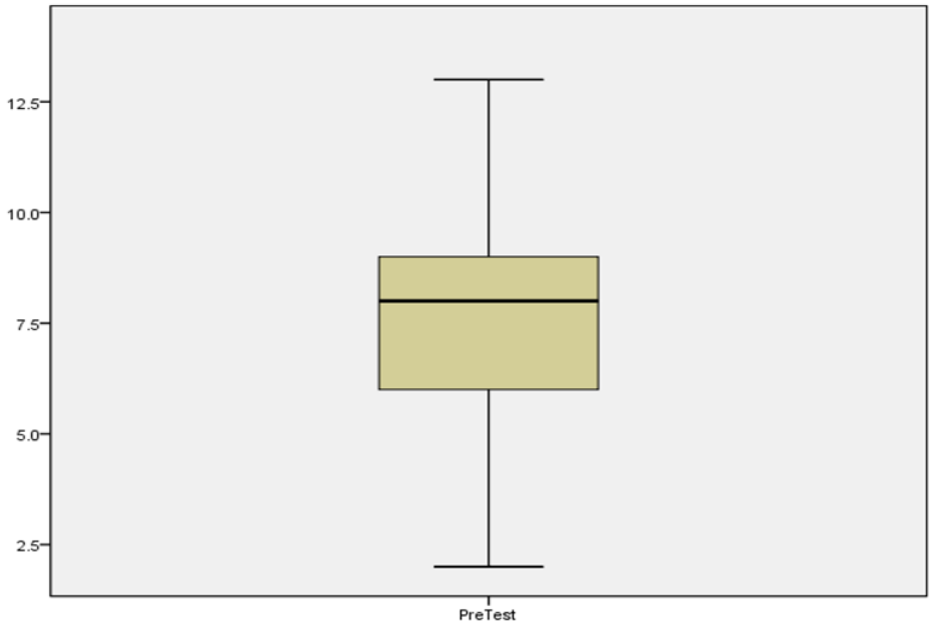
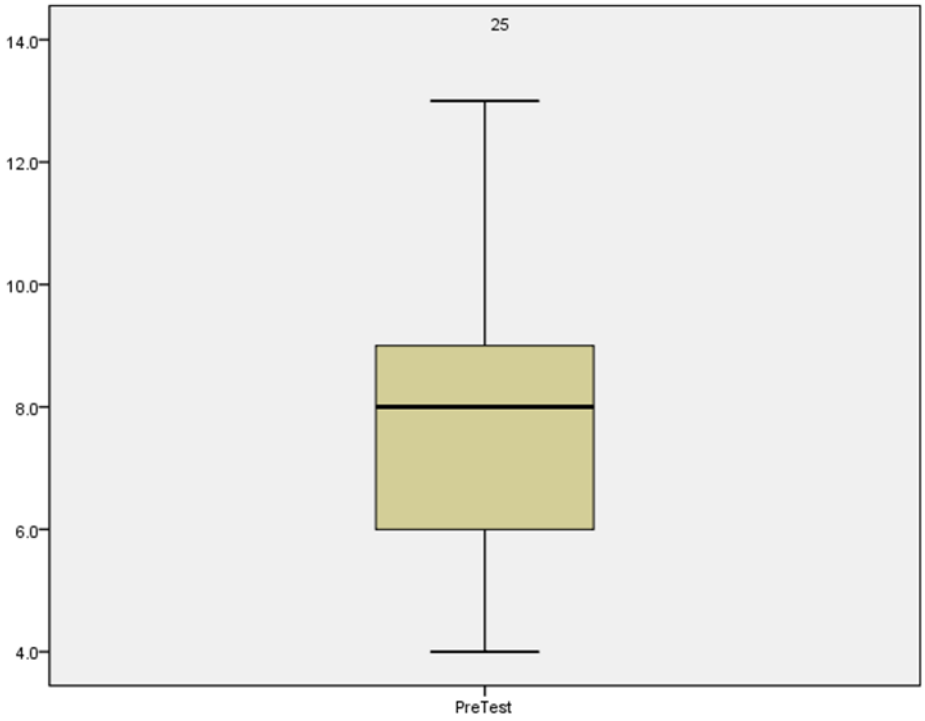


Fig. 2 ***Experimental Group Pre-test Box plot***



Criteria 4: There should be no significant outliers. Outliers are simply single data points within your data that do not follow the usual pattern. The problem with outliers is that they can have a negative effect on the independent t-test, reducing the validity of your results. The box plots above in Fig.1 and Fig.2 show the pre- test scores for both the control and experimental groups. Both groups do not show any outlier on either side of the whiskers of the two-box plot. So, it could therefore be concluded that there are no extremes scores in the pre-test values.

Table 4. ***Pre-test Control group normality test***

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre test	.130	25	.200*	.968	25	.589

Fig. 3. ***Pre-test control group histogram***

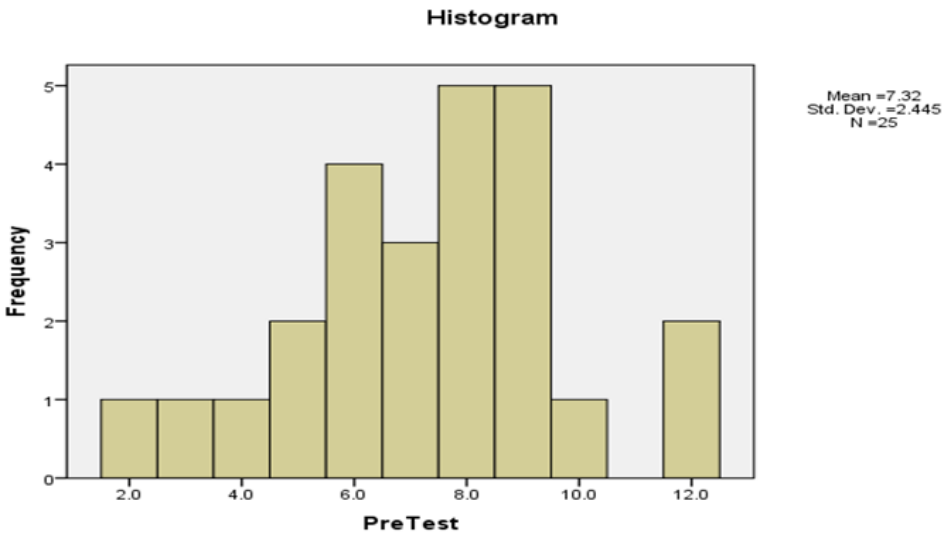
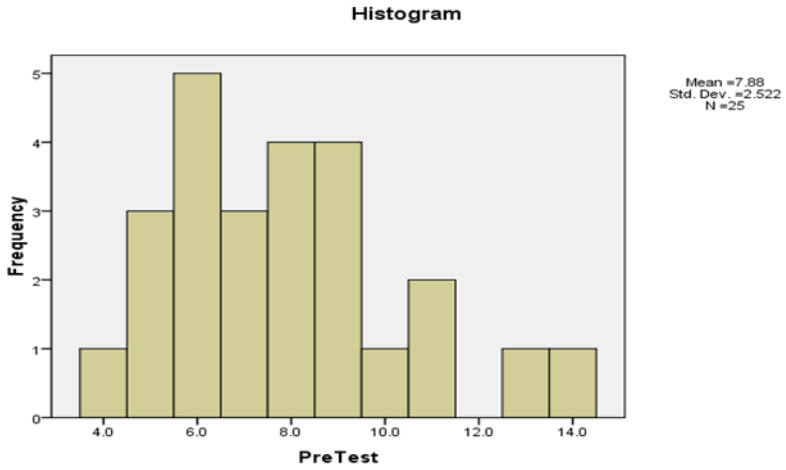


Table 5. ***Pre-test experimental group normality test***						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	.132	25	.200*	.941	25	.155

Fig. 4. ***Pre-test experimental group histogram***



Criteria 5: The dependent variable should be approximately normally distributed for each group of the independent variable. The independent t-test requires approximately normal data; therefore, normality test was done on the pre-test scores for the control and experimental groups in which tables 4 and 5 show the results of the test. Kolmogorov-Simirov and Shapiro-Wikk normality test were used and the significant values (Sig.) were greater than 0.05 for both groups, the values were 0.200, 0.589, 0.200 and 0.155. It could therefore be concluded that the scores were normally distributed. The histograms in Fig. 3 and 4 also showed the scores were normally distributed with scores falling with the different quartiles, with a range of scores from 2 to fourteen.

Criteria 6: There needs to be homogeneity of variances; therefore, the Levene's test for homogeneity of variances was used as shown in Table 5. The variances were found to be 0.963 which is greater than 0.05. Therefore, the variances are said to be statistically equal.

Pre-test analysis

Table 6. ***Pre-test mean score and standard deviation***					
	Groups	N	Mean	Std. Deviation	Std. Error Mean
Pre-Test	Control	25	7.320	2.4447	.4889
	Experimental	25	7.840	2.4269	.4854

Table 7. ***Variance and T-test for pre- test scores***

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-test	Equal variances assumed	.002	.963	-.755	48	.454	-.5200	.6890	-1.9052	.8652
	Equal variances not assumed			-.755	47.997	.454	-.5200	.6890	-1.9052	.8652

Table 6 above show the number of students for each group as twenty-five (N=25). It also shows that the pre-test mean of the control group as 7.32 and standard deviation 2.44. By comparison, the experimental groups

showed numerically larger mean score of 7.84 and a smaller standard deviation of 2.43. To determine if the difference in the two means are statistically different, a two tailed t-test was done. Based on the analysis in table 7 above, the p value which is same as the Sig value on SPSS output is 0.454, this value is greater than 0.05 which is the significant level that was used in this test. It could therefore be concluded that the difference in the means score are not statically significant and this difference may have been due to chance. The researcher therefore continued with the study by implementing the treatment to the experimental group; and the control group students were taught using the tradition method.

Gain analysis

Table 8. ***Pre-test and Post-test Gain mean and standard deviation***

Group Statistics					
	Groups	N	Mean	Std. Deviation	Std. Error Mean
Gain1	Control	25	1.320	.7483	.1497
	Experimental	25	2.520	1.0050	.2010

Table 9 ***Variance and T-test for gain test scores (Post-test – Pre-test)***

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Gain1	Equal variances assumed	2.402	.128	-4.789	48	.000	-1.2000	.2506	-1.7039	-.6961
	Equal variances not assumed			-4.789	44.356	.000	-1.2000	.2506	-1.7049	-.6951

Table 8 shows that the gain means (Post-test scores minus Pre-test scores) of the control group as 1.32 and standard deviation 0.75. By comparison the experimental group showed numerically larger values of 2.52 and 1.00 respectively. To test hypothesis one to determine if the groups have statistically different mean, an independent sample two tailed t-test was performed. Based on the analysis in table 9 above, the p value which is the same as the Sig. value on SPSS output is 0.00, this value is less than 0.05 which is the significant level used in this test. It could therefore be concluded that the difference in the gain means is statically significant, this difference is not due to chance but because of the use of Differentiated Instruction.

Based on these findings, it rejects the null hypothesis HO1that there is no significant difference between the performance of Biology students who are exposed to the method of differentiated instruction and those who are expose to the traditional method.

IV. Discussion

The results of the study indicate a greater mean gain in performance for students taught using Differentiated Instruction compared to those who were taught through Traditional Instruction. Additionally, a statistically significant difference was observed in the performance of students exposed to Differentiated Instruction in comparison to those taught using Traditional Instruction. These findings suggest that the students in the experimental group demonstrated better performance relative to those in the control group. Consequently, the data imply that the improved performance of the experimental group can be attributed to the instructional approach employed, namely Differentiated Instruction. This finding aligns with the conclusions of Dodge (2009) and Tomlinson and Jarvis, whose research has demonstrated that Differentiated Instruction positively impacts academic achievement. Furthermore, Hodge (1997), Osuafo and Okigbo (2013) found that the use of Differentiated Instruction in Biology, as opposed to the traditional lecture method, led to significant improvements in student performance. Osuafor and Okigbo (2013) pointed out that the use of a single paced lesson delivered through a singular methodological approach disregards the differences in learning styles and interests present in many classrooms. Given the broad curriculum scope of Biology and the interconnected nature of its topics, the application of differentiated instruction in Biology can effectively stimulate student interest and place them at the centre of the learning process. These prior studies provide corroborative evidence supporting the efficacy of Differentiated Instruction in enhancing student outcomes.

The researcher observed that students in the experimental group, who were exposed to Differentiated Instruction, not only exhibited higher academic performance but also displayed significantly greater engagement in the learning process. These students were more active in class discussions, frequently participating and connecting more deeply with the content. Their ability to choose how they engaged with the material appeared to foster a more personalized learning experience, with students regularly asking clarifying questions and offering relevant examples to enrich the conversation. This finding aligns with Osuafo and Okigbo's (2013) assertion that Differentiated Instruction can stimulate student interest. For example, during the unit on the circulatory system, students in the experimental group were able to approach complex topics through various modalities, such as visual aids, group discussions, and hands-on activities. This approach is also consistent with Tomlinson and McTighe's (2006) argument that interest is critical in explaining a student's affinity for and engagement with a topic. When teachers tap into students' interests, learning becomes more enjoyable, students become more autonomous in their learning, and the overall outcome is more productive. The use of Differentiated Instruction in this study appeared to enhance students' understanding and retention of the material, in contrast to those in the control group, who were primarily engaged through traditional lectures.

In conclusion, the findings from this study suggest that Differentiated Instruction significantly enhances academic performance.

V. Conclusion

Based on the findings of this study, there was a significant difference in the academic performance of students exposed to Differentiated Instruction compared to those taught using the traditional method. This difference in performance may be attributed to the treatment—specifically, the use of Differentiated Instruction in teaching the experimental group. The integration of this instructional method into the teaching of Biology appeared to foster greater student engagement, as it encouraged students to become active participants in their learning process. This increased engagement likely contributed to the improved academic outcomes observed in the experimental group, suggesting that Differentiated Instruction can be a more effective approach in enhancing student performance in the subject area.

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