UNIVERSITY OF EDUCATION, WINNEBA

IMPROVING SENIOR HIGH SCHOOL STUDENTS' ACADEMIC PERFORMANCE IN SELECTED CONCEPTS IN INTEGRATED SCIENCE THROUGH DIFFERENTIATED INSTRUCTION

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DECLARATION

STUDENT'S DECLARATION

I, **EDWARD BARIAM,** declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:…………………………….

DATE:…………………………………….

SUPERVISORS' DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

SUPERVISOR: PROF. KODJO DONKOR TAALE

SIGNATURE: ……………………...….………

DATE: ……………………………………………

DEDICATION

I dedicate this academic work to my beloved family, whose unwavering love and support have been a constant source of inspiration and encouragement throughout this journey.

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LIST OF ABBREVIATIONS

CRDD	**:**	Curriculum Research and Development Division
DI	**:**	Differentiated Instruction
DIVQ	**:**	Differentiated Instruction Views Questionnaire
EFA	**:**	Education For All
GAST	**:**	Ghana Association of Science Teachers
GES	**:**	Ghana Education Service
IE	**:**	Inclusive Education
ISPT	**:**	Integrated Science Performance Test
NCLB	**:**	No Child Left Behind
SDG	**:**	Sustainable Development Goal
SES	**:**	Socio Economic Status
SHS	**:**	Senior High School
SPSS	**:**	Statistical Package for the Social Sciences
UN	**:**	United Nation
UNESCO	**:**	United Nations Educational, Scientific and Cultural Organization
ZPD	**:**	Zone of Proximal Development

ABSTRACT

The purpose of this study was to improve senior high school students' academic performance in selected Integrated Science concepts through differentiated instruction. The study was done in Ghana National College, Cape Coast-Ghana. The study adopted an action research design with an intervention covering four weeks, and utilised the purposive sampling technique to select an intact form two General Arts class of thirty-four (34) students for the research. The study sought to answer three research questions: 1. What is the effect of differentiated instruction on the academic performance of SHS students in selected Integrated Science concepts? 2. What is the differential effect of differentiated instruction on the academic performance of the male and female SHS students? 3. What are the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science? Data were gathered using achievement tests (ISPT) and questionnaire (DIVQ), and analysed using descriptive and inferential statistics. The findings of the study indicated that students exhibited a notable improvement in academic performance from the pre-test (Mean= 7.94) to the post-test (Mean= 24.29). The t-test analysis revealed a statistically significant difference between the pre-test mean score and the post-test mean score (p = 1.09E-18, sig. at 0.05). Also, the findings revealed that differentiated instruction had a positive and equitable effect on the academic performance of both male (Mean= 24.74) and female (Mean=23.73) senior high school (SHS) students in Integrated Science. The t-test analysis of the post-test scores revealed no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction (p= 0.5, not sig. at 0.05). Moreover, the findings of the study revealed that SHS students have overwhelmingly positive views on the use of differentiated instruction in the teaching and learning of Integrated Science. In light of these findings, it was recommended that Integrated Science teachers should consider incorporating differentiated instruction strategies to improve student learning outcomes. Teachers are urged to master various instructional methods and actively seek feedback for continuous improvement. Also, policymakers and educators should collaborate to promote widespread adoption of differentiated instruction, recognizing its positive impact. Support and resources for teacher training in differentiated instruction are recommended, with a focus on professional development programs. Furthermore, government and educational bodies should sponsor workshops and seminars, while curriculum planners are advised to incorporate differentiated instruction in developing the Integrated Science curriculum. Additionally, publishers are encouraged to produce textbooks using the differentiated instruction format.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter contains the background to the study, the statement of the problem, the purpose of the study, the objectives of the study, the research questions, research hypotheses, significance of the study, limitations of the study, delimitations of the study as well as organisation of the study.

1.1 Background to the Study

Science and technology have become the hallmark of sustainable development in any national economy. According to Zinchenko (2019), no industrialised or developing country can afford to neglect scientific education in its schools if it wishes to advance in the socioeconomic sphere. A strong science and technology base, therefore, constitutes the currency for the social and economic transformation of nations (Richta, 2018). Science is the use of systematic methods of empirical investigation, the analysis of data, theoretical thinking, and logical assessments of arguments to develop a body of knowledge about a particular subject matter (Ajayi, 2017). Bennett, et al. (2017) viewed science as an integral part of human society. The study of science helps us to understand the natural world and also to approach challenges in life and the workplace systematically and logically.

The development of the Integrated Science education curriculum at different educational levels in Ghana is due to the significance of science to national development. According to Abbey (2012), science is integrated when all aspects of science that is biology, chemistry, physics and agriculture are treated holistically such that none of the aspects stands alone. The study of Integrated Science and the application of its product has improved the standard of living of humankind worldwide (Owusu & Baiden, 2018).

According to Bawa (2018), one of the major issues with science education in Ghana is that science teachers are unable to develop pedagogical strategies that will aid students in understanding scientific concepts and enhancing their performance. Research in science education indicates that students have difficulties in comprehending abstract scientific concepts, particularly in Integrated Science therefore, many learners perceive Integrated Science as a difficult subject and part of the difficulty can be traced to the use of only one approach by subject teachers (Lederman, 2017). Using a single instructional method to deliver lessons is believed to ignore the different learning needs of students in a class (Marais, 2016). Today"s classrooms are filled with students who vary greatly in terms of knowledge, skills, and other educationally significant attributes, and therefore have different educational needs (Garcia, 2016). Thus, no two students enter a classroom with identical abilities, experiences and needs. Regardless of their individual differences, however, students are expected to master the same concepts, principles, and skills (Ogunkunle & Onwunedo, 2014)**,** and educators are expected to address all learners" needs through their instructional and assessment practices (Suprayogi et al., 2017). Also, teachers need to ensure that all students have access to high-quality instruction and equitable academic outcomes (Fatima, 2023).

In an era of inclusive educational environments as described in "No Child Left Behind" (NCLB, 2001), where the goal is to provide each child with equal access to a high-quality education program, educators are mandated by accountability measures to increase student performance with limited resources (Husband, 2015). Again, policymakers stress that all students should be supported to develop their knowledge and skills at their own level (Schleicher, 2016) and there is a wish to improve equity or equality among students (UNESCO, 2017). In light of this, researchers urge teachers to embrace diversity and adapt their instruction to the diverse learning needs of students in their classrooms (Schleicher, 2016). Teachers can respond to this diversity by adapting their lessons to individual students‟ needs; an approach known as differentiated instruction (Tomlinson, 2014). To adapt their instruction, teachers need to identify students‟ learning needs and use this as a basis to make informed decisions about instructional adaptations. Identifying students‟ learning needs can be carried out by collecting data from students and analysing and interpreting these data (Gulikers & Baartman, 2017).

Differentiated instruction is a pedagogical theory founded on the concept of meeting the needs of academically diverse learners according to their readiness levels, interests, and learning profiles (Magableh & Abdullah, 2020). It involves modifying teaching instruction in such a way that all learners can be considered successful (Morgan, 2014). This approach promotes practices of monitoring students‟ needs and adjusting lesson components to those needs. With modifications made to lessons, students are challenged at appropriate levels to eliminate frustration and boredom. Educational researchers agree that differentiation is a hallmark of effective teaching (Tomlinson, 2014). According to Dack (2019), a teacher in a differentiated classroom recognises that, students enter learning experiences at different starting points and with different backgrounds; thus, they will benefit from multiple options to access information, an array of ways to process information, a variety of outlets to demonstrate learning, and a range of supports. Thus, DI is a way of thinking about teaching and learning rather than a prescriptive or packaged approach (Whitley et al., 2019).

Differentiation in education is a widely addressed concept that has been particularly relevant in the wake of the global visions of Education For All (EFA) and Inclusive Education (IE) (Tikly, 2017). These visions have been reaffirmed several times, including at the World Education Forum in Dakar, at the 48th session of the UNESCO International Conference on Education in Geneva, and finally by the Incheon Declaration that was signed at the World Forum on Education (UNESCO, 2015). The Education 2030 Incheon Declaration and Framework for Action not only reaffirms the visions of EFA and IE but is also a commitment to an education agenda captured by UN Sustainable Development Goal (SDG) 4: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (UNESCO, 2015). Both EFA and IE emphasise that all students should learn together, which entails a greater diversity in classrooms and schools, and that all students should benefit from the provided education which should lead teachers and schools to engage in creating a good learning environment for all students.

Differentiation can be applied to the content, process, and product (Dixon et al., 2014). Content includes what teachers intend to teach and how the students will achieve the level of knowledge and understanding. According to Tomlinson (2014), differentiating the content is to provide multiple ways to get the facts, concepts, generalisations or principles, attitudes, and skills related to the subject, as well as materials that represent those elements. Another area to differentiate is the process of teaching and learning or "how" the students get the information. To differentiate the process of learning, choices should be provided in expressing the concepts and facts

(Tomlinson & Imbeau, 2023). It is also added that the differentiated process should be directly relevant to the content and assist the learners in getting the knowledge and skills (Aliakbari & Haghighi, 2014). The third area of implementing differentiation is the product. It is the "output" through which the students show what they have gotten. Teachers differentiate the products by providing a variety of items students employ to demonstrate what they have learned as the result of a period of study (Aliakbari & Haghighi, 2014). The differentiated content, process, and product should be based on students‟ strengths, needs, and learning styles (Bal, 2016).

Differentiated instruction caters for the needs of all learners, transcending the inequality in knowledge dispersal and promoting the quality of teaching and learning (Ariss, 2017). Differentiated Instruction (DI) is eminent in ensuring that learners are provided with sufficient avenues of learning to make the most of their learning process (Moreno, 2015).

The effectiveness of utilising differentiated instruction to motivate learners to certain fundamental skills was discussed by Robinson et al., (2014), who discovered that on average, 83.4 percent of students' grades increased, while 12.5 percent stayed the same (Olicia, 2017). This means that differentiated instruction strategy provided a leap of increase in their academic performance. Also, Alsalhi et al. (2021) stated that, differentiated instruction is vital to effecting positive change in student performance because the one strategy-fits-all approach does not work in a real classroom. Moreover, according to Hollie (2017), students' attitudes and academic performance are enhanced when they are in responsive classrooms where they are treated as unique individuals and supported in their learning. Acknowledging the importance of differentiated instruction in today‟s diverse classrooms, the current study, therefore, aims at improving SHS students" academic performance in selected concepts in Integrated Science through differentiated instruction.

While differentiated instruction is an effective way to improve students' performance in various subjects, it is particularly crucial in subjects like integrated science, where students need to understand complex concepts, principles, and theories. According to a recent study by Tella et al. (2019), the integration of science subjects like biology, chemistry, and physics poses a significant challenge for students due to the abstract nature of the content. In most cases, students struggle to make connections between different concepts in science subjects, leading to poor understanding, application, and retention of scientific principles. Several studies also suggest that single teaching methods like traditional lecture-based teaching methods in science subjects are inadequate in catering to the diverse learning needs of students (Marolf, 2016; Chigbu & Adamu, 2023). Differentiated instruction recognizes the unique needs of each student and offers them appropriate support to achieve their academic potential. This approach enables the teacher to tailor instruction to individual students' needs and abilities, thus increasing their academic achievement and engagement (Tomlinson, 2017).

By differentiating instruction in integrated science, teachers can help students build cognitive connections between various scientific concepts and improve their academic performance. One of the essential aspects of differentiated instruction is the use of various instructional strategies and materials to meet students' individual learning needs. For example, Hughes and Arnold (2018) suggest that teachers can differentiate instruction by using varied questioning techniques, hands-on activities, simulations, and virtual labs, among others. Differentiated instruction also involves providing students with different avenues to demonstrate their understanding of concepts and principles. For instance, teachers can use performance-based assessments, such as project-based learning, to evaluate students' understanding of integrated science concepts.

According to Tomlinson (2014), DI promotes inclusivity and leverages on the unique strengths of each student, thereby motivating every student to learn. DI strategies in integrated science may include using real-life problem-solving activities, self-paced learning, project-based learning, and incorporating individualized activities, among others. According to Park and Park (2019), incorporating differentiated instruction in the classroom can help learners to feel valued, supported, and capable of pursuing goals beyond their classroom settings. Additionally, the study conducted by Egbe (2016) found out that the use of these differentiated strategies can help students to understand how to apply lesson concepts in real-world situations, leading to better comprehension and long-term retention.

Moreover, according to Reiff (2015), differentiating instruction can positively impact student attitudes towards learning, and increase the level of engagement and motivation of students, leading to better student outcomes in subjects such as integrated science. Additionally, studies show that students who are engaged in differentiated instruction tend to be more confident in their abilities and responsibilities as they get to identify their strengths and limitations (Sanders, 2018). Through Differentiated instruction, students' performances in integrated science can be considerably improved. The strategy provides multiple paths to learning, which, when properly implemented, lead to improved performance. Therefore, DI is an effective educational approach that encourages students to be active participants in the learning process, thereby improving performance significantly.

1.2 Statement of the Problem

The majority of Ghanaian teachers continue to use one method to teach all students the same concept (Bobi & Ahiavi, 2023). Interactions with students and observations of teachers of Ghana National College revealed that teachers of the school mostly use the lecture method to deliver Integrated Science lessons. According to the teachers, the Integrated Science syllabus is too voluminous therefore, the lecture method is the best method to use as it will help complete the syllabus on time.

However, this teaching method has not yielded the expected results as students continue to perform poorly in the subject. It has been found in most universities by many science education researchers that the lecture method in the classroom is less effective in both teaching and learning (Sakyi-Hagan & Hanson, 2020). Also, using a single instructional method to deliver lessons is believed to ignore the different learning needs of students in a class (Suprayogi et al., 2017). Because of this, most students do not benefit from classroom instructions. The story is not different at Ghana National College where the researcher teaches. The researcher‟s analysis of the results of class exercises and end-of-semester examinations of General Arts students of the school revealed low students‟ academic performance in the Integrated science subject.

Authors and researchers have attacked the idea of one-size-fits-all instruction (Wormeli, 2023; Belghoul, 2014), and numerous studies have demonstrated the effectiveness of differentiated instruction on students‟ perfomance (Little et al., 2014; Valiandes, 2015). Despite the extensive body of literature on differentiated instruction, there is a noticeable gap concerning its application to improve senior high school students‟ academic performance in selected concepts in Integrated Science. Consequently, this highlights the need for additional research to bridge this gap. Hence, the current study sought to improve senior high school students‟ academic performance in selected concepts in Integrated Science through the application of differentiated instruction.

1.3 Purpose of the Study

The purpose of this study was to improve senior high school students‟ academic performance in selected concepts in Integrated Science through differentiated instruction.

1.4 Research Objectives

This study sought to;

1. determine the effect of differentiated instruction on the academic performance of SHS students in selected Integrated Science concepts.
2. establish the differential effect of differentiated instruction on the academic performance of the male and female SHS students.
3. ascertain the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science.

1.5 Research Questions

The study was guided by the following research questions:

1. What is the effect of differentiated instruction on the academic performance of SHS students in selected Integrated Science concepts?
2. What is the differential effect of differentiated instruction on the academic performance of the male and female SHS students?

3. What are the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science?

1.6 Null Hypotheses

The following null hypotheses were formulated for the study:

H_{01}: There is no statistically significant difference between the mean academic performance of students before and after the use of differentiated instruction in the teaching and learning of selected Integrated Science concepts.

H_{02}: There is no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction.

1.7 Significance of the Study

This study is important because today‟s classrooms have become more academically diverse. By meeting the learning needs of all students, the current study may improve SHS students‟ academic performance in selected concepts in Integrated Science.

Also, the findings of this study may benefit teachers in their choice of effective and relevant approach in teaching Integrated Science.

In addition, the findings could motivate curriculum planners and designers to incorporate the use of differentiated instruction strategies in Integrated Science curriculum.

Moreover, fellow researchers may use the outcome of this study to replicate it in other study areas, improve on it or adopt it for similar studies. The outcome of this study may also serve as a basis for further researches.

Lastly, Professional bodies like Ghana Association of Science Teachers (GAST) may be motivated to use the findings of this study to organize workshops, seminars and conferences for teachers on differentiated instruction.

1.8 Limitations of the Study

This research was limited by time and cost constraints. This study was also limited by absenteeism on the part of some students due to sickness. Again, there was the problem of lateness of students to class. In furtherance, some of the targeted students were involved in other school activities such as sports, drama, debates and so did not participate fully in the research work. This made the implementation of the intervention difficult. Finally, test anxiety and mood of the students also influenced their responses to the research instruments.

1.9 Delimitations of the Study

Ghana National College was the only school selected for the study. Also, the study focused on only form two General Arts students of Ghana National College. Only some selected concepts in Integrated Science were used in this study. Time span for the intervention was six weeks.

1.10 Operational Definition of Terms

Terms applicable to this research were defined as follows:

Academic Performance: refers to a student's achievements and accomplishments in an educational setting, typically measured through assessments, examinations, grades, and other indicators of learning.

Content: Content is what we plan to teach, what we want students to learn (Tomlinson, 2015).

Differentiated Instruction: An approach implemented by teachers in a mixed ability classroom, aimed at ensuring that each student successfully masters any given concept, regardless of their learning style (Tomlinson, 2017).

Effect: Effect is a change that results when something is done or happens: an event, condition, or state of affairs that is produced by a cause.

Gender: Refers to the socially constructed roles, behaviours, expressions and identities of girls, women, boys, men, and gender diverse people.

Interest: Topics or pursuits that intrigue students (Kovtiuh, 2017).

Learning profile: Alludes to desired forms of learning or methods by which children thoroughly comprehend what they need to know and understand (Aulakh & Meloche, 2015).

Learning styles: A learning style is a preferred way of thinking, processing, and understanding information.

Pre-assessment: Pre-assessment is any means used by teachers to gather information about students prior to instruction.

Process: Process is how students come to own what they should know, understand, and can do (Tomlinson, 2017).

Product: Methods for students to demonstrate what they have learned, grasped, and can accomplish as a consequence of a long period of study.

Readiness: This has to do with a student‟s proximity to or proficiency with particular knowledge, understanding, and skill (Tomlinson & Imbeau, 2023).

Views: The beliefs or opinions that people have about something, for example whether they think it is good, bad, right, or wrong.

1.11 Organisation of the Study

This research study has been organized into five chapters. Chapter one covers the introduction of the study. Chapter two covers a review of relevant related literature. Chapter three covers the research methodology used to accomplish this study. Chapter four deals with the presentation of results. It also includes the analysis and discussion of the findings. It provides answers to the research questions outlined in chapter one. Finally, Chapter five covers the summary of the findings, conclusions and recommendations made.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter presents the review of relevant related literature to the study. The review is organised under the following sub-headings: Theoretical Framework, Conceptual Framework, The Concept of Integrated Science, Teaching and Learning of Integrated Science, Methods of Teaching Integrated Science, Gender and Academic Performance in Science Education, Differentiated Instruction, Benefits of Differentiated Instruction, Implementation of Differentiated Instruction, Barriers of Differentiated Instruction and Empirical Evidence of the Study.

2.1 Theoretical Framework

Learners differ in many ways, such as appearance, learning styles, multiple intelligence, previous experience, individual preference and social/emotional development (Mustafa, 2022). The goal of the differentiated instruction is to meet student needs in each of these areas. Consequently, there are a variety of learning theories which are applicable to differentiated instruction (Garderen & Whittaker, 2006). Specifically, the current study is underpinned by Vygotsky‟s socio-cultural learning theory and brain-based learning theory.

2.1.1 Socio-cultural learning theory

Differentiated instruction is grounded in the socio-cultural learning theory which is based on the work of Russian psychologist Lev Vygotsky (1962). The socio-cultural learning theory holds that the previous experiences and culture of the learner are critical because these influence the learning process for each individual. It is the background and culture of the learner that frames how he/she interprets the world, and what she/he discovers and attains in the process of learning (Formosinho & Formosinho, 2017). Consequently, the individual learner must be studied within a particular social and cultural context, as it is within the context of social relations with others that learning takes place. Therefore, social interaction is fundamental to the development of cognition (Vygotsky, 1962; Formosinho & Formosinho, 2017).

The Zone of Proximal Development (ZPD) is a central proposition of the socio-cultural learning theory. Vygotsky (1962) posits that the ZPD must be acknowledged in order to gain an understanding of the true relationship between learning and development. Vygotsky suggests that teachers should consciously tailor the instructions within learners‟ zone of proximal development- difference between what learners independently learn the concept and what learners can do with the help of more knowledgeable others with scaffolding (Fani & Ghaemi, 2011). Differentiated instruction based on ZPD would help variance learners as instructions will be tailored as per the learners‟ development (Magableh & Abdullah, 2019). If the content delivered is beyond the learners‟ ability to understand, it results in frustration and withdrawal of leaners (Morgan, 2014) or if the content is too easy, not up to their readiness level, learners get demotivated to learn resulting in creating the chaotic learning environment. During instruction, a teacher considers the learners‟ previous development and nudges the student forward, taking care not to go too far. If the learner is pushed out of his/her comfort level without an appropriate amount of guidance and support, the student will not be able to move forward to the ZPD. Vygotsky (1962) recommends that the teacher remain slightly ahead of the students‟ actual level of development in order to be within the ZPD. It is in this range that the learner is able to work independently and where new learning takes place. Consequently, the learning process leads the developmental process and learning occurs. Vygotsky (1962) asserts that pre-testing is essential in order to place students in their proper ZPD range. The readiness element of differentiated instruction is linked to this developmental component (Ginja & Chen, 2020). With an awareness of a students‟ ZPD, the teacher can assess student readiness levels and differentiate instruction according to student need.

2.1.2 Brain-based learning theory

Although brain research is relatively new, it continues to gain attention for having key implications for teaching and learning (Thomas et al., 2019). Universally, educators are noticing how the brain works and creates meaning, and how this knowledge impacts what should be happening in classrooms (Willingham, 2021). The brain-based learning is about being conscious about how the brain processes, stores, and retrieves information effectively (Degen, 2014). Brain-based learning has important implications for the differentiated classroom (Park, 2017). Research on brain-based learning suggests three broad related concepts that highlight the need for the instructional approach (Gaspar, 2014). First, in order for students to learn they must be in an environment conducive to learning (Lian, 2018). Gaspar (2014) maintains that students who feel unaccepted, intimidated or unsafe are unlikely to learn. If a student feels threatened or unsafe, they will have a flight or fight response where the adrenalin glands become overloaded and the student focuses on self-preservation rather than school work. In contrast, the differentiated classroom provides a safe and non-threatening environment that promotes student learning (Gibbs, 2023). Second, students need to be challenged at appropriate levels in order for learning to occur. Similar to Vygotsky‟s ZPD, it is important to challenge the learner just enough, taking care not to over or under challenge students. If the learner is over challenged, he/she will become frustrated and unable to learn (Pekrun, 2014). Further, when an assignment is at the right level of difficulty and challenge, the student has the opportunity to enter a state of “flow” (Hun et al., 2015). In this state the learner is fully engaged in the activity, yet at the same time highly detached from the act of doing it (Csikszentmihalyi et al., 2014). When teachers plan with student readiness in mind and students are highly interested in the task, the state of flow is likely to occur. In addition to the just right level of challenge, feedback is important for student success because it lets the learner know how he is doing and thus reduces anxiety (Brookhart, 2017). Consequently, when anxiety is lessened it lowers the pituitary-adrenal stress response which then makes room for new learning to take place (Stokes, 2019). Third, the brain needs to create its own understanding of ideas and skills by being presented with the whole (the concept) to part (the facts) so the learner can see the relationship between these and thus connect new information to prior knowledge (Halpern, 2014). Building on prior knowledge is critical, as isolated bits of information disconnected to what a learner already knows and makes sense of are resisted by the brain (Willingham, 2021). Thus, teachers need to construct many opportunities for students to connect the new with the old (Bada & Olusegun, 2015). The three concepts of brain-based learning can be presented in a variety of ways depending on student levels of readiness, the needs of the teacher, and the nature of the content being taught (Burkett, 2014).

The socio-cultural, and brain-based learning theories provide a lens through which to view the differentiated classroom and a theoretical framework for the study. Within this framework, this study sought to improve senior high school students‟ academic performance in selected concepts in Integrated Science through differentiated instruction.

2.2 Conceptual Framework

To differentiate instruction is to recognise students‟ varying background knowledge, readiness, language, preferences in learning, interests, and to react responsively. Differentiated instruction is a process to approach teaching and learning for students of differing abilities in the same class. The intent of differentiating instruction is to maximise each student‟s growth and individual success by meeting each student where he or she is, and assisting in the learning process. The model of differentiated instruction requires teachers to be flexible in their approach to teaching and adjusting the curriculum and presentation of information to learners rather than expecting students to modify themselves for the curriculum. Classroom teaching is a blend of whole-class, group and individual instruction. Differentiated Instruction is a teaching theory based on the premise that instructional approaches should vary and be adapted in relation to individual and diverse students in classrooms.

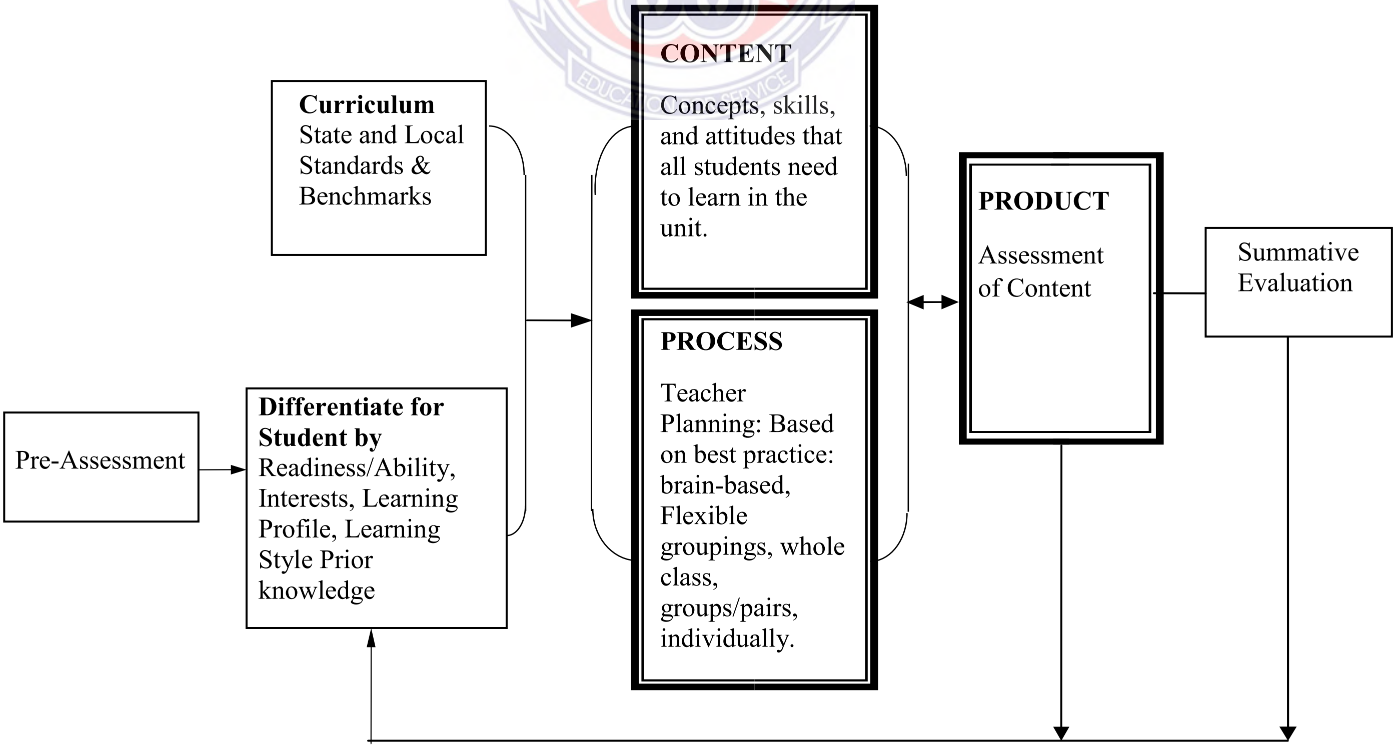


Figure 1: Conceptual framework of differentiation (Adapted from Hall, 2004)

As shown in Figure 1, pre-assessment is an important tool to assess students" readiness. Pre-assessment data allows the teacher to create lessons and activities that are appropriate for the students, no matter what level they are performing. Tomlinson (2014) identifies three elements of the curriculum that can be differentiated: Content, Process, and Products. Also, as Figure 1 shows, the curriculum can be differentiated by content, process, and product to adapt to the readiness level of the student.

The content is what the teacher plans on teaching, what the students need to learn about the topic. *Several elements and materials are used to support instructional content*: These include acts, concepts, generalisations or principles, attitudes, and skills. The variation seen in a differentiated classroom is most frequently the manner in which students gain access to important learning (Tomlinson & Imbeau, 2023). Access to the content is seen as key. *Align tasks and objectives to learning goals*: Designers of differentiated instruction determine as essential the alignment of tasks with instructional goals and objectives. Goals are most frequently assessed by many high-stakes tests at the state level and frequently administered standardized measures (Finn, 2015). Objectives are frequently written in incremental steps resulting in a continuum of skills-building tasks (Ogunkunle & Henrietta, 2014). An objectives-driven menu makes it easier to find the next instructional step for learners entering at varying levels (Ogunkunle & Henrietta, 2014). *Instruction is concept-focused and principle-driven*: The instructional concepts should be broad based and not focused on minute details or unlimited facts. Teachers must focus on the concepts, principles and skills that students should learn. The content of instruction should address the same concepts with all students but be adjusted by degree of complexity for the diversity of learners in the classroom (Boelens et al., 2018).

The process is the "how" the teacher decides to design the lesson. Student background data are taken into consideration when planning. Teachers need to understand that the prior knowledge with which students enter their classroom is based on many factors such as cultural background and family opportunities (Nelson & Guerra, 2014). The "how" must be based on best practices in instruction and student learning such as readiness, interest, learning profile, choice, and learning styles of the students. *Flexible grouping is consistently used*: Strategies for flexible grouping are essential. Learners are expected to interact and work together as they develop knowledge of new content. Teachers may conduct whole-class introductory discussions of content big ideas followed by small group or pair work. Student groups may be coached from within or by the teacher to complete assigned tasks. Grouping of students is not fixed. Based on the content, project, and on-going evaluations, grouping and regrouping must be a dynamic process as one of the foundations of differentiated instruction (Tawil, 2014). *Classroom management benefits students and teachers*: Teachers must consider organization and instructional delivery strategies to effectively operate a classroom using differentiated instruction (Benjamin, 2014).

The product, which is some form of assessment of the content, also revolves around the readiness, interests, and learning profile of the student. *Initial and on-going assessment of student readiness and growth are essential*: Meaningful pre-assessment naturally leads to functional and successful differentiation (Doubet & Hockett, 2017). Assessments may be formal or informal, including interviews, surveys, performance assessments, and more formal evaluation procedures. Incorporating pre-assessment and on-going assessment informs teachers to better provide a menu of approaches, choices, and scaffolds for the varying needs, interests and abilities that exist in classrooms of diverse students (Westedt, D.2019). *Students are active and* *responsible explorers*: Teacher‟s respect that each task put before the learner will be interesting, engaging, and accessible to essential understanding and skills. Each child should feel challenged most of the time (Tomlinson, 2017). *Vary expectations and requirements for student responses*: Items to which students respond may be differentiated for students to demonstrate or express their knowledge and understanding. A well-designed student product allows varied means of expression, alternative procedures, and provides varying degrees of difficulty, types of evaluation, and scoring ((Ogunkunle & Henrietta, 2014).

2.3 The Concept of Integrated Science

Kurniawati et al. (2017) saw integrated science as one way of teaching science. Integrated Science is an approach to the teaching of science in which concepts and principles are presented so as to express the fundamental unity of scientific thought and avoid premature or undue stress on the distinctions between the various scientific fields (Asrizal et al., 2018). According to Abbey et al. (2001), science is integrated when all aspects of science that is biology, chemistry, physics and agriculture are treated holistically such that none of the aspects stands on their own. Also, science becomes integrated when the problems of mankind are not considered from only one direction of science. For example, a medical doctor needs to have ample knowledge in biology to be able to understand the anatomy of a patient, chemistry will provide him/her with knowledge about drug composition, and physics will equip him/her with the right skills in measuring the height, weight and temperature of the patient and agriculture, which will deal with the diet of the patient. All this knowledge is very essential in quality health delivery on the part of a medical doctor.

The term "integrated science" is often used as a synonym for interdisciplinary and unified science, which may be applied generally to curriculum, effort in which two or more previously separated science subjects are combined (Tripp & Shortlidge, 2019). Green and Andersen (2019) identified four groups of meanings of integration in science; *as the unity of all knowledge, as the conceptual unity of the sciences, as a unified process of scientific enquiry, and as interdisciplinary.*

On 17th June 1969, when Stephen Oluwole Awokoya gave his opening address in Paris at the planning meeting for UNESCO"s program in integrated science teaching, he naturally was optimistic concerning the future achievement of the program (Nielsen, 2016). Most children in the developing regions of the world do not go beyond primary education if they have any formal education at all (Glewwe & Muralidharan, 2016). Introducing Science to even the youngest school children and pre-schoolers, therefore, was necessary, or they would miss it entirely. This course has been designed to offer a body of knowledge and skills to meet the requirement of everyday living and also provide an adequate foundation for the study of other subjects and for those who wish to pursue further education and training in science-related vocations.

The CRDD and GES in September 2010 placed some emphasis on the rationale for the teaching and learning of Integrated science in the SHS syllabus (CRDD, 2010). The syllabus talked about scientific literacy for every Ghanaian. They saw it to be the only way by which the country can create a scientific culture towards achieving the country"s strategic program of scientific and technological literacy in the shortest possible time. The study of Integrated Science and the application of its product has improved the standard of living of humankind worldwide (Owusu & Baiden, 2018).

Farrant (2002) stated that teaching Integrated science should help students gain an understanding of the concepts themselves and their environment. This will help them to develop their intellectual skills which will increasingly allow them to meet other aims and objectives of science. Therefore, in order for all students to benefit from Integrated science lessons, teachers must develop lessons that will take care of the diverse needs of students in their classrooms.

2.4 Teaching and Learning of Integrated Science

Learning science is a changing process of shaping and reshaping thoughts based on new knowledge and experiences. It is the creative, ongoing synthesis of observations, reflection, and information about the physical and social world (Russell & Martin, 2023). Learning, is a purposive activity on the part of the student and requires active engagement. Some science teachers teach science as lists of facts to be memorised (Russell & Martin, 2023). Students learn science content in school by studying a textbook that reports the conclusions of what scientists have learned over the decades. According to Kind and Osborne (2017), science had been taught as rhetoric of conclusions, a presentation of facts already known, so students often fail to integrate the content of one science with another. Good teachers" help students learn meaningfully to achieve quality over quantity, meaning over memorization, and understanding over awareness (Sprenger, 2018). Tomlinson (2015) suggested that the science classroom should be learner-centered, knowledge-centered, assessment-centered, and community-centered which is a useful framework to employ in the design of instruction. Assessment is one of the key roles in teaching and learning science. Gioka (2007) mentioned that *assessment for learning* is any assessment for which the first priority in its design and practice is to promote learning. Assessment methods can be categorised into two major uses: Summative and formative (Svensäter

& Rohlin, 2023). Summative assessment measures which students have learnt at the end of set of learning activities (Kibble, 2017). In contrast, formative assessment focus on opportunities for students and teachers to use feedback to revise their thinking (Irons & Elkington, 2021).

Matthews (2014) noted that it has been hoped that science teaching would have a beneficial impact on the quality of culture and personal life by virtue of students not only knowing science, but also by internalising something of the scientific spirit, and knowing and appreciating something of the nature of science. Teaching methods are the most important techniques employed by teachers to realise the objectives of a lesson (Kistner et al., 2015). There are many teaching methods in education that enhance the learning processes of students. For a particular teaching method to be appropriate and efficient it has to be in relation with the characteristic of the learner and the type of learning it is supposed to bring about.

According to Kim and Seidman (2019) teaching is a continuous process that involves bringing about desirable changes in learners through use of appropriate methods. Firman et al. (2020) indicated that in order to bring desirable changes in students, teaching methods used by educators should be best for the subject matter. So, to aid the process of transferring knowledge to students, the teacher has to adopt a technique that can assist students in retaining the information acquired, arousing the interest of the students and improving their understanding of the subject matter. Focusing on this, Furner (2017) advocated the use of a more effective method of teaching science; differentiated instruction, no doubt can be one of such technique. Therefore, this study sought to improve senior high school students‟ academic performance in selected concepts in Integrated Science through differentiated instruction.

2.5 Methods of Teaching Integrated Science

The term teaching methods refers to the general principles, pedagogy and management strategies used for classroom instruction (Jackson, 2012). However, Joshi (2008) also defined teaching methods to include a utilisation of appropriately selected curriculum materials, content and learning experiences, motivational strategies, an application of learning theories and a demonstration of a knowledge of developmental psychology or other aspects of educational psychology in the teaching and learning process. Chifwa (2015) posits that in order for teachers to decide what teaching method to use, the teacher must know what teaching methods are available, what strengths and weaknesses these methods have, what purpose each method serves and how to use the methods. Teaching methods are chosen on the basis of fitness for a particular purpose. A number of factors determine what strategies a teacher should use to accomplish a given learning outcome. These factors may include age and academic level of students, amount of time available, physical environment, availability of teaching and learning resources as well as the topic being presented. Danjuma (2015), posits that for any meaningful learning and teaching to take place, there should be suitable means of presenting the content to the learners at all levels of education. The means or strategies of presenting the content to the learners depend on the familiarity with the basic principle of effective teaching method in science. Bichi (2009) states that the basic principles of effective pedagogy in science teaching include mastery of science contents, wise use of instructional methods, knowing the psychology of the students, teacher‟s knowledge about himself and conducive environment for learning. A variety of teaching methods increase students‟ attention and interests and also help the teacher to manage the class well (Petty, 2009).

Many teaching methods have been used in teaching of Integrated Science over the years but the most notable of them are as follows: demonstration method, project method, inquiry method, guided discovery method, problem solving method, laboratory activity method, discussion method, and lecture method.

2.5.1 Demonstration method

According to Ekeyi (2013), demonstration method is a type of teaching method in which the teacher is a principal actor while the learners watch with the intention to act later. Demonstration means an act of showing something by proof or evidence. From the definition, it can be seen that the purpose is to show and explain how something works or is accomplished. Demonstration method is a teaching method that relies heavily upon showing the learner a model performance that he/she should match or pass after he has seen a presentation that is live, filmed, or electrically operated. The teacher shows the students how to do it and explains the step-by-step process (Nkwocha & Owolabi, 2023). Demonstration often occurs when students have a hard time connecting theories to actual practice or when students are unable to understand application of theories. Demonstration method is an elegant method of teaching because it improves students" understanding and retention (Mckee, Williamson & Ruebush, 2007). Mohan (2010) agrees that a demonstration method has several advantages that make it very useful in teaching science as it allows learners to observe real objects and events, it helps in economising resources, minimise risks and hazards associated with certain experiments. Demonstration method focus to achieve psychomotor and cognitive objectives. In demonstration method, no time is wasted because students see the process live and understand how to apply theoretical knowledge practically. The method of demonstration model helps to model others. It promotes self-confidence, opportunity for targeted questions and answers, allows attention to be focused on specific details rather than general theories, and saves time in its presentation. In addition, learners concentrate on relationships to be understood, makes efficient use of the power of observation. It is also a means of strong motivation, and can be used in training groups or individuals. Furthermore, it involves both senses (sight and touch) which play vital role in learning process; it helps to achieve psychomotor objectives; it makes complex tasks/skills simple to students (Umar, 2013). However, demonstration can be of limited value for people who do not learn best by observing others, it may not be appropriate for the different learning rates of the participants, it requires that demonstrator should have specialized expertise if highly technical tasks are involved. Furthermore, demonstration method can be used only for skills subject. Also, acquiring demonstration equipment and tools is sometimes not easy, and it requires that the teacher should be an expert in that field otherwise a resource person should be invited (Umar, 2013).

2.5.2 Project method

This is a method in which students learn through independent activity under the guidance of a teacher (Yuliani & Lengkanawati, 2017). The Project Method is a teaching approach which allows students to identify and choose a piece of work, topic or a problem to investigate. Here, students are allowed to go out to obtain relevant information for the purpose of the project. The Project method is entirely student-centred and students could either work individually or in groups. The teacher"s role is to monitor how the project is being executed, give encouragement and offer assistance when necessary. At the end of the project, students are expected to write their report. It is important that students" reports are discussed in class. The project method is one of the most effective methods of teaching science since it provides an excellent opportunity for students to think and afford the opportunity to study on their own. This implies that in project method the students have the chance to define problem, plan his or her own work, find appropriate resources to carry out his or her plan and at end draw a conclusion, they learn to train themselves for the task ahead of them in the future.

Since this method enables them to carry out an investigation on their own, it leads students to develop science process skills, stimulate the development of scientific attitude and of course facilitate meaningful learning of science (Danjuma, 2015). Boss and Krauss (2022) noted, that the use of project was very helpful in assisting the learning of students. It also helps to foster cooperation and unity among students. It enhances creativity and motivates students. On the other hand, the project method consumes too much time and effort. The project method is very expensive to administer and use; a lot of relevant books, materials, experts and instructions are required to ensure success of a project.

2.5.3 Inquiry method

According to Quintana et al. (2018), inquiry method is an art of questioning, exploring and experimenting which is the process of science. Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation (Pedaste et al., 2015). In scientific inquiry, students engage in a thoughtful and coordinated attempt to search out, describe and explain and predict a natural phenomenon (Rönnebeck et al., 2016). As highlighted out by Lazonder and Harmsen (2016), inquiry method of teaching is of two types: guided inquiry and open inquiry. In guided inquiry, the students determine the methods they will use to produce their own conclusions to a problem posed by the teacher, and as such, the teacher plays the role of a guide to the students. In the open inquiry, the students select the topic to be studied and the methodology used to yield their own conclusions from the investigation. Some of the advantages of inquiry method of teaching include:

student-centred instruction because students carry out investigation themselves; students developing more interest in the lesson because they are actively involved; inquiry learning builds in students‟ self-concept, meaning that students are willing to take explore, tolerate minor failures and learn science. Also, research has shown that students who have historically been low achievers in science can succeed in inquiry based-learning (Sotiriou et al., 2020). However, Pierre (2014) is of the opinion that inquiry method can be time consuming and slow and may not be suitable under the structured school curriculum.

2.5.4 Guided discovery method

The Guided Discovery Method is an approach in science teaching which was postulated by Brunner (1961) is seen to enable students to get first-hand experience in getting facts, concepts, principles and processes by using mental process and manipulating scientific equipment and materials. Brunner believed that a child who is exposed to guided discovery gets four benefits: a shift from extrinsic to intrinsic motivation, an increase in intellectual attainment, valuable to students‟ investigation processes and, serves as a memory aid. The Guided Discovery Method is applicable to virtually all areas of teaching and the types of activities in which the students are involved, vary from topic to topic and with the age and ability of the student. The amount of guidance the students receive from the teacher also varies but is never excessive. The method encourages mental skills development of students as well as their observing, measuring, classifying ability among others (Yuliani & Saragih, 2015).

2.5.5 Problem-solving method

The Problem-solving method is an instructional strategy in which problems (scientific in nature or related to the real world) are carefully formulated and presented to students (Yu et al., 2015). In the process of solving problems, students interact with one another using instructional materials and ultimately construct knowledge and acquire the process of science. The Problem-solving method is a way of helping students to see the personal relevance and the applicability of the science they learn. Problem-solving provides opportunities for students to work as scientists, investigating phenomena in a systematic way and finding solutions to scientific problems. Problem-solving promotes investigative thinking in children and it enables the learner to experience new ideas. Problem-solving process is interesting, challenging and therefore motivating (Griffin & Guez, 2014).

2.5.6 Laboratory activity method

The Laboratory Activity Method is an activity performed by an individual or group of students for the purpose of making personal observations or processes, products or events. It has been used in teaching science as a means of verifying principles, laws or theories; practicing one or more cognitive skills such as ability to observe, classify, measure, interpret data, etc. and, to determine the relationship between causes and effects (Abdullah & Mohammed, 2018).

2.5.7 Discussion method

Chifwa (2015) observes that discussion method is one of the teaching methods used to teach science subjects. According to Phd and Phd (2016), discussion is a process of giving and talking, speaking and listening, describing and witnessing which helps expand horizons and foster mutual understanding. It represents a type of teamwork, based on the principle that the knowledge, ideas, and feelings of several members have great merit than those of a single individual. An important ingredient of many teaching-learning situations is group discussion (Palappallil el al., 2016). Rosaline and Prasetyo (2017) emphasised that, discussion is a forum in which students can practice expressing themselves clearly and accurately, hearing the variety of forms that expression of the same idea can take, and criticising and evaluating successive approximations to an adequate statement. Since student-initiated questions are more common in discussion classes, their needs and interests are dealt with more readily and spontaneously than in other methods. Discussion method offers not only the benefit of students becoming active in the discussion but also to teach students how to become well-functioning members of their societies since they learn to contribute in the discussion. It increases students‟ awareness of and tolerance for ambiguity or complexity. Also, it helps students learn the processes and habits of democratic discourse and to explore a diversity of perspectives. Looking at the disadvantages of the discussion method, it does not allow for easy coverage of syllabus. Not all topics can be handled through discussion since there are topics in which students may not have any prior knowledge. If discussion lasts for a long time, attention of students‟ wade. Discussion consumes a lot of time during the course of knowledge negotiation.

2.5.8 Lecture method

This is the most popular and traditional teaching method used by teachers in presenting scientific information. According to Danjuma (2015), the lecture method is a teacher-centred method, which is seen as the traditional talk – chalk method of teaching. Here, teacher does the talking while students serve as receivers only by listening and taking down notes. Sadeghi et al. (2014) describes the lecture method simply as an oral presentation of instructional material. Zhampeiis et al. (2022)

defined lecture method as a didactic instructional method, involving one-way communication from the active presenter to the more or less passive audience. The teachers are the source of information whiles students have to remember what the teacher says (Willingham, 2021). Marmah (2014) described lecture method as education through the transmission of information and suggested that this theory of learning assumed that students are passive recipients of knowledge transmitted by the teacher. Teachers are more active and students are passive but the teacher also has to ask questions to keep the students attentive. This method is used for a large number of students, materials can be covered in a structured manner and the teacher has a great control of time and material. The lecture method of teaching has a lot of advantages. Among these are as follows: It is good for teaching facts and basic skills (Killen, 2007), Lecture method is quite economical and it is possible to handle a large number of students at a time and no laboratory, equipment, aids, and materials are required (Marmah, 2014). It presents large amount of information to large groups (Roach, 2014). Apart from these advantages, the lecture method of teaching also has its accompanying disadvantages. In the lecture method, teachers are not able to teach motor skills, influence attitudes and values, teach application, synthesis or evaluation. It often renders learners passive (Roach, 2014). Students become dependent on the teacher to tell them what they need to know and can avoid taking responsibility for their own learning. The teaching method that a teacher adopts is one factor that may affect students‟ performance (Lawrence & Tar, 2018). Also, Atadoga and Lakpini (2013) posited that the persistent low academic performance in science education is attributed to teacher instructional strategies, learning style preferred, among others. Thus, instructional strategies used by teachers in teaching- learning process have significant influence on learners‟ academic performance. Therefore, the use of appropriate teaching method is critical to the successful teaching of Integrated science. Several studies suggest that traditional lecture-based teaching methods in science subjects are inadequate in catering to the diverse learning needs of students (Ge et al., 2020; Bhat et al., 2022)

For effective teaching to take place, skilful science teachers need to use different teaching methods, techniques and approaches at their disposal. A carefully designed teaching method can make teaching and learning effective (Morrison el at., 2019). Therefore, teachers need to use effective teaching methods that cater for students" differences and needs. Differentiated instruction caters for the needs of all learners, transcending the inequality in knowledge dispersal and promoting the quality of teaching and learning (Ariss, 2017). This approach enables the teacher to tailor instruction to individual students' needs and abilities, thus increasing their academic achievement and engagement (Tomlinson, 2017). By differentiating instruction in Integrated Science, teachers can help students build cognitive connections between various scientific concepts and improve their academic performance. Focusing on this, the current study sought to improve senior high school students" academic performance in selected concepts in Integrated Science through differentiated instruction.

2.6 Gender and Academic Performance in Science Education

Several studies have examined gender differences in academic performance across various subjects, including Integrated Science. In their study, Smith and Johnson (2015) analysed the test scores of 500 high school students in Integrated Science and found that female students outperformed their male counterparts. The researchers suggested that this advantage might be attributed to girls' better verbal skills and higher motivation levels in science subjects. Contrarily, a study conducted by Jones et al. (2018) involving a sample of 800 middle school students revealed that male students achieved higher scores in Integrated Science compared to their female peers. The researchers speculated that boys' greater spatial reasoning abilities and interest in hands-on experiments contributed to their superior performance in the subject. Also, Smith (2018) conducted a comprehensive study involving a large sample of secondary school students and found significant gender differences in academic performance in Integrated Science. The study revealed that male students tend to outperform their female counterparts, particularly in practical components and higher-order thinking tasks. Sharma (2013) carried out a research work on gender related effects on academic performance. The findings show a markedly low performance of female students than their male counterparts in science educational programme and science related courses. This low performance of females over their male counterparts lead to greater dominance of males over females compared to their male counterparts in the field of science and technology, and has led many scholars to say that science is gendered as it is practiced (Akanbi, 2002).

Several factors have been identified as potential contributors to the gender differences observed in academic performance in Integrated Science. Studies have shown that the presence of a supportive and inclusive learning environment, where teachers promote gender equality and provide equal opportunities for participation, can positively impact girls' performance (Master et al., 2017). Additionally, incorporating hands-on activities, collaborative learning, and inquiry-based approaches have been found to enhance academic achievement for all students, irrespective of gender (Tsui & Treagust, 2013). Conversely, traditional didactic teaching methods and gender-biased classroom interactions were associated with lower academic performance among female students. Additionally, according to a study by Brown and Davis (2016), gender stereotypes regarding science-related abilities and interests can affect students' self-perception and academic performance. Females may experience stereotype threat, which negatively impacts their performance and engagement in science subjects, including Integrated Science. A study by Martinez and Lee (2017) revealed that parents' educational expectations and involvement in their children's education were significant predictors of academic performance in Integrated Science. The researchers found that parents who held gender-biased beliefs regarding science-related abilities tended to have lower expectations for their daughters' academic achievements, which, in turn, affected their performance in the subject. Factors such as stereotyping, teaching methods, classroom dynamics, and parental influence have been identified as potential contributors to these differences. Understanding these factors is crucial for developing interventions and educational strategies that promote gender equality in Integrated Science education and enhance academic outcomes for all students.

Science teachers play a vital role in addressing the problem of gender in science education. According to Levi (2000), there are three roles a science teacher must play. Namely: i. Ensure provision of equal opportunities and respect for differences in the classroom. ii. Ensure that boys and girls have the same experience and that is, treat boys and girls equally. iii. Compensate for gender difference in the society.

This study sought to improve senior high school students‟ academic performance in selected concepts in Integrated Science through differentiated instruction.

2.7 Differentiated Instruction

Literature regarding differentiated instruction includes several definitions of it. According to Ginja and Chen (2020), differentiated instruction is a method of teaching that is characterised by deliberate and conscious attempts to address students‟ diversity. Kotob and Arnouss (2019) defined differentiated instruction as a set of strategies that will help teachers meet each student where they are when they enter class and move them forward as far as possible on their educational path. Tobin and Tippett (2014) also added that, differentiated instruction is an approach to teaching and planning that can address the needs of diverse learners in an inclusive classroom. To Tomlinson and Jarvis (2023), differentiated instruction is 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. Furthermore, differentiated instruction, is the process of ensuring that what a student learns, how he or she learns it, and how the student demonstrates what he or she has learned is a match for that student's readiness level, interests, and preferred mode of learning (Tomlinson, 2014). Heacox (2012) also defined differentiated instruction as changing the pace, level, or kind of instruction you provide in response to individual learners‟ needs, styles, or interests. It is a proactive, student-centered, qualitative, and rooted-in-assessment process and a series of whole-class, large/small group, and individual instruction (Tomlinson, 2014). Besides, differentiated instruction considers that all students are different; they learn differently and like different things (Shareefa, 2021). Teachers who practice differentiated instruction are sensitive to the developmental differences among children (Dixon et al., 2014) and thus they plan, teach, and arrange the classroom environment in a way that accommodates each child‟s unique needs and interests. Differentiated instruction occurs when a teacher plans a lesson that adjusts either the content being discussed, the process used to learn or the product expected from students to ensure that learners at different starting points can receive the instruction they need to grow and succeed. The reason for adopting this method of teaching, as believed by Tomlinson (2014), is to enhance three crucial elements: efficiency of learning, access to learning and motivation to learn. Also, Tomlinson (2017) added that, the chief objective of differentiated instruction is to take full advantage of every student"s ability to learn. Using differentiated instruction inside the classroom recognises the diversity of the learner, and it affirms that each learner has his or her own style of learning inside the classroom. The differentiated classroom will help the teacher to support and respond to the academic needs of the learner.

According to Tomlinson (2014), in a differentiated classroom, there is no room for fear and students are free to take risks in their learning. By developing lessons according to students" readiness levels, interest, learning profiles, teachers will be able to integrate students" prior knowledge and experiences outside the school environment which will empower students to view things differently and share their opinions because they already have knowledge and interest in the topic. Differentiated Instruction requires the modification of a given curriculum with respect to students" needs, learning styles and strengths (Freedman, 2015). With modifications made to lessons, students are challenged at appropriate levels to eliminate frustrations and boredom.

Differentiated instruction can be applied in different areas like the content, process, and product based on students" readiness, interests and learning profile (Tomlinson, 2017).

2.7.1 Differentiation by content, process and product

According to Ismael and Fahady (2022), content is the input of teaching and learning. It is what is being taught or what teachers teach. Content can be differentiated by targeting specific goals for the student to master (Tomlinson, 2014). Content is differentiated when teachers focus on the most important concepts and skills while increasing the complexity of learning. Content is usually based on the standards determined by the school or district. It encompasses both what the teacher plans for students to learn, and how the learning will occur (Tomlinson, 2014). Tomlinson (2017) stated that differentiating the content will provide multiple ways to deal with the facts, the concepts, principles or attitudes and the skills the students are dealing with. Sebihi (2016) explained that all students in the same level should go through the same content but the teachers should adjust the complexity degree by following varied instructional processes to teach the content. The idea is that all students should learn the same concepts in different ways. Teachers can either vary the content by differentiating the complexity or having the same content to all but differentiate the activities. When differentiating content, the teacher strategically selects what is to be taught and what resources to use. This can be accomplished by using a variety of differing instructional materials, offering students choices, and eliminating unnecessary content (Tomlinson & Imbeau, 2023). Organising instructional content enables students to make connections between their lives and learning which is meaningful and personal (Paolini, 2015). Typically, what the student learns is constant while the ways in which students gain access to the content is modified.

Sebihi (2016) stated that the process is the activities that help the students gain the concepts of the content. He added that the key to differentiate the process is the flexible grouping in which students are grouped based on readiness, interests and sometimes based on learning profiles. Modifying the process requires variety of activities and teaching strategies for students to make sense of learning (Tomlinson, 2014). The activities provided for student learning must address differing student abilities, learning styles, and interests. Teachers must adjust their teaching style to reflect the needs of different students by finding out where students are when they come into the process and building on their prior knowledge to advance their learning (Awla, 2014). Care should be taken to support less-able as well as advanced students (Tomlinson, 2014). Consequently, different amounts of teacher or student support for a task can be provided based on student need. The teacher also supports students by providing them with different options at varying levels of difficulty. Tomlinson (2017) explained that the process should be linked to the content and it is integrated with it. Learning has to happen in students not to them. An effective activity calls for students to use a critical skill to gain understanding of an important idea and is focused on a learning goal (Tomlinson, 2017). Further, effective activities ask students to grapple with a skill so they come to own it and make sense of it themselves. Effective activities help students to progress from a current point of understanding to a more complex level of understanding (Tomlinson, 2014).

The product is the outcome by which students demonstrate what they have learnt. It must reflect student learning styles and abilities (Biggs, 2014). Here, the teachers differentiate the product by giving a variety of items students can employ to show their learning (Tomlinson, 2017). Thus, differentiating product is offering students varied opportunities to express what they know in various ways. Different students can produce different products based on their readiness, interests and learning profiles. Students may choose to work alone in their product or they may choose to work with a group of interests (Tomlinson, 2014). Heather (2013) remarked that the product the teachers suggest to students should be authentic and deal with real problems, depend on problem solving and express concerns. The product should not summarise but rather synthesise information. A quality product requires students to think critically and creatively about what they learned, apply this information, and extend their understanding and skill (Tomlinson, 2017). Culminating products vary according to student readiness, interest and learner profile and should be interesting and challenging (Tomlinson, 2017). By differentiating instruction by content, process, and product, teachers are likely to find more ways for all students in a classroom to be engaged and motivated and will probably reach more students‟ valuable learning differences in a classroom.

2.7.2 Differentiation by students' interest, readiness and learning profiles

Students are all different; they come to school from different backgrounds with different interests, knowledge and learning styles. These student characteristics influence the need for teachers to modify curriculum and instruction for learners. According to (Westwood, 2018), teachers are clearly challenged by the task of diversifying instruction in order to help every child meet their full potential. When teachers consider and are aware of students‟ diverse interests, readiness levels, and learning profiles then they will provide better instruction and plan learning opportunities that promote student success. Curriculum can also be differentiated according to students‟ interests, readiness, and learning profiles.

Interests refer to topics that motivate a student or peak one‟s curiosity (Hidi & Renninger, 2019). Allowing for student interests ensures that every single learner finds a place in the learning community (Burden, 2020). Weselby (2014) stated that interests start from topics that arouse passion in learners‟ learning and in which they would like to spend their time and effort in learning. Sebihi (2016) remarked that teachers differentiate instruction using different resources to fulfil students‟ varied needs in the same classrooms. Tomlinson (2014) explained that the curriculum may sometimes seem limited; however, different students may show different interests in different topics. The idea behind differentiating students‟ interests is to hook (Tomlinson, 2014) students on certain areas of study to keep interest which fosters task, behaviour and increase marks as well.

Differentiating by interest is very validating for students. It makes school lessons relevant to their lives and supports them in making connections between concepts, both of which increase student performance and retention of concepts (Tomlinson, 2014). When differentiating according to student interest, essential skills and material for making meaning from content are linked with topics that fascinate students (Tomlinson, 2014). When learning is exciting and interesting students are more likely to be engaged. In addition, motivation to learn is likely to increase when students are passionate about the topics they study (Johnson, 2017).

Student interests vary, these interests can become effective tools to support learning in the differentiated classroom (Tomlinson, 2017). Tomlinson (2017) sees student interests as a powerful motivator, which wise teachers could take advantage of within the differentiated classroom. Teachers should find ways to engage students, by tapping into what interest students, and by involving students in the daily running of the classroom (Johnson, 2015). Activities and discussions that are built around students‟ concerns and their life experiences allows the curriculum to become more meaningful to students (Bovill et al., 2016).

Allowing for student interests within the learning community, ensures that even marginalised students find a place (Nieto, 2015). Most students, even struggling learners, have aptitudes and passions, providing an opportunity within the classroom for them to explore and express these interests, mitigates against the sense of failure previously experienced by these students (Tomlinson, 2017). Opportunities can be created to foster group learning and provide options for individual instruction or independent learning (Martín-Gutiérrez et al., 2015). Teachers who are perceptive to the learning needs of their students help learners to make productive choices about the ways in which they will learn best (Sreena & Ilankumaran, 2018).

Readiness refers to the level of skill and understanding a student has for a topic and the extent to which he/she can be challenged with a task and still be successful (Chavan & Carter, 2018). It has to do with student‟s prior learning, experiences, and students‟ attitudes toward school and subjects. Teachers should recognize the readiness levels of students and accommodate them by providing different levels of tasks (Borja & Sanchez, 2015). Readiness can vary widely in the classroom overtime based on the circumstances and the topic as well. Tomlinson (2014) remarked that if readiness varies in one classroom, so should the complexity of provided material. So, to solve the readiness variance, tiered activities are the solution. (Weselby, 2014). To determine student readiness, assessment must occur in order for teachers to gain awareness about what students already know as well as any misconceptions students may have regarding a topic. Differentiating tasks by readiness level nudges students to go beyond their comfort level and provides support in bridging the gap between the known and the unknown (Tomlinson, 2014). Thus, teachers can plan appropriate lessons and assignments which challenge students just enough to promote further learning (Pollock & Tolone, 2020).

When differentiating by readiness, teachers give more challenging assignments to advanced learners and more basic ones to struggling learners. All students must be engaged in respectful work which teaches essential understandings, rather than having higher-performing students doing interesting work and lower-performing students doing dull drills (Tucker, 2019).

Learning profiles are central in determining how lessons will be taught (Kirschner, 2017). The learning profile of a student is the specialised style in which the student prefers to learn (visually, auditory or kinaesthetically). Sebihi (2016) refers to learning profile as how a student learns best. Tomlinson (2014) suggested that each individual has a learning method and style that best meets their needs. So, if teachers have the awareness of all methods and they use them, they are meeting the different learning profiles of the students. In this way, teachers differentiate by learning profiles whenever they provide activities that meet students" choices to master learning. So, when different models are presented to students, more students will successfully finish the task (Gillies, 2016).

The goal of learning profile differentiation is to help students know the ways in which they learn best and give them opportunities to use that particular mode in their learning. In this way, every student can find a good fit for himself/herself in the classroom (Tomlinson, 2014). Responding to student learning profile involves addressing student"s intelligence preference, learning style, gender and culture (Tomlinson, 2014).

Intelligence preference refers to the ways of learning and thinking each of us has that reflects our strengths and weaknesses within these (Biggs, 2014). Gardner"s framework (1993) refers to these as: verbal linguistic, logical mathematical, visual spatial, musical rhythmic, bodily kinaesthetic, interpersonal, intrapersonal, and naturalistic. Gardener (1993) contends that everyone has at least some of each of the eight intelligences in various combinations and strengths. Both teachers and students benefit from knowing the intelligences. The multiple intelligences are helpful to students from elementary through high school. Students benefit from having an understanding of why they do well with some assignments and not as well in others. In addition, having an understanding of the intelligences assists students in making wise decisions when they are given choices about learning (Ndlovu, 2020).

When students utilise their intelligence preferences to approach learning, the outcome is very positive (Biggs, 2014). Another preference essential to a student"s learning profile is learning style. Learning style reflects individual student preferences for where, when and how students take in and make sense of information (Awla, 2014). Learning styles encompass the following factors: Environmental elements (sound, light, temperature), social organisation (working alone or with others), physical circumstances (degree of movement, time of day), emotional climate (amount of structure, student motivation), and psychological factors (the degree to which a student is analytical, reflective, or impulsive) (Heacox, 2012). According to Awla (2014), matching students' learning styles with appropriate instructional strategies improves their ability to concentrate and learn. Consequently, if there is a mismatch between learning styles and instruction, students feel anxious and even physically ill trying to learn (Weinstein & Underwood, 2014). Effectively differentiating instruction is necessary for success using learning styles. Tsingos et al. (2015) asserts that teachers must strategically use varied teaching and assessment methodology if they are to reach the different learning styles of students.

Differentiating according to learning profile often means that teachers need to base assignments on students" differing rates of learning. Students who understand ideas at different speeds need time to work at their own pace. Slower learners, in particular, need extra time to comprehend the material and to explore ideas (Brown, 2017). Students who work more quickly may benefit from curriculum compacting. This consists of compressing the regular curriculum into a shorter time for students with a faster rate of learning. These students then go on to alternative assignments. Tomlinson (2014) strongly emphasises that these students need alternative activities, not activities in addition to the regular curriculum. Otherwise, faster learners may feel that they are being punished.

Lastly, gender and culture preferences also influence how students learn. The cultural-influenced preferences include: Perception of time as fixed or flexible, use of expression to convey emotion, whole to part learning versus part to whole, valuing creativity versus conformity and more, can influence student learning.

Further, learning patterns can also vary from culture to culture (Tomlinson, 2014). Gender patterns can also vary. To illustrate, while males are considered more likely than females to be competitive learners, a teacher could have a classroom with several competitive female learners and few competitive male learners (Tomlinson, 2014). Viewing each student as an individual is the cornerstone of differentiation, thus teachers in the differentiated avoid generalising groups of students. Differentiated instruction supports the classroom as a community, accommodating differences and sameness (Tomlinson, 2017). It allows for the creation of an environment in which all students can succeed and derive benefit (Tomlinson, 2017).

2.7.3 Benefits of differentiated instruction

Today"s classrooms are diverse (Tomlinson, 2017); students come to classrooms from different backgrounds, cultures, interests, readiness, preferences, and needs. Teachers need to reach all these types of learners at the same time in one classroom period. Differentiated instruction is a possible way to enhance learning and to raise achievement for all (Tomlinson, 2017). The use of DI provides several benefits to learners as well as teachers in diverse ways.

Differentiation in teaching and learning assists teachers in addressing the issue of dealing with learners of varied abilities and responding to their individual needs (Tomlinson & Jarvis, 2023). Thus, DI helps teachers to address the learning needs of each learner by teaching to their readiness levels through their learning styles and interests (Gheyssens et al., 2022). Successful differentiation can fulfil the varied needs and abilities of students in the same classroom (Haelermans et al., 2015). When planning for differentiated instruction, knowing students' interests and dominant learning styles, or profiles, can allow the teacher to plan learning activities that specifically target what students would like to learn and how they learn best (Tomlinson & Jarvis, 2023). When teachers teach to students' readiness level, they can accommodate a student who has mastered the lesson content, and is ready to be challenged. In this case, a harder text or a more complicated project could be assigned. Once a need is identified, the teacher responds by finding a method or solution to answer the need in order for all students to be successful in learning (Tomlinson, 2014). However, Magableh and Abdullah (2019) came to a conclusion that differentiated instruction can help mixed-ability classrooms to be more homogeneous to reduce classroom diversity.

Another benefit of differentiated instruction is that it leads to increased student achievement. A combination of a differentiated curriculum and the options for student choice are ideal for promoting success for learners with disabilities and it can improve outcomes for other students as well (Tomlinson, 2017). No matter how slowly a learner learns, when he or she is able to complete a task on his or her own, he becomes intrinsically motivated and would be compelled to do more. When teachers use DI, all learners of different ability levels improve in the comprehension of the taught content, and thereby resulting in a more positive learning experience (Shareefa, 2021) Furthermore, learners" choices of learning processes that best reveal their unique individual skills as they participate in DI allow them to take responsibility for their own learning.

Tomlinson (2017) again reports that DI motivates learners to learn harder when they are given the chance to choose learning activities that they are required to complete. This would enable learners to be motivated to learn to the brim. Effective use of differentiation has been associated with increased learner motivation, higher academic achievement and greater collaboration among students with similar ability (Smale-Jacobse et al., 2019). When students are given more options on how they can learn, they take on more responsibility for their own learning. The learner centred nature of DI allows learners to be independent and responsible learners throughout their learning endeavours.

In another development, teachers also benefit from the use of DI within the classroom, according to Suprayogi et al. (2017). When DI is employed, learners became more independent and teachers are able to create an exciting, active learning environment and at the same time facilitate their learning which reduces the teacher"s workload in the long run (Suprayogi et al., 2017). In this regard, DI permits teachers to teach their learners how to learn. This consequently agrees with the Chinese adage that emphasises the relevance of "teaching people how to fish rather than fishing for them". When learners are trained in this manner, they would not wait for their teachers" instructions before they learn, they would rather initiate and sustain their own learning since they have been taught to do so on their own. This would guide and help them to learn for and by themselves throughout their learning endeavours. DI compels educators to provide relevant remediation for learners with special needs and offers appropriate opportunity to challenge gifted learners (Collins et al., 2022). This enables no child to be left behind and prevents having them experience frustration (Franz, 2009). With DI, classrooms become active learning environments, and the roles of learners and the teachers change dramatically. The teacher"s role changes to a facilitator of students" learning while the learners became more independent learners (Agbeko et al., 2023). Tomlinson (2017) states that, the ultimate inspiration to the teacher who differentiates instruction is taking care of all learners by providing a learning environment and opportunities that exclude no child. Several countries that aim to educate every learner in their schools are opting for DI due to its effectiveness (Palmer & Maag, 2010).

2.7.4 Implementation of differentiated instruction

There are many ways in which differentiation can be implemented in the classroom. Regardless of which strategies or combinations of strategies are used, though, differentiation is mostly a proactive rather than a reactive process (Eysink & Schildkamp, 2021). Teachers must prepare their lessons by starting from the learning needs of the students. Therefore, effective differentiation is based on three main activities: (a) identifying learning needs, (b) preparing differentiated instruction, and (c) providing differentiated instruction.

Identifying learning needs: Differentiation starts with identifying students" learning needs (Prast et al., 2015). These needs are shaped by the characteristics of the students, such as their readiness, interests, or learning profiles (Tomlinson & Jarvis, 2023). For instance, high ability students have learning needs different from those of less able students. Pre-assessment is an important informational source in identifying students" characteristics and their subsequent learning needs (Smets & Struyven, 2018).

Preparing differentiated instruction: When the learning needs have been determined, differentiated instruction can be prepared. This preparation involves decisions on what students have to learn, how they are going to learn it, and how they will be assessed on what they have learned. Teachers can decide to apply differentiation to the content, process, and product (Tomlinson, 2014). The first decision concerns the goals students should reach (Prast et al., 2015). A good goal extends the knowledge, understanding, or skills of the student in a way that corresponds to the student"s learning needs. Each student should be pushed a little beyond their current capacity, and the students should be able to bridge the gap between what is known and unknown with some help (Eysink & Schildkamp, 2021). This means that teachers should set challenging goals for each group of students with similar learning needs. For abler students, this could result in compacting and enrichment of the standard curriculum. Examples of how differentiated goals can be established were given by Tomlinson (2017), who presented different continua on which instruction can be adjusted. For instance, less able students might profit more from goals that focus on the basic knowledge of a domain, whereas the abler ones might be ready to transfer their knowledge to other situations. The second decision concerns how students are going to reach their goals. It involves what content is presented, what activities students must engage in, and how much structure and guidance are given based on students" learning needs. Again, the continua identified by Tomlinson (2017) can guide teachers in this. For example, when differentiation is based on students" readiness, a teacher can decide to differentiate instructional content by providing concrete, highly tangible materials for less able students on the one hand, and abstract materials for the abler on the other (Eysink & Schildkamp, 2021). Alternatively, a teacher could differentiate the instructional process by providing less able students with tasks that ask for smaller leaps of insight, whereas the abler receive tasks that ask for greater leaps of insight. However, a teacher can also decide to differentiate instructional content based on students" interests – for example, by providing texts that match their interests (this might be a text about athletics for students who like sports, or a text on weaving for those who enjoy craft activities).

Part of this decision-making involves deciding on group composition. The study by Eysink and Schildkamp, (2021), has suggested that small, within-classroom learning groups provide teachers with greater flexibility to address student variance properly than when whole-class instruction is given. However, research is inconclusive about the best way to compose groups (Eysink & Schildkamp, 2021). For example, on the one hand, abler students may benefit more from honours programmes especially designed for them, rather than from working in a heterogeneous setting (Nurenberg, 2016). On the other hand, research has shown that performance of less able and average ability students is positively affected when they work in a heterogeneous setting with at least one high ability student present. However, this setting can also lead to less able students not critically reflecting on the contributions of their abler group member, due to feelings of being less knowledgeable (Eysink & Schildkamp, 2021). This is in line with the conclusion of the meta-analysis of Diamond (2023), who found that there is not one way to compose groups that benefits all students, although a second-order meta-analysis of Steenbergen-Hu et al. (2016) indicated that homogeneous ability grouping has at least a small positive impact on the academic achievement of all students, regardless of their ability level. Moreover, research has also shown that the quality of the group process is influenced by the group atmosphere, such as the presence or absence of help-giving behaviour, rather than group composition (Eysink & Schildkamp, 2021). As students also vary in readiness, interest, and mode of learning across subjects, an important teaching activity is, therefore, to group students in various ways and to be flexible in doing this (Eysink et al, 2017). The third decision in preparing differentiated instruction concerns how students are being assessed or how students can demonstrate what they have learned. If a teacher decides to differentiate in this way, they differentiate the instructional product (Tomlinson, 2014). For example, students must write a summary, or perform a play, or make a design. Related to this is deciding on the evaluation criteria. In the differentiated classroom, the learning process and product is always evaluated, and criteria should be clear, specific, and transparent.

An overarching decision in the preparation phase concerns the level of responsibility given to the students. A truly differentiated classroom involves students in the decisions that are made in this phase (van Geel et al., 2019). This can range from having students state their own learning goals to deciding on how learning should be demonstrated and defining the criteria on which the product will be assessed. Another example comes from the whole-task approach (Janssen, Hulshof, & van Veen, 2016) in which the final task is presented to the students, after which they must decide for themselves what instruction or assignments they can skip and which they need in order to reach the goal.

Providing differentiated instruction: After preparing the lesson, the teacher implements it in the classroom, as prepared (although being flexible when necessary), and guides the students in their learning process. This requires the teacher to continually monitor students" needs and progress through ongoing assessment (van Geel et al., 2019), and to be a coach facilitating learning instead of being an instructor transferring knowledge directly to the students (Little, 2018). Teachers must be able to promote reasoning and critical thinking, ask probing questions, and provide feedback (VanTassel-Baska, 2012). Although this is beneficial for all students, teachers can also differentiate in the way this coaching is put into action. Less able students, for example, profit most from coaching and feedback when guiding questions are posed, whereas more able students might benefit from questions that merely hint at the right direction for coming to a solution (van Dijk, Eysink, & de Jong, 2016).

Tomlinson (2017) emphasised three important strategies when implementing differentiated instruction which can make it more powerful, emphasising learner"s interests, depending in the right starting point and allowing students to work depending on their own pace. If students lack the interests in the subject that is taught at school, there will be no motivation to learn or a very little (Smit & Humpert, 2012). Emphasising students involves that teachers should know their students well and teach according to their motivation. So, when students have good feelings about the topic because either they enjoy it or the teachers employ different activities that interest students, learners tend to react positively (Ellis, 2010). Teachers can emphasise learners‟ interests by engaging and allowing students to participate in an independent study to learn what they are interested in. Using the right starting point involves that students who lack the basic skills may have to do different tasks than the others in the same classroom. Allowing students to work at their own pace involves giving motivated students chances to follow advanced topics instead of limiting them to learn just the topic based on their grade level (Park & Datnow, 2017). So, these three ways of differentiated instruction involve different kinds of learners, the below avearge, the average and the above average. The instruction as Morgan (2014) suggested should be modified to suit all of these learners in order to maximize their effort.

2.7.5 Barriers of differentiated instruction

Differentiated instruction is an instructional approach that recognises and accommodates the diverse learning needs of students. Although the concept of DI is recognised as one of the most advantageous incorporation when catering for mixed ability classes (Chien, 2015) several barriers hinder its effective implementation in classrooms.

Teachers‟ insufficient knowledge of DI proved to be a base factor that led to many problems in the implementation of DI. Jager (2017) indicated in her study that teachers lack knowledge in identifying students‟ learning difficulties as well as in modifying the curriculum to meet the needs of the students. Lack of teacher training and professional development is another barrier to the effective implementation of DI in classrooms. Teachers may lack the necessary knowledge, skills, and confidence to effectively implement differentiated instruction strategies. Merawi (2018) reported that teachers have high perception of DI, but they do not have sufficient knowledge of DI due to lack of training, which causes teachers to employ the "one-size-fits-all" approach. Limited training opportunities and inadequate professional development programs contribute to this barrier (Tomlinson, 2019).

Sebihi (2016) stated that the time needed for preparation in order to meet the individuals‟ interests, readiness and learning profiles is a major barrier to apply differentiated instruction. Differentiated instruction often requires significant planning, preparation, and individualized attention, which can be time-consuming for teachers. Heavy workloads, standardized testing pressures, and limited instructional time pose significant barriers to implementing differentiated instruction (Gregory & Chapman, 2012). Jager (2017) concluded that teachers face difficulty due to time constraint where they have insufficient time in catering to various needs and ensuring that students comprehend what is being taught.

Another important barrier Tomlinson (2014) identified is the one heavy standard curriculum. This puts teachers under pressure trying to finish all of it rather to teach based on students‟ needs leaving the teachers under a race against time (Magableh & Abdullah, 2020). Teachers are under pressure to teach and prepare students for the test or meeting students‟ individual needs (Maeng & Bell, 2015).

Again, another challenge is the class size. Teachers with large class sizes face difficulties in providing individualized instruction to meet the diverse needs of all students. The high number of students per classroom makes it tougher for teachers to differentiate the lesson. This is due to the rise in the diversity, needs, number of groups formed, time taken for product delivery and complication of classroom management (Stollman, 2018).

The lack of administrative support and school-wide commitment to differentiated instruction can impede its effective implementation. A lack of resources, competing priorities, and inconsistent policies can undermine teachers' efforts to differentiate instruction (Johnston, 2018). The support, influence and understanding of the school administration is crucial in providing teachers with the means necessary for effective DI implementation (Stollman, 2018; Aldossari, 2018). However, Aldossari (2018) and Avgousti (2017) report that their teacher participants do not receive sufficient support from the administration which make it more strenuous to carry out a DI lesson.

Assessment challenges also hinder the effective implementation of DI in classrooms. Traditional assessment practices may not align with differentiated instruction. Standardized assessments and grading systems can undermine the principles of differentiation, making it difficult for teachers to accurately assess student progress and provide appropriate feedback (Moon, 2023).

Moreover, Jager (2017) reported that teachers face challenges in searching for material resources for their lessons. Teachers may struggle to find appropriate curriculum materials and resources that align with differentiated instruction principles. A lack of diverse instructional materials that cater to varied learning needs and abilities can hinder effective implementation (Westwood, 2018). Ample resources are a necessity for both teachers and students in effective employment of DI.

Resistance to change among teachers, administrators, or stakeholders can also be a significant barrier to implementing differentiated instruction. Lack of understanding, skepticism, and reluctance to deviate from traditional instructional methods can hinder progress (Chan et al., 2017).

In addition, limited access to technology is another significant barrier to implementing differentiated instruction. Technology can enhance differentiated instruction, but limited access to technology resources, such as computers, tablets, or software, can create disparities and hinder implementation (Tomlinson, 2014). Overcoming the barriers to implementing differentiated instruction requires a comprehensive approach that addresses teacher training, time constraints, assessment practices, administrative support, technology access, curriculum materials, and resistance to change. By recognizing these barriers and developing strategies to mitigate them, educators can create inclusive learning environments that meet the diverse needs of all students.

2.8 Empirical Evidence of the Study

Several studies conducted have shown positive outcomes from the use of differentiated instruction. To begin with, Awofala & Lawani (2020) investigated the impact of varied instructional techniques on secondary students' mathematics success in the context of mathematics teaching and learning. The quasi-experimental research used pre-tests and post-test instruments to collect data from 220 samples. The intervention lasted eight weeks, with the experimental group receiving a differentiated instructional strategy and the control group receiving traditional direct instructions. The findings revealed a statistically significant difference between the two research groups, with the experimental group outperforming the control group, indicating that differentiated teaching improved students' math proficiency.

In addition, Magableh and Abdullah (2019) investigated the effectiveness of differentiated instruction strategies on grade 7 male students" reading comprehension achievement in Irbid, Jordan. The sample consisted of 55 grade 7 male students from two male schools in Irbid District. This quasi-experimental study distributed students into two groups, 28 students for the experimental group which was taught through differentiated instruction strategies of flexible grouping, tiered assignment and tiered instruction in the areas of content, process and product. The control group was 27 students and taught reading comprehension following the whole class instruction. Two instruments were used to collect data, a reading comprehension, pre-test/post-test and a semi-structured interview with the experimental group students. The results indicated that using differentiated instruction was effective in developing grade 7 students. T-test results showed that the difference is statistically significant and differentiated instruction has a big effect size in reading comprehension.

Ariss (2017) investigated the effectiveness of differentiated instruction in Math secondary classrooms in America. Different differentiated instruction strategies were used in the experimental classrooms. Five instruments were used to collect data, students‟ reflections, observations, lesson plans, assessment tools and interviews. A convergent parallel quantitative and qualitative design was adapted to collect data from 30 participants in grade 10 who were randomly distributed in two sections, one of 15 students for the experimental group and another of 15 for the control group. The findings showed that there was a positive feedback towards differentiated instruction. The findings also indicated that students enjoyed being with flexible grouping, and tiered activities, where the teacher is not standing in the front and just lecturing.

Also, Valiandes (2015) conducted a quasi-experimental study with 24 teachers and 479 students from 24 classrooms. The study took place at 13 elementary schools (grade four) in Cyprus, where the study examined the implementation and effect of differentiated instruction for all students and evaluated its potential to result in learning equality and thus improve the quality of the learning process. The study was conducted by comparing the effect between classes where differentiation was systematically employed against the classes that were not. The students in the differentiated classes were found to be making better progress. The study‟s quantitative data suggested a statistically significant difference between achievement by students who were exposed to differentiated instruction and those who were not. Another important finding of Valiandes‟ study is the confirmation of learning outcome maximisation by using differentiated instruction. Despite the students‟ socioeconomic status (SES) which displayed a correlation with their academic performance, no effect of SES on students‟ progress was found. Valiandes further suggests that differentiation can be used to provide equal learning opportunities for all students across all socioeconomic groups, a finding that was not evidenced in the control group.

In furtherance, Karadag and Yasar (2010) conducted a 15-week differentiated programme on a Turkish language course for 30 elementary school students to determine its effects on their attitudes. Data were collected through a pre-test and post-test in the form of an attitude scale, complemented by semi-structured student interviews. The quantitative analysis suggested significant post-test mean as opposed to the pre-test and the interview analysis revealed that the differentiated lessons had a positive effect on the students‟ attitudes.

Moreover, Hassan (2016) investigated the effect of differentiated instruction on students‟ achievement in History of Art subjects. The sample consisted of 50 students distributed into 25 respondents for the experimental group and was taught depending on the differentiated instruction strategies. Another 25 students were selected for the control group which was taught using traditional method. The researcher followed the pre/post-test as the instrument of the study which consisted of 30 multiple choice items. The results showed that differentiated instruction was effective in developing students" achievements. Moreover, statistically significant differences were found favouring the experimental group.

Another study is by Chamberlin and Powers (2010), who conducted a quasi-experimental pre-test and post-test control-group mixed methods study in an undergraduate mathematics course involving students in their freshman year from two universities in the United States. The study employed a pre-test and post-test control-group research design, and drew on data from interviews and student work using differentiated instruction. Both control and treatment group participants answered the same tests and quizzes (post-tests). The quantitative results from the study revealed that the experimental group scored higher in the post-tests than the control group, suggesting the effectiveness of differentiated instruction over regular whole class instruction. The positive effect was further corroborated by the qualitative results from the experimental group that suggested that differentiated instruction supported student learning.

A study by Mavido and Kakana (2019) investigated the effect of differentiated instruction strategies on children"s reading achievement. This quasi-experimental study involved pre-tests/ post-tests instruments to investigate the effect of differentiated instruction strategies of three experiments including curriculum adjustment, differentiated content and product. One hundred and fifty-four (154) kindergarten students were distributed into 80 students for the experimental group which was taught using differentiated instruction according to students" readiness, interest and learning profiles. However, 74 students were selected for the control group which was taught traditionally. The content, process and product were differentiated by tailor-made content, flexible grouping and a board of choice for product. The study findings indicated a statistical significant difference between the two groups of the study favouring the experimental group, which indicated that differentiated instruction developed students‟ achievements.

Butler and Lowe (2010) also investigated the effect of using differentiated instruction in Mathematics education for pre-service teachers who enrolled in a Concepts of Mathematics for Teacher course which was open to students with a plan to major in elementary education. The study assigned 39 research participants into two groups: treatment group (n=20) and control group (n=19). All the participants were given a pre-test before the course ensued and participants in both groups were assessed on two post-tests including their final examination to measure learning gains between the treatment and control groups. They were also surveyed before and after the intervention period. Although the surveys showed that some students felt negatively about the differentiated lessons, students in the experimental group who received differentiated instruction still outperformed students in the control group in the final exam.

Again, Johnsen (2003) conducted a study using undergraduate teachers differentiating instruction to suit different ability levels. Student teachers in this context were encouraged to differentiate content and process, using learning centres, different reading materials and different strategies. The study revealed that the use of differentiated techniques proved to be engaging, stimulated student interest and providing a gratifying experience for the undergraduate teachers.

Lai et al. (2020) also investigated the effect of differentiated instruction in enhancing overall mathematics achievement by employing the longitudinal approach with pre-test and post-test design of 25 students in each group. The finding reveals that differentiated instruction significantly enhances students‟ overall mathematics achievement.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter describes the methodology employed in the study and includes the research design, research approach, study area, population, sample and sampling procedures, research instruments, data collection procedure (pre-intervention activities, intervention design and post-intervention activities), and methods of data analysis.

3.1 Research Design

According to Kelly (2017), a research design is the researcher"s plan of how to proceed with the investigation. Research design refers to the overall plan or structure that guides the collection, analysis, and interpretation of data in a research study. It outlines the steps and procedures that researchers follow to address their research questions or objectives. The research design influences the reliability and validity of the study's findings. This study sought to improve senior high school students" academic performance in selected concepts in Integrated Science through differentiated instruction. In effect, the study adopted an action research design. According to Creswell (2012), action research is used when we have any specific educational problem or issue to solve. An essential goal of action research is improving teaching-learning activities (Nicodemus & Swabey, 2015). This design was chosen for the study due to its flexibility for the classroom teacher (Mokhele, 2014). Also, action research design is the most appropriate approach for this study because it easily diagnoses classroom problems and seeks to identify lasting solutions to the problem. Furthermore, an action research deals with an intervention which is appropriate for a small heterogeneous group context to improve the understanding of concept. Another equally important aspect of this research is the use of different methods for data collection to determine student acquisition of knowledge through varied teaching methods (Cohen etal., 2017).

3.2 Research Approach

This study adopted the quantitative research approach. Quantitative research methods emphasise the objective measurement of numerical data (Creswell, 2014). To Cohen, Manion and Morrison (2018), quantitative research focuses on gathering arithmetic data and generalising it across groups of people or explaining a particular phenomenon. The focus of this study was to gather arithmetic data to explain the effect of 00differentiated instruction on the academic performance of senior high school students in selected concepts in Integrated Science, hence the approach.

3.3 Study Area

The study area for this research is Ghana National College, a co-educational institution located in Cape Coast in the Central Region of Ghana. Ghana National College is an inclusive public second cycle institution that provides education to students from diverse socio-economic backgrounds. It was established in the year 1948 by Osagyefo Dr. Kwame Nkrumah, the first president of Ghana. The school offers a broad range of academic programs, including General Science, General Arts, Visual Arts, Business, and Home Economics. Ghana National College was chosen because it has a well-established academic programs. Additionally, the school has a diverse student population, which will enhance the external validity of the study. The study area was also chosen because it is accessible and conveniently located, which will make it easy for the researcher to collect data and conduct the study.

3.4 Research Population

A population refers to the group of individuals from whom samples are taken for measurement (Creswell, 2014). For any study, the target population is all the members of a group defined by the researcher‟s specific interest; for him or her to answer research questions and to whom the findings of a study may be generalized. The target population for this study comprised all form two (2) students of Ghana National College. The accessible population, however, consisted of form two (2) General Arts students of Ghana National College.

3.5 Sample and Sampling Techniques

A sample is a subset of people, items, or events from a larger population from whom the researcher collects and analyse data to make inferences (Creswell, 2014). Sampling technique is the method used to select the sample for the study. The purposive sampling technique was utilised in choosing an intact form-two General Arts class of thirty-four (34) students to form the sample of the study. The justification for the choice of this sampling technique was because the researcher taught that class and therefore has sufficient knowledge on the performances of the students. Also, the purposive sampling was employed to conveniently select a General Arts class that the researcher was handling in order that normal class schedules are not disrupted. The thirty-four students selected comprised nineteen males and fifteen female students. The students were aged between fifteen and twenty.

3.6 Research Instruments

In this study, achievement tests dubbed "Integrated Science Performance Tests [ISPT]" and questionnaire dubbed "Differentiated Instruction Views Questionnaire [DIVQ]" were the instruments used for data collection. These instruments were constructed by the researcher under the supervision of the researcher‟s supervisor. The selection of these instruments were guided by the nature of data to be collected; the time available as well as the objectives of the study.

3.6.1 Achievement tests

Lebagi et al. (2017) defined test as an instrument or systematic procedure for measuring a sample of behaviour. Integrated Science Performance Tests [ISPT] were constructed and used by the researcher to collect data before and after the intervention. These tests were used to determine the performance of the thirty-four research participants comprising the sample before and after the intervention. The ISPT was reshuffled and used one week after the intervention to collect data on participants‟ achievement after the intervention. The test items covered the concepts of acids, bases and salts and the respiratory system in the SHS Integrated Science syllabus. Moreover, the test items were constructed using a specification table based on the six Bloom‟s cognitive domains (Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation). ISPT comprised 30 multiple choice items carrying thirty (30) marks in total. Four alternative options were provided for each item. Both the pre-ISPT and post-ISPT were equivalent in terms of number of items and difficulty. However, items were reshuffled in the post-ISPT.

3.6.2 Questionnaire

According to Cohen et al. (2018), a questionnaire is a collection of written questions which are usually answered in order to obtain information from the participants. The purpose of using Differentiated Instruction Views Questionnaire [DIVQ] was to collect data from the research participants on their views of the use of differentiated instruction in the teaching and learning of Integrated Science. The questionnaire contained fifteen (15) closed-ended items constructed on five points likert scale having responses of Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), and Strongly Agree (SA) respectively. The respondents were required to tick in boxes corresponding to their options. The questionnaire was based on the third objective of the study. The questionnaire also sought background information on gender, and age category of the respondents.

3.7 Validity of Research Instruments

Gyamfi (2022) defined validity as the soundness of the interpretations and use of students‟ assessment results. Validity of an instrument is the extent to which the instrument measures what it is intended to measure. The instruments were face and content validated by experts from Science Education. The data collecting instruments were assessed and critically scrutinised by the researcher‟s supervisor and colleague teachers to eliminate any ambiguity, bias and the necessary modifications were made in the test items to suit the purpose of the study. The validity of the instruments was further verified during the piloting of the study in a sister school. Suggestions and pieces of advice offered by assessors were used by the researcher to modify the instruments to make them more appropriate for the study.

3.8 Reliability of the Research Instruments

Reliability refers to the extent to which a measuring instrument yields the same results on repeated application (Durrheim et al., 2023). It means the degree of dependability of measuring instruments (Mahembe & Engelbrecht, 2014). The test-retest reliability method was used to determine the reliability coefficient of the test items [ISPT]. The instrument was administered twice on the same group of students that were pilot tested at two weeks interval as recommended by Glick and Orsillo (2015). The result obtained was analysed using Pearson Product Moment Correlation (PPMC). A Pearson‟s Product Moment Correlation Coefficient of 0.89 was obtained. Creswell (2014) asserted that in research, a reliability coefficient of 0.8 or more would imply that there was a highly reliable data. Cronbach‟s Alpha statistical tool was used to measure the internal consistency of the questionnaire [DIVQ]. The reliability coefficient of the instrument (DIVQ) was 0.76. An alpha value of 0.70 and above is considered suitable to make group inferences that are accurate enough (Graham, 2006). This suggests a positive reliability and the instrument is reliable to determine the views of the students.

3.9 Data Collection Procedure

The data collection procedure involves systematic steps to obtain accurate and reliable data. In view of this, the procedure was done in three phases; the pre-intervention, intervention, and post-intervention. The researcher used 6 weeks to conduct the study. One week for the pre-intervention, four weeks for the intervention and the remaining week for the post-intervention. The data collection started with the presentation of an introductory letter from the Department of Science Education, University of Education, Winneba to the Headmaster of Ghana National College to conduct the study. Data was collected through the administration of Integrated Science Performance Tests (pre-test and post-test) and Differentiated Instruction Views Questionnaire to the respondents.

3.9.1 Pre-intervention phase

During the first week of the study, permission was sought from the head teacher to enable the researcher to undertake the study. This was followed by consent letter indicating the purpose and intent of the researcher. After getting permission, pre-test was administered to students by the researcher. The pre-test was used to do a pre-assessment of students‟ readiness and entry behaviours. The data collected was used to group the students. The duration of the pre-test was thirty (30) minutes. The pre-test was marked, scored and recorded by the researcher.

3.9.2 Intervention phase

The intervention phase started a week just after the pre-intervention phase, and spanned through a period of four weeks. The intervention adopted was to use differentiated instruction to improve senior high school students‟ academic performance in selected concepts in Integrated Science. The selected concepts were acids, bases, and salts, and the respiratory system. Respiratory system was the first topic that was treated which lasted for two weeks, and two lessons were taught each week. Following that, the concept of Acids, Bases, and Salts was also treated and was taught in four different lessons (two lessons per week) which also lasted for two weeks. In all, eight different lessons took place to cover all the selected concepts. During the four weeks of active teaching and learning, various heuristics of differentiated instruction that involve pre-assessment, flexible grouping, tiered instruction, scaffolding, and many more were followed to meet the needs of the students. In each learning unit, formative assessment was conducted to provide feedback to the students. The researcher set minimum goals for all students and expressed different expectations for students with different abilities by adjusting the learning objectives/expectations to relevant differences between students. The researcher enabled flexible grouping and ensured that learning materials were adjusted to the level and development of all students. The researcher adjusted the processing of the learning content to relevant differences between students and allowed all students to work at their own pace by providing the below-average students with content with more structure and extra instructional support, and the above-average students were provided with content with more depth and extra challenge during instruction. The researcher also provided extra support or challenge to students, based on their progress during lesson as revealed by on-going assessments and at the end the researcher evaluated the learning of the students. The details of each lesson are presented as follows:

LESSON ONE

Week ending: 21/04/2023	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Tuesday	**Class**: SHS 2	**Topic:** Respiratory System
Time: (9:25 – 10:25 am)	**Class size:** 34	**Sub-topic**: Cellular or Tissue Respiration

Reference: Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.
Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.
Oddoye, E. O., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Ofori, D. O. (2011). *Integrated Science for Senior High Schools, Student's Book*. Accra: Sam-Woode Ltd.

Objective/RPK	Teacher-Learner Activities	Teacher-Learner Resources	Core Points	Evaluation & Remarks
Objectives By the end of the lesson, the student will be able to; i. define respiration	**Introduction** Teacher introduces the lesson by sharing a compelling narrative about an individual grappling with breathing difficulties. Teacher initiates a thought-provoking discussion by inquiring about the students' prior knowledge on respiration. With the help of a marker, students‟ ideas about respiration are written on the whiteboard. **Activities** 1. Teacher brainstorms with students to come out with the meaning of respiration. 2. Provides a rich array of learning resources (articles, books, videos, websites) for students to explore respiration at their own pace. 3. Allow students to select a resource of their choice and	Whiteboard, markers, laptop, articles, books, videos, websites.	Respiration is the process by which cells obtain energy from food. This energy, as emphasized, fuels all vital bodily functions, encompassing breathing, cognition, and physical mobility.	**Evaluation** 1. Define the term “respiration” 2. Briefly explain the importance of respiration to human beings.

ii. explain the importance of respiration. **RPK** Students have basic understanding of cells, energy and oxygen.	circulate around the classroom to offer guidance and support as needed. 4. Introduces creative avenues (report, presentation, drawing, song) for students to express their understanding of respiration. 5. Asks students to work on their chosen projects, while circulating to ensure accessibility to assistance. 6. Observes students' progress informally, assessing their grasp of respiration. 7. Teacher conducts a whole-class discussion where students present their final projects, answer questions, and receive feedback. **Closure** Teacher ends the lesson by summarising the pivotal aspects of respiration, reinforcing the key takeaways and assigns students exercise.		**Application** Students can apply their understanding of respiration to various situations, such as understanding the importance of exercise.	**Remark** Lesson was successfully taught.

LESSON TWO

Week ending:21/04/2023	**Duration:** 60minutes	**Subject:** Integrated Science
Day: Thursday	**Class**: SHS 2	**Topic:** Respiratory System
Time: (9:25 – 10:25am)	**Class size:** 34	**Sub-topic**: Aerobic and Anaerobic Respiration

Reference: Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.

Kwarteng, C., Antwi, I. B., & Gyamfi, A.-J. (2013). *Integrated Science Workbook 2*. Kumasi: Unijay Publications.

Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.

Objective/RPK	Teacher-Learner Activities	Teacher-Learner Resources	Core Points	Evaluation & Remarks
Objectives By the end of the lesson, the student will be able to; i. distinguish between aerobic and anaerobic	**Introduction** Teacher starts the lesson by reviewing the concept of respiration that had been covered in the previous lesson. Teacher clearly outlines the primary lesson objective: to understand the differences between aerobic and anaerobic respiration. **Activities** 1. Teacher uses visual aids, diagrams, and animations to illustrate the differences between aerobic and anaerobic respiration, catering to diverse learning styles. 2. Divide the class into small groups and assign them sets of cards with the following information: aerobic respiration, anaerobic	Whiteboard, markers, visual aids, diagrams, animations, coloured cards with information on aerobic and anaerobic respiration, and worksheets or handouts.	Aerobic respiration: Requires oxygen, produces more ATP, slower process, occurs in the mitochondria. Anaerobic respiration: Does not require oxygen, produces less ATP, faster process, and occurs in the	**Evaluation** State three (3) differences between aerobic and anaerobic respiration.

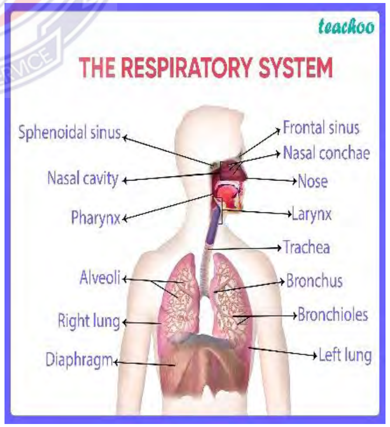
respiration. **RPK** Students already understand respiration.	respiration, oxygen, ATP, mitochondria, and cytoplasm and instruct to categorize them into two groups: aerobic respiration and anaerobic respiration. 3. Each group shares their work with the class, fostering discussion about similarities and differences between the two types of respiration. 4. Provide a worksheet/handout prompting students to compare and contrast aerobic and anaerobic respiration. 5. Have them work individually or in pairs to complete the worksheet and Circulate the classroom to provide support, followed by a collective discussion of answers to ensure understanding. 6. Task students with writing a short paragraph explaining the differences between aerobic and anaerobic respiration. 7. Review their paragraphs to assess their understanding of the concept. **Closure** The teacher ends the lesson by summarising the key points of the lesson and encouraging students to ask any remaining questions or seek clarification on the topic.		cytoplasm. **Application** Students can apply their understanding of aerobic and anaerobic respiration to real-life situations, such as the production of yogurt and other fermented foods.	**Remark** The lesson was successfully taught.

LESSON THREE

Week ending: 28/04/2023	**Duration:** 60minutes	**Subject:** Integrated Science
Day: Tuesday	**Class**: SHS 2	**Topic:** Respiratory System
Time: (9:25 – 10:25am)	**Class size:** 34	**Sub-topic**: The Structure and Functions of the Respiratory System of Mammal

Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.

Oddoye, E. O., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Ofori, D. O. (2011). *Integrated Science for Senior High Schools, Student's Book*. Accra: Sam-Woode Ltd.

Objective/RPK	Teacher-Learner Activities	Teacher-Learner Resources	Core Points	Evaluation & Remarks
Objectives By the end of the lesson, the student will be able to; i. identify the organs of the respiratory system and describe their functions.	**Introduction** Teacher introduces the lesson by asking students what they already know about the respiratory system. Students are made aware that they will be learning about the different organs of the respiratory system and their functions. **Activities** 1. Through direct instruction, teacher provides students with a brief overview of the respiratory system, including the names and functions of the different organs. Display the respiratory system diagram on the whiteboard. 2. Teacher distributes papers with names of the respiratory system organs and students are asked to match the names to the corresponding organs on the diagram. Encourage peer teaching for collaborative learning. 3. Teacher divides the class into groups of three to four students and assigns each group an organ to research its function using textbooks or online resources.	Whiteboard, markers, textbooks, online resources, Papers with names of respiratory organs, pens or pencils and diagram of the respiratory system. 	The respiratory system consists of several organs that work together to facilitate the exchange of gases, primarily oxygen and carbon dioxide. The respiratory system includes the nose, pharynx (throat), larynx (voice box), trachea (windpipe), bronchi, bronchioles, lungs, alveoli and diaphragm	**Evaluation** 1. Identify four (4) organs of the respiratory system. 2. Briefly describe the functions of the organs of the respiratory system identified in (1) above.

	4. Each group presents their findings to the class, by explaining their assigned organ's role in the respiratory system. 5. Engage students in a whole-class discussion with open-ended questions about how respiratory organs work together and the consequences if one fails. Teacher encourages students to ask questions and express their thoughts.			
RPK Students already understand respiration.	**Closure** The lesson is concluded by summarising the key points of the lesson, and students are assessed by having them share what they have learned.		**Application** Students can apply their knowledge of the respiratory system by understanding how each organ functions and how they work together to facilitate the exchange of oxygen and carbon dioxide.	**Remark** The lesson was successfully taught.

LESSON FOUR

Week ending: 28/04/2023	**Duration:** 60minutes	**Subject:** Integrated Science
Day: Thursday	**Class**: SHS 2	**Topic:** Respiratory System
Time: (9:25 – 10:25am)	**Class size:** 34	**Sub-topic**: Respiratory Problems and Disorders

Reference:

Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.

Ministry of Education. (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.

Oddoye, E. O., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Ofori, D. O. (2011). *Integrated Science for Senior High Schools, Student's Book*. Accra: Sam-Woode Ltd.

Centres for Disease Control and Prevention. (2023). *Respiratory Diseases*. Retrieved *from* https://www.cdc.gov/ |

Objective/RPK	Teacher-Learner Activities	Teacher-Learner Resources	Core Points	Evaluation & Remarks
Objectives By the end of the lesson, the student will be able to; i. enumerate three (3) problems and disorders	**Introduction** The teacher initiates the lesson by engaging students in a discussion, inviting them to share their existing knowledge about the respiratory system and any prior awareness of problems and disorders associated with it. **Activities** 1. Teacher provides a brief lecture on common respiratory problems and disorders, including causes, symptoms, and treatments. 2. To facilitate a more in-depth exploration of the topic, students are	Whiteboard, markers, projector, visual aids (diagrams and charts), research materials (textbooks, articles, online resources) handout on respiratory problems and disorders, access to the computers with internet or library resources	The human respiratory system may be exposed to certain disorders due to germs or improper functioning of certain parts of the respiratory system.	**Evaluation** Identify and discuss three (3) major respiratory disorders.

associated with the respiratory system in humans. ii. identify the causes, symptoms, and treatments of common respiratory problems and disorders. **RPK** Students can identify the major organs of the respiratory system and describe their functions.	organized into small groups, each assigned a specific respiratory problem or disorder to investigate. Groups research causes, symptoms, and treatments, with additional support provided based on individual needs. 3. Advanced students explore real-life case studies or recent developments related to their assigned topics. 4. Each group presents their findings to the class using visual aids such as diagrams or charts to make presentations more engaging. 5. Teacher encourages questions and discussions after each presentation. **Closure** Teacher concluded the lesson by summarising the key points and concepts discussed in the lesson. Students asked to reflect on what they have learned and its relevance to real-life health and well-being. Each student is assigned an individual respiratory problem or disorder to research further and write a short report on.		The problems and disorders of the respiratory system include: Asthma, Tuberculosis, Lung cancer, Pneumonia, Bronchitis, and Whooping cough. **Application** Students can use their knowledge of respiratory problems and disorders to raise awareness among their peers and family members about the importance of respiratory health.	**Remark** The lesson was successfully taught.

LESSON FIVE

Week ending: 05/05/2023	**Duration:** 60minutes	**Subject:** Integrated Science
Day: Tuesday	**Class**: SHS 2	**Topic:** Respiratory System
Time: (9:25 – 10:25am)	**Class size:** 34	**Sub-topic**: Exchange of Respiratory Gases in Plants

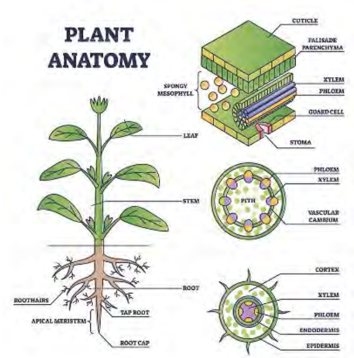
Reference: Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.

Kwarteng, C., Antwi, I. B., & Gyamfi, A.-J. (2013). *Integrated Science Workbook 2*. Kumasi: Unijay Publications.

Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.

Plant Respiration: https://www.nagwa.com/en/lessons/526104036916/

Objective/RPK	Teacher-Learner Activities	Teacher-Learner Resources	Core Points	Evaluation & Remarks
Objectives By the end of the lesson, the student will be able to; i. explain how respiratory gases are taken in and out of plants.	**Introduction** The teacher begins the lesson by engaging the students in a thought-provoking discussion, asking them to share their existing knowledge about how plants absorb and release gases. The teacher introduces the core concept of the day's lesson, explaining that they would delve into the intricate process of how plants take in and expel respiratory gases. **Activities** 1. The teacher explains the process of gas exchange in plants using compelling visual aids and diagrams. 2. The teacher thoughtfully divides the students into three groups based on readiness levels. 3. High readiness group is provided with advanced texts and tasked with researching and presenting a plant adaptation related to respiration. 4. Medium readiness group receives handouts containing key terms and questions and are encouraged to collaborate in pairs to	Whiteboard, projector, markers, diagrams of plant anatomy, pictures or videos of plants in various environments, simplified texts on gas exchange in plants, worksheets for fill-in-the-	In roots, stems & leaves the exchange of gases takes place through diffusion. The surface of young stem has stomata, while that of an older stem have lenticel for gaseous exchange. Stomata are mainly present on the surface of leaves apart from the epidermal surface of young stem for gaseous exchange.	**Evaluation** Briefly explain how the exchange of gases occur in plants.

RPK Students can identify the parts of a plant that are involved in gas exchange.	discuss and clarify concepts. 5. Low readiness group receives simplified texts and are by the teacher guided through a fill-in-the-blank activity to scaffold their learning experience. 6. The class reconvenes for a knowledge-sharing session where each group presents their findings and discoveries. **7.** Students are assessed based on their completion of their group activity. **8.** The teacher addresses any lingering questions or uncertainties, ensuring clarity and comprehension. **Closure** The teacher summarises the main points of the lesson, providing a clear and concise overview. Students are encouraged to reflect on their learning through a written reflection.	blank activity, rubric for assessing student presentations**,** advanced texts on plant adaptations for respiration, and handouts with key terms and questions about gas exchange in plants.	 **Application** Students will be able to apply their knowledge to explain how plants contribute to the balance of gases in the atmosphere.	**Remark** The lesson was successfully taught.

LESSON SIX

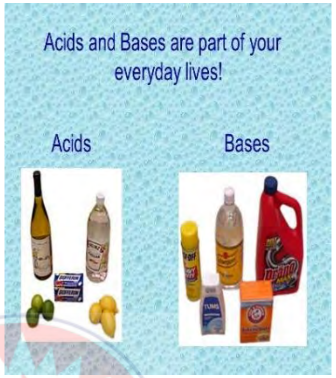
Week ending: 05/05/2023	**Duration:** 60minutes	**Subject:** Integrated Science
Day: Thursday	**Class**: SHS 2	**Topic:** Acids, Bases and Salts
Time: (9:25 – 10:25am)	**Class size:** 34	**Sub-topic**: Acids, Bases, and their Properties

Reference: Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.

Kwarteng, C., Antwi, I. B., & Gyamfi, A.-J. (2013). *Integrated Science Workbook 2*. Kumasi: Unijay Publications.

Ministry of Education. (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.

Objective/RPK	Teacher-Learner Activities	Teacher-Learner Resources	Core Points	Evaluation & Remarks
Objectives By the end of the lesson, the student will be able to; 1. Define acids and bases. 2. State the	**Introduction** Teacher introduces the lesson by asking students what they know about acids and bases. Students may mention their experiences with sour foods (acids) or soapy or bitter substances (bases). **Activities** **1.** The teacher explains to the students that acids and bases are two important classes of chemicals that are found all around us. **2.** Teacher brainstorms with students to bring out	Markers, textbooks, worksheets, whiteboard, lemon juice, vinegar, baking soda, ammonia, sodium hydroxide and pictures.	Acids are substances that produce hydrogen ions (H+) in aqueous solution. Bases are substances that produce hydroxide ions (OH-) in aqueous solution. Acids have a sour taste and turn blue litmus paper red. Acids react with	**Evaluation** 1. Define the following ; a. Acid b. Base 2. State two (2) each of acids and

properties of acids and bases. 3. Identify common chemical substances as acids or bases. **RPK** Students have basic understanding of pH scale, common acidic and basic substances from JHS.	the definitions of acids and bases. **3.** Through discussion, the teacher guides students to identify the characteristic properties of acids and bases. **4.** Teacher guides students to create a table that lists the properties of acids and bases. **5.** Students are given a list of common chemical substances and asked to identify which ones are acids and which ones are bases. Substances include lemon juice, vinegar, baking soda, ammonia, and sodium hydroxide. 6. To assess students' understanding of acids and bases, teacher guides students to complete a worksheet that includes multiple-choice questions, short answer questions, and a diagram identification task. **Closure** The teacher concludes the lesson by summarising the salient points of the lesson, emphasising the key concepts of acids and bases, their properties, and their role in various chemical reactions.		metals to produce hydrogen gas Bases have a bitter taste and turn red litmus paper blue. Bases react with acids to produce water and salt. Common examples of acids: Lemons, oranges, vinegar, urine, sulphuric acid, hydrochloric acid, Nitric acid. Common examples of bases: Soap, toothpaste, bleach, cleaning agents, limewater, ammonia water, sodium hydroxide, Potassium hydroxide, Ammonia **Application** Students apply their knowledge by identifying acids and bases in real-world scenarios.	bases. 3. List two (2) example of acids and bases. **Remark** The lesson was successfully taught.

LESSON SEVEN

Week ending: 12/05/2023	**Duration:** 60minutes	**Subject:** Integrated Science
Day: Tuesday	**Class**: SHS 2	**Topic:** Acids, Bases and Salts
Time: (9:25 – 10:25am)	**Class size:** 34	**Sub-topic**: Salt Formation

Reference: Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.

Ministry of Education. (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.

Objective/RPK	**Teacher-Learner Activities**	**Teacher-Learner Resources**	**Core Points**	**Evaluation & Remarks**
Objectives By the end of the lesson, the student will be able to; • describe the process of salt formation.	**Introduction** The teacher begins the lesson by asking students what they know about salts. Teacher brainstorms with the students to come out with the meaning of salt. **Activities** 1. The teacher explains the process of salt formation using a diagram. 2. Teacher demonstrates the preparation of a salt through a	Whiteboard, markers, laboratory equipment (beakers, test tubes, etc.), chemicals (HCl, NaOH), safety goggles, gloves, diagrams illustrating the salt preparation process, lab report sheets and reference materials on acid-base reactions. |	Salts are ionic compounds formed from the reaction of an acid and a base. Salts are ionic compounds formed by the neutralization reaction between an acid and a base. The neutralization reaction involves the exchange of protons (H^+) from the acid to	**Evaluation** 1. Define the term „salt". 2. Briefly describe the process of salt formation. 3. Identify the

• prepare salts from acids and bases. • identify the products of an acid-base reaction.	neutralization reaction using hydrochloric acid and sodium hydroxide. 3. Students observe the reaction and take notes on the steps involved. 4. The teacher divides the students into pairs or small groups and each group is tasked with preparing a salt of their own choosing. 5. Students are guided through the preparation process, ensuring they follow safety precautions. 6. Upon completion, students identify the products of the reaction and list the properties of the salt they prepared. 7. Students write a lab report describing the steps they took to prepare the salt and present their results to the class and answer questions from their peers. 8. Students are assessed based on their lab report, class presentation, and their ability to answer questions.		the base, resulting in the formation of water (H_2O) and a salt. The properties of a salt depend on the specific acid and base used in its formation.	products formed from the reaction between HCl and NaOH.
RPK Students have a basic understanding of acids and bases.	**Closure** The teacher summarises the lesson and provides additional support for those who need it. Teacher provides feedback and answers any questions. Teacher encourages advanced students to explore further.		**Application** Students can appreciate the chemical processes involved in salt production for both consumption and industrial applications.	**Remark** The lesson was successfully taught.

LESSON EIGHT

Week ending: 12/05/2023	**Duration:** 60minutes	**Subject:** Integrated Science
Day: Thursday	**Class**: SHS 2	**Topic:** Acids, Bases and Salts
Time: (9:25 – 10:25am)	**Class size:** 34	**Sub-topic**: Understanding pH and its Measurement

Reference: Brown, T. L., LeMay, H. E., & Bursten, B. E. (2016). *Chemistry: The Central Science*.

Kwarteng, C., Antwi, I. B., & Gyamfi, A.-J. (2013). *Integrated Science Workbook 2*. Kumasi: Unijay Publications.

Ministry of Education. (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra.

Oddoye, E. O., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Ofori, D. O. (2011). *Integrated Science for Senior High Schools, Student's Book*. Accra: Sam-Woode Ltd.

Objective/RPK	Teacher-Learner Activities	Teacher-Learner Resources	Core Points	Evaluation & Remarks
Objectives By the end of the lesson, the student will be able to; 1. describe the effect of acid-base indicators. 2. use	**Introduction** Teacher begins the lesson by asking students what they know about pH. Teacher encourages students to share their understanding of the concept and its significance and guides the discussion to establish the meaning of pH as a measure of acidity or basicity of a solution. **Activities** 1. Teacher demonstrates how to use an acid-base indicator to test the pH of a solution by showing students how to use litmus paper to test the pH of acidic, basic, and neutral solutions. 2. Teacher explains the colour changes that occur in each indicator when it comes into contact with solutions of different pH levels. 3. Teacher divides students into small groups of 3-4 and provides each group	Litmus paper, universal indicator, pH meter, lemon juice, phenolphthalein, methyl orange, dilute HCl, dilute NaOH, dilute NaCl, distilled water, vinegar, palm oil, shampoo, local soap, whiteboard and	pH is a measure of the acidity or basicity of a solution. A pH of 7 is neutral, a pH below 7 is acidic, and a pH above 7 is basic. Acid-base indicators change colour in response to different pH levels.	**Evaluation** 1. Explain how to determine the pH of a given solution. 2. Which is more acidic: a

universal indicators and the pH meter to determine the pH of given solutions. **RPK** Students have a basic understanding of acids, bases, and salts.	with a set of litmus paper, phenolphthalein, methyl orange, and the following solutions: dilute HCl, dilute NaOH, dilute NaCl, distilled water, and lemon juice. 4. Teacher guides students to test the pH of each solution using litmus paper, phenolphthalein, and methyl orange and encourages students to observe the colour changes carefully and record their observations in a table. 5. Also, teacher provides each group with universal indicator, a pH meter, and household chemicals (vinegar, palm oil, shampoo, local soap). Students use universal indicators and pH meters to determine pH and record measurements in a table. 6. Teacher facilitates a whole-class discussion, where students share their observations and explain the acidity or basicity of household chemicals. 7. Students are assessed orally and also given a short quiz on how to use universal indicators and the pH meter to determine the pH of given solutions. **Closure** The teacher concludes lesson with a recapitulation of key points, reinforcing the students' understanding of pH and its practical applications.	markers.	Universal indicators and pH meters can be used to determine the pH of a solution. **Application** Students can apply the knowledge gained in this lesson to real-life scenarios, such as testing the acidity or alkalinity of various household items.	solution of pH = 1 or a solution of pH = 9 **Remark** The lesson was successfully taught.

3.9.3 Post-intervention phase

A week after the intervention phase, a post-test of the same standard as the pre-test, which also lasted for thirty (30) minutes, was administered to students by the researcher. This was done to compare the performance of the students before and after the intervention phase to measure the efficiency of the intervention procedures. The post-test was marked, scored and recorded by the researcher. After the post-test, Differentiated Instruction Views Questionnaire was also administered to the students by the researcher. The Differentiated Instruction Views Questionnaire was used to solicit for students‟ views on the use of differentiated instruction in the teaching and learning of Integrated Science. Data gathered were subjected to descriptive and inferential statistics using the Statistical Package for the Social Sciences (SPSS) programme version 20.

3.10 Data Analysis Technique

Creswell (2014) explained that data analysis involves organizing what we have observed, heard and read, to make sense of the acquired knowledge. He maintained that as one does so he or she categorizes, synthesizes, search for patterns and interprets the data collected. Cohen, Manion and Morrison (2018) defined data analysis as a systematic process involving working with data, organizing and breaking them into manageable units. It is also concerned with synthesizing data, searching patterns, discovering what is important, what is to be learned and deciding what to tell others. Data collected were analysed using the appropriate descriptive and inferential statistics of the Statistical Package for the Social Sciences (SPSS) Programme version 20. T-tests were employed to validate whether or not there were significant differences between students‟ scores on the pre- and post-intervention tests. Where necessary, measures of central tendency were used to analyse the data. The data were organized into frequencies and percentages and presented them using frequency tables.

3.11 Ethical Considerations

Ethical considerations are values and principles that distinguish between rights and wrongs in research studies (Burgess, 2019). Gray (2019) insists on the need of the researcher to observe the principle of ethics when conducting educational research. The researcher observed ethical principles throughout the conduct of the study. The researcher maintained the highest level of objectivity in the discussions and analysis of findings throughout the study. Works of other authors utilized in this study in any part of the published articles and highly refereed journals with the use of the APA referencing system were acknowledged. Before the commencement of the study, permission was sought from the authorities of the school where the research was conducted. Also, prospective participants were made aware of the purpose of the study and their rights as a participant. The researcher acknowledged the protection of privacy, anonymity, and dignity of the respondents involved in the study as it is of paramount importance. The researcher also ensured that the gathered data from the respondents were given with the highest degree of confidentiality. The respondents were neither harmed nor abused, both physically and psychologically, during the conduct of the research.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The study sought to improve senior high school students" academic performance in selected concepts in Integrated Science through differentiated instruction. This chapter presents the analysis of the data collected from the study"s respondents and the interpretation of the same. The chapter includes respondents" demographic information. The results were presented based on the research questions and null hypotheses posed in chapter one. The results were discussed alongside the presentation.

4.1 Demographic Data of Respondents

Completion rate is an important metric for assessing the validity and reliability of research findings. It is defined as the proportion of participants who fully engage in all aspects of the study protocol (Demerouti & Rispens, 2014). In this particular study, all 34 student participants completed all research procedures, resulting in a 100% completion rate. This high completion rate suggests that the study's findings are likely to be representative of the target population (students). The study also collected demographic data from the participants, including gender and age.

Table 1: Gender of Respondents

Gender	Frequency (f)	Percentage (%)
Male	19	55.9
Female	15	44.1
Total	**34**	**100**

The results (from Table 1) showed that the majority of participants (55.9%) were male, while 44.1% were female. Even though gender of the respondents for the study may not have direct influence, it remains a sensitive issue under discussion in every working environment (Mohamed, 2013). Further to this, the study included respondents of various age groups, as evidenced by the questionnaire responses.

Table 2: Age of Respondents

Age Groups	Frequency	Percentage (%)
11-15	5	14.7
16-20	27	79.4
20 and over	2	5.9

The data shows how the responses were distributed across three age groups. The study found that the majority of respondents were aged 16 to 20 years (79.4%), followed by 14.7% of respondents aged 11 to 15 years and 5.9% of respondents aged over 20 years. This suggests that the study sample was primarily composed of adolescents and young adults.

4.2 Research Question One

What is the effect of differentiated instruction on the academic performance of SHS students in selected Integrated Science concepts?

The means and standard deviations of pre-test and post-test scores of students are calculated and presented in Table 3.

Table 3: Means and Standard Deviations of Pre-test and Post-test Scores of ISPT

Group	Test	N	Mean	SD	Mean Difference
Intact Class	**Pre-test**	34	7.94	3.56	16.35
	Post-test	34	24.29	4.52	

The initial mean score on the pre-test for the intact class was 7.94, with a standard deviation of 3.56 while the mean post-test score was 24.29, with a standard deviation of 4.52 (Table 3). Also, the calculated mean difference between the two tests was 16.35. The substantial mean difference of 16.35 suggests a positive effect of differentiated instruction on the academic performance of SHS students in Integrated Science concepts. The results therefore indicate a notable improvement in academic performance from the pre-test to the post-test, suggesting that differentiated instruction has a positive effect on the academic performance of SHS students in selected Integrated Science concepts.

Testing null hypothesis H_{01}: There is no statistically significant difference between the mean academic performance of students before and after the use of differentiated instruction in the teaching and learning of selected Integrated Science concepts.

Comparative sample t-test was used to test null hypothesis 1 using data of test scores of students in pre-test and post-test. The result of the analysis is presented in Table 4.

Table 4: Summary of t-test Analysis of Pre-test and Post-test Scores of ISPT

Group	Test	N	Mean	SD	t-value	df	p-value
	Pre-test	34	7.94	3.56			
Intact Class					-18.08	33	1.09E-18
	Post-test	34	24.29	4.52			

***Significant at P < 0.05 level of significance**

Table 4 shows a calculated t-value of -18.08 and a corresponding P-value of 1.09E-18 observed at 33 degrees of freedom. Since the P-value of 1.09E-18 is less than the chosen significance level (alpha value) of 0.05, the null hypothesis is rejected. This suggests that there is a statistically significant difference between the mean academic performance of students before and after the use of differentiated instruction in the teaching and learning of selected Integrated Science concepts. Judging from the mean performance of the students, it is clear that the difference was in favour of the post-intervention test. This may be credited to the intervention. These results indicated that the intervention improved the academic performance of the students in the selected Integrated Science concepts. These findings affirm the effectiveness of differentiated instruction in improving student outcomes in science education.

The findings are consistent with a growing body of research that suggests that differentiated instruction can be an effective strategy for improving student outcomes in science education. The findings are in tandem with the earlier study by Obafemi and Olawole (2022) which revealed that there was a significant main effect of differentiated instruction on pupils‟ academic performance. In his influential meta-analysis, Hattie (2009) synthesised findings from over 800 studies and identified factors that have the most substantial impact on student achievement. Differentiated instruction emerged as a high-impact practice, reinforcing its significance in influencing positive learning outcomes. Additionally, research by Bybee and Fuchs (2006) contributes to the growing body of evidence supporting the effectiveness of differentiated instruction, particularly in the context of science education. Their study underscores how tailoring instructional approaches to individual student needs can enhance understanding, retention, and overall performance in science subjects. A study by Mavidou and Kakana (2019) investigated the effect of differentiated instruction strategies on children‟s reading achievement. The study findings indicated a statistically significant difference between the two groups of the study favouring the experimental group, which indicated that differentiated instruction developed students‟ achievements. Another study is by Chamberlin and Powers (2010), who conducted a quasi-experimental pre-test and post-test control-group mixed methods study in an undergraduate mathematics course involving students in their freshman year from two universities in the United States. The quantitative results from the study revealed that the experimental group scored higher in the post-tests than the control group, suggesting the effectiveness of differentiated instruction over regular whole class instruction. A study by Tomlinson (2000) concluded that differentiated instruction can promote student engagement, motivation, and achievement in science classrooms. Also, a meta-analysis by Tomlinson (2017) found that DI had a small but significant positive effect on student achievement in science. The positive impact of differentiated instruction on SHS students' academic performance in Integrated Science concepts can be attributed to its ability to cater to the diverse learning needs and styles of students. By providing multiple pathways to understanding, differentiated instruction allows students to access information and engage in learning in ways that are most effective for them. This personalised approach fosters increased student engagement, motivation, and, ultimately, improved academic performance. This amalgamation of evidence consolidates the assertion that differentiated instruction is a valuable strategy for promoting positive student outcomes in the realm of science education.

4.3 Research Question Two

What is the differential effect of differentiated instruction on the academic performance of the male and female SHS students?

To answer this question, means and standard deviations of post-test scores of ISPT for male and female students were computed and presented in Table 5.

Table 5: Means and Standard Deviations of Post-test Scores (ISPT) of Male and Female Students

Group	Test	N	Mean	SD	Mean Difference
Male	**Post-test**	19	24.74	4.37	
					1.01
Female	**Post-test**	15	23.73	4.80	

The data presented in Table 5 suggests that differentiated instruction has a positive and equitable effect on the academic performance of both male and female senior high school (SHS) students in Integrated Science. Specifically, Table 5 shows that, the mean post-test score for male students was 24.74 with a standard deviation of 4.37 while the mean post-test score for female students was 23.73 with a standard deviation of 4.80. Also, the observed mean difference between the two groups was only 1.01, suggesting a minimal discrepancy in their academic performance. This indicates that the post-test scores of male and female students were quite similar. This indicates that differentiated instruction does not appear to favour one gender over the other in terms of learning outcomes.

Testing null hypothesis H_{02}: There is no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction.

To test null hypothesis $H_{02,}$ post-test scores of ISPT of male and female students were subjected to t-test statistics. A summary of the analysis is shown in Table 6.

Table 6: Summary of t-test Analysis of Post-test Scores of ISPT of Male and Female Students

Group	Test	N	Mean	SD	t-value	Df	p-value
Male	Post-test	19	24.73684	4.37	-0.64	32	0.53
Female	Post-test	15	23.73333	4.80			

***Not Significant at P > 0.05 level of significance**

Table 6 shows a calculated t-value of -0.64 and a corresponding P-value of 0.53 observed at 32 degrees of freedom. Since the P-value of 0.53 is greater than the chosen significance level (alpha value) of 0.05, the null hypothesis is retained. This means that there is no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction. This non-significant result reinforces the idea that differentiated instruction is equally effective for both genders in enhancing academic performance. This result also lends strong support to the idea that differentiated instruction is not only inclusive but also a highly effective strategy for fostering equitable learning outcomes in the realm of science education. The finding aligns with existing literature that emphasises the efficacy of differentiated instruction in fostering equitable learning outcomes. Studies by Adams (2020) and Bondie et al. (2019) highlight the benefits of differentiated instruction in addressing diverse learning needs, promoting engagement, and enhancing academic achievement. Tomlinson (2014) underscores the importance of personalised approaches in accommodating various learning styles, further contributing to the idea that differentiated instruction is an effective strategy for both male and female students. Moreover, the result resonates with the principles of gender-inclusive education, acknowledging that instructional approaches should be tailored to meet the unique needs of all students regardless of gender (Singh, 2022). The concept of gender equity in education emphasises providing equal opportunities and support to students of all genders to excel academically (Johnson, 2019). This result agrees with the result of Ajai and Imoko (2015) which showed that there is no gender difference when good teaching method is used.

4.3 Research Question Three

What are the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science?

Table 7 summarises the responses to various statements regarding the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science.

Table 7: Students' Responses to Differentiated Instruction Views Questionnaire

Item	Response Type				
	SA F(%)	A F(%)	U F(%)	D F(%)	SD F(%)
1. I have better understanding of integrated science concepts because of differentiated instruction.	25(73.5)	5(14.7)	3(8.8)	1(2.9)	0(0)
2. I feel like I have more control over my own learning when differentiated instruction is used.	22(64.7)	9(26.5)	0(0)	1(2.9)	2(5.9)
3. I feel like I am able to contribute more to class discussions when differentiated instruction is used.	19(55.9)	13(38.2)	1(2.9)	1(2.9)	0(0)
4. I do not always enjoy the lesson when my teacher uses differentiated instruction.	1(2.9)	2(5.9)	1(2.9)	17(50)	13(38.2)
5. I appreciate the variety of activities and assignments that are available when differentiated instruction is used.	12(35.3)	18(52.9)	1(2.9)	2(5.9)	1(2.9)
6. I feel like I am a more successful learner when differentiated instruction is used.	10(29.4)	16(47.1)	6(17.6)	2(5.9)	0(0)
7. I think differentiated instruction should not be used in all schools.	2(5.9)	3(8.8)	3(8.8)	12(35.3)	14(41.2)
8. I think differentiated instruction helps all students learn, regardless of their ability level.	20(58.8)	12(35.3)	1(2.9)	1(2.9)	0(0)
9. I feel challenged and engaged when my teacher uses differentiated instruction.	18(52.9)	12(35.3)	2(5.9)	1(2.9)	1(2.9)
10. My teacher uses a variety of teaching strategies to meet the needs of all learners.	21(61.8)	10(29.4)	2(5.9)	1(2.9)	0(0)
11. My teacher provides me with feedback that helps me learn.	15(44.1)	18(52.9)	0(0)	1(2.9)	0(0)
12. I feel like I am getting the help I need in my integrated science class.	19(55.9)	12(35.3)	2(5.9)	0(0)	1(2.9)
13. I feel like I am motivated to learn in my integrated science class.	16(47.1)	15(44.1)	0(0)	2(5.9)	1(2.9)
14. I think differentiated instruction is not fair way to teach students.	1(2.9)	2(5.9)	3(8.8)	11(32.4)	17(50)
15. I would like to recommend differentiated instruction to teachers of other subjects.	21(61.8)	11(32.4)	2(2.9)	0(0)	0(0)

Table 7 reveals that, SHS students hold positive views on the use of differentiated instruction in the teaching and learning of Integrated Science. A significant majority of respondents (88.2%) agreed that they have better understanding of Integrated Science concepts because of differentiated instruction. Only one respondent (2.9%) disagreed, and three (8.8%) were undecided. Similarly, a substantial number of respondents (91.2%) expressed agreement with the statement that they have more control over their learning when differentiated instruction is used, while three (8.8%) disagreed. Regarding class discussions, 94.1% of respondents agreed that they are able to contribute more when differentiated instruction is used. Only one respondent (2.9%) was undecided, and another (2.9%) disagreed. Some students (8.8%) indicated that they do not always enjoy the lesson when their teacher uses differentiated instruction, with one (2.9%) being undecided, and the majority (88.2%) disagreeing.

Furthermore, 88.2% of the respondents agreed that they appreciate the variety of activities and assignments available with differentiated instruction. One student (2.9%) was undecided, and three (8.8%) disagreed. The majority of students (76.5%) feel like more successful learners when differentiated instruction is used. Six (17.6%) were undecided, and two (5.9%) disagreed. Concerning the application of differentiated instruction in all schools, 14.7% of respondents agreed that it should not be used universally. Three (3.8%) were undecided, and a substantial proportion (76.5%) disagreed. Notably, 94.1% of students agreed that differentiated instruction helps all students learn, regardless of their ability level. Only one respondent (2.9%) was undecided, and another (2.9%) disagreed. In terms of feeling challenged and engaged, 88.2% of respondents agreed when their teacher employs differentiated instruction, while two (5.9%) were undecided, and two (5.9%) disagreed. A high percentage (91.2%) agreed that their teacher uses a variety of teaching strategies to meet the needs of all learners. Two (5.9%) were undecided, and one (2.9%) disagreed. The overwhelming majority (97%) of respondents agreed that their teacher provides feedback that aids in their learning. None (0%) were undecided, and one (2.9%) disagreed. Again, regarding receiving the necessary help in their Integrated Science class, 91.2% of students agreed, while two (5.9%) were undecided, and one (2.9%) disagreed. Most students (91.2%) expressed feeling motivated to learn in their Integrated Science class. None (0%) were undecided, and three (8.8%) disagreed. A small number of students (8.8%) agreed that differentiated instruction is not a fair way to teach, with three (8.8%) being undecided, and the majority (82.4%) disagreeing. Finally, a notable percentage (94.2%) of respondents agreed that they would recommend differentiated instruction to teachers of other subjects. Two students (2.9%) were undecided, and none (0%) disagreed.

The findings from Table 7 strongly suggest that SHS students have overwhelmingly positive views on the use of differentiated instruction in the teaching and learning of Integrated Science. They perceive differentiated instruction as a valuable pedagogical approach that enhances their understanding, engagement, and overall learning experience. The majority of respondents express positive views of differentiated instruction, with strong agreement regarding understanding, control over learning, and contribution to class discussions. The results also highlight positive views on the variety of activities and teaching strategies. While a few concerns and uncertainties exist, the overall sentiment suggests a favourable reception of differentiated instruction in the context of Integrated Science education. The positive views of Senior High School (SHS) students on differentiated instruction (DI) are consistent with previous research findings highlighting the effectiveness of DI in science education. A study conducted by Agyeman-Duah and Osei-Mensah (2018) in Ghana revealed that SHS students generally hold favourable perceptions of DI, emphasising its ability to address individual learning needs and styles. Similarly, Owusu-Ansah and Adjei's (2020) study demonstrated that SHS students appreciated the variety of learning activities and the flexibility to work at their own pace provided by DI. Furthermore, Alhassan (2019) found that DI positively impacted student learning and engagement in Integrated Science within senior high schools in Ghana. These findings also align with previous research indicating that students across various contexts generally view differentiated instruction favourably, particularly its ability to cater to their individual needs and preferences (Smale-Jacobse et al.,2019).

In addition to the positive views, the literature consistently demonstrates that differentiated instruction has a positive impact on student learning outcomes in science. Research studies, such as those by Alsalhi et al. (2021) and Zens (2021), have consistently shown that DI can enhance student achievement, engagement, and motivation. The constructive impact of differentiated instruction (DI) on SHS students' perspectives is attributed to its effectiveness in addressing diverse learning needs and styles (Owusu-Ansah & Adjei, 2020). By offering multiple pathways to understanding, DI enables students to access information and engage in learning in ways that suit them best (Tomlinson, 2017). This approach fosters a sense of ownership over their learning experience and contributes to a more inclusive and equitable learning environment (Lindner & Schwab, 2020). As a result of the research conducted by Demir (2021), the differentiated teaching methods have increased solidarity among students, improved communication skills, and increased interaction with friends in the group.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the main findings and conclusions drawn from the study. The chapter also presents recommendations for stakeholders and suggestions for further research.

5.1 Summary of the Study

This study sought to improve senior high school students' academic performance in selected Integrated Science concepts through differentiated instruction. To realise the research purpose, the study was guided by the following specific objectives: to determine the effect of differentiated instruction on the academic performance of SHS students in selected Integrated Science concepts, to establish the differential effect of differentiated instruction on the academic performance of the male and female SHS students and ascertain the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science. Three research questions were answered: What is the effect of differentiated instruction on the academic performance of SHS students in selected Integrated Science concepts? What is the differential effect of differentiated instruction on the academic performance of the male and female SHS students? What are the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science? Further, two null hypotheses: H_{01}: There is no statistically significant difference between the mean academic performance of students before and after the use of differentiated instruction in the teaching and learning of selected Integrated Science concepts, and H_{02}: There is no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction, were tested at 0.05 level of significance. The study adopted an action research design and utilised the purposive sampling technique to choose an intact class of thirty-four (34) students to form the sample of the study. Data were collected using achievement tests and questionnaire. Data collected were analysed using descriptive statistics such as the mean, organised into frequencies and percentages and presented through frequency tables. T-tests were employed to validate whether or not there were significant differences between the mean scores obtained on the tests.

5.2 Summary of Main Findings

5.2.1 Effect of differentiated instruction on the academic performance of SHS students in selected Integrated Science concepts

The descriptive statistics of pre-test and post-test scores indicated a notable improvement in academic performance from the pre-test to the post-test. The mean score on the pre-test for the intact class was 7.94, with a standard deviation of 3.56 while the mean post-test score was 24.29, with a standard deviation of 4.52. The substantial mean difference of 16.35 suggests a positive effect of differentiated instruction on the academic performance of SHS students in Integrated Science concepts. The t-test analysis revealed that there was a statistically significant difference between the pre-test mean score and the post-test mean score (P-value = 1.09E-18) thus the null hypothesis stating that there is no statistically significant difference between the mean academic performance of students before and after the use of differentiated instruction in the teaching and learning of selected Integrated Science concepts was rejected. These findings affirm the effectiveness of differentiated instruction in improving senior high school students' academic performance in selected Integrated Science concepts.

5.2.2 Differential effect of differentiated instruction on the academic performance of the male and female SHS students

The analysis of post-test scores revealed that differentiated instruction had a positive and equitable effect on the academic performance of both male and female senior high school (SHS) students in Integrated Science. The mean post-test score for male students was 24.74 with a standard deviation of 4.37 while the mean post-test score for female students was 23.73 with a standard deviation of 4.80. The observed mean difference of 1.01 between the two groups, suggests a minimal discrepancy in their academic performance. This indicates that differentiated instruction does not appear to favour one gender over the other in terms of learning outcomes. The t-test analysis revealed that there was no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction (P-value = 0.53) thus the null hypothesis stating that there is no statistically significant difference between the mean academic performance of the male and female SHS students after being taught with differentiated instruction was retained. This non-significant result reinforces the idea that differentiated instruction is equally effective for both genders in enhancing the academic performance of the male and female SHS students.

5.2.3 Views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science

Data were collected from the respondents of the study using questionnaires. Respondents were asked to respond to statements that could indicate their views on the use of differentiated instruction in the teaching and learning of Integrated Science. A significant majority of respondents (88.2%) agreed that they have better understanding of Integrated Science concepts because of differentiated instruction. Only one respondent (2.9%) disagreed, and three (8.8%) were undecided. Similarly, a substantial number of respondents (91.2%) expressed agreement with the statement that they have more control over their learning when differentiated instruction is used, while three (8.8%) disagreed. Regarding class discussions, 94.1% of respondents agreed that they are able to contribute more when differentiated instruction is used. Only one respondent (2.9%) was undecided, and another (2.9%) disagreed. Some students (8.8%) indicated that they do not always enjoy the lesson when their teacher uses differentiated instruction, with one (2.9%) being undecided, and the majority (88.2%) disagreeing. Furthermore, 88.2% of the respondents agreed that they appreciate the variety of activities and assignments available with differentiated instruction. One student (2.9%) was undecided, and three (8.8%) disagreed. The majority of students (76.5%) feel like more successful learners when differentiated instruction is used. Six (17.6%) were undecided, and two (5.9%) disagreed. Concerning the application of differentiated instruction in all schools, 14.7% of respondents agreed that it should not be used universally. Three (3.8%) were undecided, and a substantial proportion (76.5%) disagreed. Notably, 94.1% of students agreed that differentiated instruction helps all students learn, regardless of their ability level. Only one respondent (2.9%) was undecided, and another (2.9%) disagreed. In terms of feeling challenged and engaged, 88.2% of respondents agreed when their teacher employs differentiated instruction, while two (5.9%) were undecided, and two (5.9%) disagreed. A high percentage (91.2%) agreed that their teacher uses a variety of teaching strategies to meet the needs of all learners. Two

(5.9%) were undecided, and one (2.9%) disagreed. The overwhelming majority (97%) of respondents agreed that their teacher provides feedback that aids in their learning. None (0%) were undecided, and one (2.9%) disagreed. Again, regarding receiving the necessary help in their Integrated Science class, 91.2% of students agreed, while two (5.9%) were undecided, and one (2.9%) disagreed. Most students (91.2%) expressed feeling motivated to learn in their Integrated Science class. None (0%) were undecided, and three (8.8%) disagreed. A small number of students (8.8%) agreed that differentiated instruction is not a fair way to teach, with three (8.8%) being undecided, and the majority (82.4%) disagreeing. Finally, a notable percentage (94.2%) of respondents agreed that they would recommend differentiated instruction to teachers of other subjects. Two students (2.9%) were undecided, and none (0%) disagreed. These findings strongly suggest that SHS students have overwhelmingly positive views on the use of differentiated instruction in the teaching and learning of Integrated Science. This provides strong evidence that differentiated instruction is a valuable approach for teaching Integrated Science, leading to improved understanding, engagement, and overall student success. While there are some concerns to address, the overall consensus supports the implementation of differentiated instruction as a beneficial and inclusive teaching strategy.

5.3 Conclusions

Based on the findings of this novel study, the following main conclusions were drawn:

Firstly, the implementation of differentiated instruction demonstrated a statistically significant improvement in SHS students' academic performance, as evidenced by notable differences between pre-test and post-test scores. This affirms that differentiated instruction has a substantial and positive impact on the academic performance of senior high school students in selected Integrated Science concepts.

Secondly, the gender analysis conducted in this study revealed a noteworthy and equitable benefit of differentiated instruction for both male and female students. The approach exhibited an equal improvement in academic performance across genders, emphasising its inclusive nature. The absence of a significant difference in impact further supports the notion that differentiated instruction fosters equitable educational outcomes for male and female students alike.

Thirdly, the overwhelming positive views that students have regarding differentiated instruction highlight how well it fosters comprehension, engagement, and an all-around improvement in the quality of learning experiences. This attests to the method's resonance with students, further emphasising its potential as a valuable and recommended approach in the teaching and learning of various subjects.

In summary, the comprehensive findings of this study collectively support the beneficial effect of differentiated instruction on the academic performance of SHS students in Integrated Science. Not only does it demonstrate a significant improvement in learning outcomes, but it also stands out for its inclusive impact on both male and female students. Furthermore, students' positive views show that differentiated instruction has the potential to become a highly regarded pedagogical strategy that can improve comprehension and engagement across diverse educational settings. This study's findings contribute to the growing body of evidence supporting the effectiveness of differentiated instruction in enhancing academic performance and fostering positive student experiences in science education.

5.4 Recommendations

Based on the findings from this study, the following recommendations were made:

1. Integrated Science teachers should consider incorporating differentiated instruction strategies to improve student learning outcomes.
2. Integrated Science teachers should master different instructional methods for effective use of differentiated instruction.
3. Teachers should actively seek feedback from students to continuously improve and adapt differentiated instruction strategies.
4. Policymakers and educators should collaborate to promote the widespread adoption of differentiated instruction, acknowledging its positive influence on student learning and views.
5. School administrators and policymakers should provide support and resources for teacher training in differentiated instruction.
6. Professional development programs for teachers should include training on differentiated instruction methods to enhance their ability to cater to diverse student needs effectively.
7. Government and other educational bodies should sponsor and organise technical workshops and seminars on the use of differentiated instruction
8. Curriculum planners and designers should incorporate the use of differentiated instruction strategies in the development of the Integrated Science curriculum.
9. Publishers should produce Integrated Science text books using differentiated instruction format.

5.5 Suggestions for further Study

The study finally recommends areas for further research.

1. Further research should be conducted to continue exploring the effectiveness of differentiated instruction in various educational settings and subjects.
2. Researchers should consider expanding the scope of the study and increasing the sample size to determine if similar or different results can be obtained.
3. Qualitative and quantitative studies can be conducted at different lessons and classes to examine the effect of the differentiated instruction on the students‟ attitudes.
4. Explore the views and experiences of teachers in implementing differentiated instruction across diverse subject areas.
5. Assess the influence of differentiated instruction on students' long-term retention of scientific concepts.
6. Investigate the influence of teacher training and professional development programs on the successful implementation of differentiated instruction.
7. Explore the role of technology in facilitating differentiated instruction and its impact on student outcomes.

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APPENDICES

APPENDIX A

Integrated Science Performance Test

(Pre-Test)

Gender: Male [ ] Female [ ] **Duration: 30mins**

Answer all questions

1. When an acid reacts with a metal, which of the following gases is produced?

   A. Ammonia gas

   B. Oxygen gas

   C. Hydrogen gas

   D. Carbon dioxide gas

2. All of the following processes occur during inspiration in a human body except the

   A. contraction of the diaphragm muscles.

   B. contraction of the intercostal muscles.

   C. increase in the volume of the chest cavity.

   D. increase in the volume of lungs.

3. The number of replaceable hydrogen atoms an acid contains is known as its

   A. acidity

   B. basicity

   C. pH value

   D. alkalinity

4. A boy who got trapped in a cupboard died because

   A. all the air in the cupboard was used up.

   B. only nitrogen gas was left in the cupboard.

   C. the greater part of oxygen in the cupboard was used.

   D. noble gases run shot in the cupboard.

5. The colour of phenolphthalein in orange juice is

   A. blue

   B. colourless

   C. pink

   D. red

6. Lactic acid can be found in

   A. grape.

   B. palm oil.

   C. orange.

   D. sour milk.

7. Which of the following structures has mucus and cilia for trapping dust and germs?

   A. Alveolus

   B. Bronchiole

   C. Bronchus

   D. Trachea

8. A strong acid is one which

   A. has a strong corrosive power.

   B. has a low concentration of water.

   C. gives high concentration of hydrogen ions in solution.

   D. gives high concentration of hydroxide ions in solution.

9. Exhaled air may readily put off a burning candle because it contains high levels of

   A. oxygen and nitrogen.

   B. nitrogen and heat.

   C. heat and oxygen.

   D. carbon dioxide and moisture.

10. Respiration is essential to life because

    A. food is oxidized.

    B. oxygen is used up.

    C. waste products are eliminated.

    D. energy is released.

11. Which of the following statements about anaerobic respiration is correct?

    A. Carbon dioxide and water are produced.

    B. Oxygen gas is released.

    C. Oxygen gas is used up.

    D. Glucose is broken down.

12. The products of the reaction between sodium hydroxide and hydrochloric acid are
    A. sodium chloride and water.
    B. hydrogen chloride and water.
    C. sodium chloride and hydrogen gas.
    D. hydrogen chloride and hydrogen gas.
13. Germinating seeds release heat energy and carbon dioxide which is an indication that
    A. heat is required for germination.
    B. seeds can supply energy to the body when eaten.
    C. seeds are living things.
    D. carbon dioxide is not required for germination
14. A soil of pH 8 is best described as
    A. strongly acidic.
    B. strongly alkaline.
    C. slightly acidic.
    D. slightly alkaline.
15. Which of the following is the correct order of the air passages in the respiratory system?
    A. Nose → trachea → bronchi → alveoli
    B. Nose → bronchi → trachea → alveoli
    C. Trachea → bronchi → alveoli → nose
    D. Bronchi → alveoli → trachea → nose
16. Consider the reaction: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
    The reaction represents
    A. esterification.
    B. polymerisation.
    C. neutralisation.
    D. vaporisation.
17. In order for inhalation to take place
    A. the rib cage must be lowered.
    B. muscles of the diaphragm must be relaxed.
    C. pressure in the lungs must be reduced.
    D. the volume of the thoracic cavity must be reduced.

18. The bronchi in the lungs divide into smaller branches which end in tiny sacs called

    A. alveoli.

    B. bronchioles.

    C. spiracles.

    D. tubules.

19. Ethanoic acid is said to be a weak acid because

    A. nearly all its molecules form hydrogen ions in solution.

    B. it does not produce hydroxide ions in solution.

    C. its aqueous solutions have pH values lower than 7.

    D. it gives relatively few hydrogen ions in solution.

20. The structure that covers the opening of the trachea during swallowing and prevents food from entering it is the

    A. epiglottis.

    B. lungs.

    C. pharynx.

    D. rib cage.

21. Which of the following substances when in solution will turn litmus paper red?

    A. Epson salt
    B. Sodium chloride
    C. Sodium carbonate
    D. Vinegar

22. During exhalation, air is forced out of the lungs because

    A. the concentration of carbon dioxide is higher within the lungs.

    B. pressure in the lungs is increased.

    C. the muscles of the diaphragm contract.

    D. the rib cage is raised upwards.

23. Water was added to a quantity of soil and the mixture shaken and filtered. When red litmus solution was added to the filtrate, the filtrate turned blue. The result shows that the soil is

    A. acidic.
    B. alkaline.
    C. clayey.
    D. neutral.

24. Which of the following is a respiratory disorder that is characterized by a build-up of fluid in the lungs?
    A. Asthma
    B. Bronchitis
    C. Emphysema
    D. Pneumonia
25. Ash from cocoa pod or baobab tree fruit pod tastes bitter because it contains
    A. acid.
    B. alkali.
    C. alcohol.
    D. salt.
26. Exchange of gases in plants occurs mainly through the
    A. buds.
    B. cuticle.
    C. epidermal cells.
    D. stomata.
27. An aqueous solution of an acid
    A. liberates hydrogen with active metals.
    B. turns red litmus blue.
    C. has a soapy feel.
    D. has a bitter taste.
28. Which of the following is a respiratory disorder that affects the airways?
    A. Asthma
    B. Bronchitis
    C. Emphysema
    D. Pneumonia
29. The balanced equation representing the reaction between iron and dilute hydrochloric acid is
    A. $Fe(s) + HCI(aq) \rightarrow FeCl(aq) + H_2(g)$
    B. $2Fe(s) + 2HCl(aq) \rightarrow Fe_2Cls) + H_2(g)$
    C. $Fe(s) + 2HCI(aq) \rightarrow FeCI_2(aq) + H_2(g)$
    D. $2Fe(s) + 2HCl(aq) \rightarrow Fe2Cl_2(aq) + H_2(g)$
30. Anaerobic respiration can be employed in industry in the
    A. brewing of beer.
    B. manufacturing of linen.
    C. gas welding.
    D. making of beads.

APPENDIX B

Integrated Science Performance Test

Marking Scheme (Pre-test)

1. A
2. D
3. B
4. C
5. B
6. D
7. D
8. C
9. D
10. D
11. D
12. A
13. C
14. D
15. A
16. C
17. C
18. A
19. D
20. A
21. D
22. B
23. B
24. D
25. B
26. D
27. A
28. A
29. C
30. A

APPENDIX C

Integrated Science Performance Test

(Post-test)

Gender: Male [ ] Female [ ] **Duration: 30mins**

Answer all questions

1. Respiration is essential to life because
   A. food is oxidised.
   B. oxygen is used up.
   C. waste products are eliminated.
   D. energy is released.
2. Which of the following is a respiratory disorder that is characterised by a build-up of fluid in the lungs?
   A. Asthma
   B. Bronchitis
   C. Emphysema
   D. Pneumonia
3. The number of replaceable hydrogen atoms an acid contains is known as its
   A. acidity
   B. basicity
   C. pH value
   D. alkalinity
4. A boy who got trapped in a cupboard died because
   A. all the air in the cupboard was used up.
   B. only nitrogen gas was left in the cupboard.
   C. the greater part of oxygen in the cupboard was used.
   D. noble gases run shot in the cupboard.
5. The balanced equation representing the reaction between iron and dilute hydrochloric acid is
   A. $Fe(s) + HCI(aq) \rightarrow FeCl(aq) + H_2(g)$
   B. $2Fe(s) + 2HCl(aq) \rightarrow Fe_2Cls) + H_2(g)$
   C. $Fe(s) + 2HCI(aq) \rightarrow FeCI_2(aq) + H_2(g)$
   D. $2Fe(s) + 2HCl(aq) \rightarrow Fe_2Cl_2(aq) + H_2(g)$

6. The structure that covers the opening of the trachea during swallowing and prevents food from entering it is the
   A. epiglottis.
   B. lungs.
   C. pharynx.
   D. rib cage.
7. Which of the following structures has mucus and cilia for trapping dust and germs?
   A. Alveolus
   B. Bronchiole
   C. Bronchus
   D. Trachea
8. A strong acid is one which
   A. has a strong corrosive power.
   B. has a low concentration of water.
   C. gives high concentration of hydrogen ions in solution.
   D. gives high concentration of hydroxide ions in solution.
9. Exhaled air may readily put off a burning candle because it contains high levels of
   A. oxygen and nitrogen.
   B. nitrogen and heat.
   C. heat and oxygen.
   D. carbon dioxide and moisture.
10. Which of the following statements about anaerobic respiration is correct?
    A. Carbon dioxide and water are produced.
    B. Oxygen gas is released.
    C. Oxygen gas is used up.
    D. Glucose is broken down.
11. The products of the reaction between sodium hydroxide and hydrochloric acid are
    A. sodium chloride and water.
    B. hydrogen chloride and water.
    C. sodium chloride and hydrogen gas.
    D. hydrogen chloride and hydrogen gas.

12. Germinating seeds release heat energy and carbon dioxide which is an indication that
    A. heat is required for germination.
    B. seeds can supply energy to the body when eaten.
    C. seeds are living things.
    D. carbon dioxide is not required for germination.
13. A soil of pH 8 is best described as
    A. strongly acidic.
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    C. slightly acidic.
    D. slightly alkaline.
14. Which of the following is the correct order of the air passages in the respiratory system?
    A. Nose → trachea → bronchi → alveoli
    B. Nose → bronchi → trachea → alveoli
    C. Trachea → bronchi → alveoli → nose
    D. Bronchi → alveoli → trachea → nose
15. Consider the reaction: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
    The reaction represents
    A. esterification.
    B. polymerisation.
    C. neutralisation.
    D. vaporisation.
16. In order for inhalation to take place
    A. the rib cage must be lowered.
    B. muscles of the diaphragm must be relaxed.
    C. pressure in the lungs must be reduced.
    D. the volume of the thoracic cavity must be reduced.
17. The bronchi in the lungs divide into smaller branches which end in tiny sacs called
    A. alveoli.
    B. bronchioles.
    C. spiracles.
    D. tubules.

18. Lactic acid can be found in
    A. grape.
    B. palm oil.
    C. orange.
    D. sour milk.

19. Ethanoic acid is said to be a weak acid because
    A. nearly all its molecules form hydrogen ions in solution.
    B. it does not produce hydroxide ions in solution.
    C. its aqueous solutions have pH values lower than 7.
    D. it gives relatively few hydrogen ions in solution.

20. Anaerobic respiration can be employed in industry in the
    A. brewing of beer.
    B. manufacturing of linen.
    C. gas welding.
    D. making of beads.

21. Water was added to a quantity of soil and the mixture shaken and filtered. When red litmus solution was added to the filtrate, the filtrate turned blue. The result shows that the soil is
    A. acidic.
    B. alkaline.
    C. clayey.
    D. neutral.

22. Ash from cocoa pod or baobab tree fruit pod, tastes bitter because it contains
    A. acid.
    B. alkali.
    C. alcohol.
    D. salt.

23. All of the following processes occur during inspiration in a human body except the
    A. contraction of the diaphragm muscles.
    B. contraction of the intercostal muscles.
    C. increase in the volume of the chest cavity.
    D. increase in the volume of lungs.

24. When an acid reacts with a metal, which of the following gases is produced?
    A. Ammonia gas
    B. Oxygen gas
    C. Hydrogen gas
    D. Carbon dioxide gas
25. Which of the following substances when in solution will turn litmus paper red?
    A. Epson salt
    B. Sodium chloride
    C. Sodium carbonate
    D. Vinegar
26. During exhalation, air is forced out of the lungs because
    A. the concentration of carbon dioxide is higher within the lungs.
    B. pressure in the lungs is increased.
    C. the muscles of the diaphragm contract.
    D. the rib cage is raised upwards.
27. Which of the following is a respiratory disorder that affects the airways?
    A. Asthma
    B. Bronchitis
    C. Emphysema
    D. Pneumonia
28. Exchange of gases in plants occurs mainly through the
    A. buds.
    B. cuticle.
    C. epidermal cells.
    D. stomata.
29. An aqueous solution of an acid
    A. liberates hydrogen with active metals.
    B. turns red litmus blue.
    C. has a soapy feel.
    D. has a bitter taste.
30. The colour of phenolphthalein in orange juice is
    A. blue
    B. colourless
    C. pink
    D. red

APPENDIX D

Integrated Science Performance Test

Marking Scheme (Post-test)

1. D
2. D
3. B
4. C
5. C
6. A
7. D
8. C
9. D
10. D
11. A
12. C
13. D
14. A
15. C
16. C
17. A
18. D
19. D
20. A
21. B
22. B
23. D
24. C
25. D
26. B
27. A
28. D
29. A
30. B

APPENDIX E

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION

Differentiated Instruction Views Questionnaire [DIVQ]

This questionnaire has been designed to collect data on the views of SHS students on the use of differentiated instruction in the teaching and learning of Integrated Science. The researcher assures you that the information gathered will be treated with utmost confidentiality and for academic purposes only. Do not write your name anywhere in this questionnaire. Kindly respond to all items as accurate as possible.

Kindly tick (√) where appropriate

Gender: Male [ ] Female [ ]

Age Group: 11 – 15 [ ] 16 – 20 [ ] 20 and Over [ ]

KEY: Strongly Agree = SA Agree = A Undecided = U Strongly Disagree = SD Disagree = D

No.	Items	Responses				
		SA	A	U	D	SD
1	I have better understanding of integrated science concepts because of differentiated instruction.					
2	I feel like I have more control over my own learning when differentiated instruction is used.					
3	I feel like I am able to contribute more to class discussions when differentiated instruction is used.					
4	I do not always enjoy the lesson when my teacher uses differentiated instruction.					
5	I appreciate the variety of activities and assignments that are available when differentiated instruction is used.					
6	I feel like I am a more successful learner when differentiated instruction is used.					
7	I think differentiated instruction should not be used in all schools.					
8	I think differentiated instruction helps all students learn, regardless of their ability level.					
9	I feel challenged and engaged when my teacher uses differentiated instruction.					
10	My teacher uses a variety of teaching strategies to meet the needs of all learners.					
11	My teacher provides me with feedback that helps me learn.					
12	I feel like I am getting the help I need in my integrated science class.					
13	I feel like I am motivated to learn in my integrated science class.					
14	I think differentiated instruction is not fair way to teach students.					
15	I would like to recommend differentiated instruction to teachers of other subjects.					

APPENDIX F

Raw Scores of Students

Gender	Pre-test	Post-test
F	12	30
F	6	23
F	9	29
F	7	23
F	7	17
F	11	19
F	2	30
F	6	24
F	9	24
F	5	20
F	9	19
F	10	16
F	16	27
F	12	30
F	11	25
M	4	24
M	15	27
M	12	17
M	6	30
M	5	26
M	2	17
M	9	19
M	6	26
M	11	30
M	4	19
M	6	28
M	4	25
M	8	29
M	11	24
M	4	21
M	13	29
M	6	26
M	6	30
M	6	23

APPENDIX G

Descriptive Statistics with Respect to Research Question One

Pre-test		Post-test	
Mean	7.941176	Mean	24.29412
Standard Error	0.610282	Standard Error	0.775665
Median	7	Median	24.5
Mode	6	Mode	30
Standard Deviation	3.558525	Standard Deviation	4.522867
Sample Variance	12.6631	Sample Variance	20.45633
Kurtosis	-0.51304	Kurtosis	-1.12287
Skewness	0.398515	Skewness	-0.31894
Range	14	Range	14
Minimum	2	Minimum	16
Maximum	16	Maximum	30
Sum	270	Sum	826
Count	34	Count	34
Largest(1)	16	Largest(1)	30
Smallest(1)	2	Smallest(1)	16
Confidence Level(95.0%)	1.241628	Confidence Level(95.0%)	1.578103

APPENDIX H

t-Test Analysis with Respect to Null Hypothesis H_{01}

t-Test: Paired Two Sample for Means

	Pre-test	Post-test
Mean	7.941176	24.29412
Variance	12.6631	20.45633
Observations	34	34
Pearson Correlation	0.16491	
Hypothesized Mean Difference	0	
Df	33	
t Stat	-18.0812	
P(T<=t) one-tail	5.44E-19	
t Critical one-tail	1.69236	
P(T<=t) two-tail	1.09E-18	
t Critical two-tail	2.034515	

APPENDIX I

Descriptive Statistics with Respect to Research Question Two

Female		**Male**	
Mean	23.73333	Mean	24.73684
Standard Error	1.240072	Standard Error	1.002459
Median	24	Median	26
Mode	30	Mode	30
Standard Deviation	4.802777	Standard Deviation	4.369619
Sample Variance	23.06667	Sample Variance	19.09357
Kurtosis	-1.21993	Kurtosis	-0.88102
Skewness	-0.08285	Skewness	-0.53385
Range	14	Range	13
Minimum	16	Minimum	17
Maximum	30	Maximum	30
Sum	356	Sum	470
Count	15	Count	19
Largest(1)	30	Largest(1)	30
Smallest(1)	16	Smallest(1)	17
Confidence Level(95.0%)	2.659689	Confidence Level(95.0%)	2.106089

APPENDIX J

t-Test Analysis with Respect to Null Hypothesis H_{02}

t-Test: Two-Sample Assuming Equal Variances

	Female	Male
Mean	23.73333	24.73684
Variance	23.06667	19.09357
Observations	15	19
Pooled Variance	20.8318	
Hypothesized Mean Difference	0	
Df	32	
t Stat	-0.63656	
P(T<=t) one-tail	0.264469	
t Critical one-tail	1.693889	
P(T<=t) two-tail	0.528938	
t Critical two-tail	2.036933	