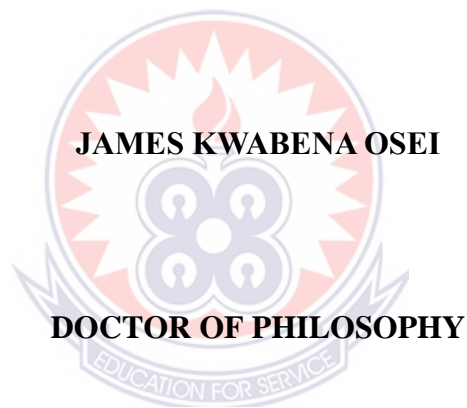


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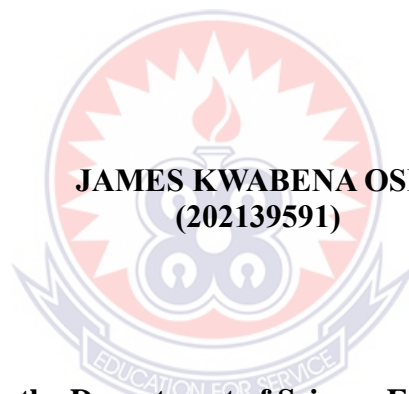
Exploring science teachers' instructional practices across regular, inclusive, and deaf basic schools in Ghana- a multiple case study



2024

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**EXPLORING SCIENCE TEACHERS' INSTRUCTIONAL PRACTICES
ACROSS REGULAR, INCLUSIVE, AND DEAF BASIC SCHOOLS IN
GHANA: A MULTIPLE CASE STUDY**



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**A thesis in the Department of Science Education, Faculty
of Science Education, submitted to the School of
Graduate Studies in partial fulfilment
of the requirements for the award of the degree of
Doctor of Philosophy
(Science Education)
in the University of Education, Winneba**

SEPTEMBER, 2024

DECLARATION

Student's Declaration

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

Signature

Date

SUPERVISOR'S DECLARATION

We 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.

Prof. John K. Eminah (Principal Supervisor)

Signature:.....

Date:.....

Dr. Charles K. Koomoson (Co-Supervisor)

Signature:.....

Date:.....

DEDICATION

To my daughters Francisca and Elsa



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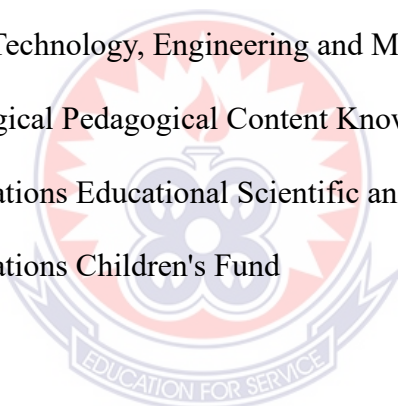
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ABBREVIATIONS

CCC	Common Core Curriculum
DHH	Deaf and Hard-of- Hearing
LSEN	Special Education Needs
IE	Inclusive Education
NaCCA	National Council for Curriculum and Assessment
NTC	National Teaching Council
PCK	Pedagogical Content Knowledge
SBC	Standards -Based Curriculum
SEN	Special Education Needs
STEM	Science, Technology, Engineering and Mathematics
TPACK	Technological Pedagogical Content Knowledge
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNICEF	United Nations Children's Fund



ABSTRACT

Science education remains central to Ghana's national development agenda, yet concerns persist regarding how effectively science is taught at the basic school level, particularly within diverse learning environments. Despite curriculum reforms and inclusive education policies, disparities in instructional practices are evident across regular, inclusive, and special schools for the deaf. Limited empirical research has systematically examined how science teachers in these varied contexts plan, deliver, and assess instruction, and how their practices respond to the unique needs of learners. This study therefore set out to explore the instructional practices of science teachers in a regular basic school, an inclusive basic school, and a school for the deaf in Ghana, with a view to identifying strengths, challenges, and context-specific implications for improving science education. A phenomenological research design was adopted to understand and describe the lived experiences of individuals. Semi-structured interviews and observations were used for data collection. The sample comprised 30 individuals, including teachers and interpreters from the targeted schools, with data saturation guided by the richness and quality of the data collected. The findings revealed that science teachers possessed varying academic qualifications, from Diplomas to Master's Degrees, influencing their preparedness for teaching. Teachers emphasized the importance of planning, delivery, and assessment in their instructional practices. Regular schools primarily used lecture-based teaching, inclusive schools adapted methods to diverse learning needs, and deaf schools relied on visual aids and sign language. Teachers in inclusive classrooms employed multi-modal approaches, individualized instructions, and technology integration, despite challenges like time constraints and resource limitations. There was a significant discrepancy between reported and actual usage of assistive technologies, with barriers like cost and maintenance limiting their effectiveness. Capacity-enhancing activities, including INSET workshops, were crucial but required more specialized training and regular refresher courses. The study recommends that educational authorities and school administrators should collaborate to provide ongoing professional development specifically tailored to the unique demands of inclusive and deaf education. The Ministry of Education and the Ghana Education Service should develop frameworks and support systems that encourage and facilitate further individualization of instruction. This includes organizing professional development workshops focused on advanced differentiated instruction techniques and creating resources to help teachers effectively tailor their teaching strategies to meet individual student needs.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter discusses the background to the study and the statement of the problem. It also sheds light on the purpose of the study, study objectives, research questions and research hypotheses formulated for the study. The chapter further presents the significance of the study, delimitations and limitations of the study. The chapter ends with abbreviations of terms, operational definition of terms, ethical considerations and organisation of the study.

1.1 Background to the Study

Education is indispensable in the socio-economic development of every nation. Realizing this, education was made a right for all citizens in Ghana as a provision in the 1992 Constitution (Government of Ghana, 1992), subsequently, successive governments after independence have continuously put in measures to increase accessibility at all levels.

Despite the provision in the 1992 constitution for free and compulsory basic education for all children of school-going age, children with disabilities were not catered for. It has become common practice globally to include children with special educational needs (SEN) in mainstream classrooms. Following the Salamanca statement, international policy has continuously worked to include these pupils (UNESCO, 1994). Article 24 of the UN Convention on the Rights of Persons with Disabilities (United Nations, 2006) ensures that all children, regardless of aptitude or disability, have a fundamental right to receive an education with their peers in a nearby school.

Following the global trend, the Ghana Government Education Strategic Plan 2010-2020 was embarked upon to provide education for all including special education needs (SEN) children (MOE, 2015). As part of the plan, the Ghana Inclusive Education (IE) Policy of 2015 sought to bring SEN children into regular classrooms so they can learn and grow together with their peers (MOE, 2015).

The IE policy as an extension for the GESP draws on a number of international commitments to particularly ensure that children with SEN are integrated into mainstream school settings. The goal of the policy is to redefine education delivery to respond to the varied needs of all learners in the mainstream classrooms in the framework of Universal Design for Learning (UDL) and the Child-Friendly School Concept (MOE, 2015). The inclusive education policy is yet to be rolled out nationwide and teachers in special schools continue to be involved in their mandate with the special school settings.

The basic School Science Curriculum which is one of the subjects of the common Core Curriculum Programme (CCP) is aimed at developing individuals to become scientifically literate, good problem solvers, have the ability to think creatively, and have the confidence and competence to participate responsibly as local and global citizens.

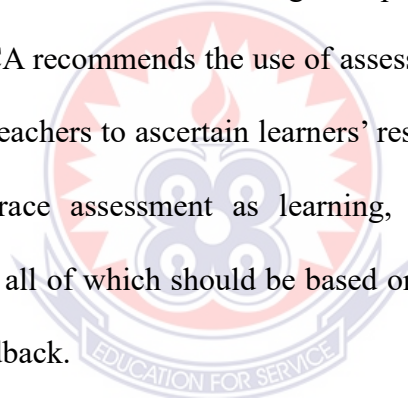
To achieve this goal the designs of the curriculum envisage a learning philosophy that embraced the constructivist and inquiry approaches where learners are expected to actively participate in the construction of the knowledge process based on their own experiences rather than acquiring it (Suduc et al., 2015; NaCCA, 2019). Thus, the teacher is expected to provide learners with opportunities to expand, change, enhance and modify the ways in which they view the world; in this case, the teacher is a

facilitator. The curriculum is further aimed at equipping learners with the necessary scientific skills, desirable attitudes and values, and core competencies.

Inquiry-based learning incorporates understanding the fundamental nature of science, providing a better understanding of scientific concepts and processes. In the elementary classroom, inquiry combines a wide range of skills and scientific processes. Students ask questions, make observations, plan and carry out experiments, collect and analyze data, apply critical thinking skills, develop explanations, conclusions, and predictions, and communicate their findings to others (Kotsis, 2024).

For a teacher to lead learners in any inquiry-based learning a teacher is expected to have competencies footed in content knowledge and pedagogical content knowledge

On assessments, NaCCA recommends the use of assessment to promote learning with the purpose to enable teachers to ascertain learners' responses to instruction. Teachers are therefore to embrace assessment as learning, assessment for learning, and assessment of learning all of which should be based on the domains of learning, with timely and prompt feedback.



On pedagogical approaches, the curriculum recommended learning-centered approaches and emphasizes:

- a. The creation of learning-centered classrooms through the use of creative approaches to teaching and learning as strategies to ensure learner empowerment and independent learning.
- b. The positioning of inclusion and equity at the center of quality teaching and learning.
- c. The use of differentiation and scaffolding as teaching and learning strategies for ensuring that no learner is left behind

- d. The use of Information and Communications Technology (ICT) as a pedagogical tool.
- e. The identification of subject-specific instructional expectations needed for making learning in the subject relevant to learners
- f. The integration of assessment for learning, as learning and of learning into the teaching and learning process, and as an accountability strategy

Thus, the standards-based science curriculum requires that teachers' instructional activities are informed by national standards to guide their instruction in their quest for advancing scientific literacy among learners.

Available literature shows that teachers prefer the expository approach to science teaching and rely on textbooks for science concepts and mostly focused on low-level scientific knowledge and concepts (Otami, 2019).

However, literature suggests that the above approach to science instruction can impair the proper development of concepts and scientific literacy. For instance, Mohammed, et al., (2020) and Adjei, (2022) noted that merely picking facts from textbooks for instructions without critical reflection and the use of learner-centered and inquiry approaches can lead to the proliferation of alternative concepts which can consequently limit opportunities for pupils to develop scientific literacy.

Science teachers are expected to create learning environments that stimulate and support, learners' interest and engagement in science; attitudes which develop at the early years of the learner (Tytler et al., 2008). Tytler, et al., (2008) asserted that:

..... considerable evidence that, for the majority of students, their life aspirations are formed before the age of 14, with the implication that engaging students in STEM pathways becomes increasingly difficult after the early secondary school years. Interventions and resources aimed at encouraging student engagement in STEM thus need to be

prioritized to engage and capture the imagination of students in the upper primary and early secondary school years (p. viii)

Thus, knowing the current instructional practices of basic school teachers during science lessons would help design professional development training for in-service teachers and programmes for pre-service science teacher education to meet the demands of the basic school science curriculum.

1.2 Statement of the Problem

Science education is crucial for developing critical thinking, problem-solving skills, and fostering innovation. However, disparities in instructional practices across different educational settings can hinder the effectiveness of science teaching. In Ghana, there is a significant variation in the quality and methods of science instruction between Regular, Inclusive, and Deaf basic schools (Kuyini, et al., 2020; Quaye, 2023). These differences can impact student engagement, comprehension, and overall performance in science subjects.

Globally, recent research has highlighted various successes and challenges in science education across different settings. For instance, Darling-Hammond et al., (2020) emphasized the importance of teacher professional development and the integration of inquiry-based learning to improve science education in the United States. Similarly, in Finland, Sahlberg (2020) discussed how a curriculum that emphasized student-centered learning and the practical application of scientific concepts could enhance learning outcomes. These references illustrate how tailored instructional practices can significantly boost science education.

In Africa, inclusive education aims to integrate students with diverse needs into mainstream classrooms, promoting equity and accessibility. Research by Engelbrecht

et al., (2013) in South Africa suggested that effective inclusive education required differentiated instruction, use of assistive technologies, and teacher training in special education needs (SEN) strategies. However, many inclusive and Deaf schools face challenges such as inadequate resources, lack of trained teachers, and insufficient support services, affecting the quality of science education provided. In Nigeria, Iroegbu (2021) found that inclusive schools often struggle with limited resources and teacher preparedness, impacting the effectiveness of science instruction.

In Ghana, the situation mirrors these global and continental challenges but with unique local dynamics. Studies by Mensah, (2021) and Nketsia, (2022) had shown that Regular basic schools often have better access to resources and more standardized teaching methods, yet these do not always translate into effective science teaching. Mensah (2021) found that traditional lecture-based approaches dominate in many Regular schools, limiting student engagement and understanding. In Inclusive and Deaf schools, the lack of specialized resources and trained teachers exacerbates these challenges. Nketsia (2022) highlighted the need for more comprehensive teacher training and better support mechanisms to cater to the diverse needs of students in these settings.

Although the standards-based curriculum was introduced in 2019, little is known about how teachers instructing learners with deafness are navigating and experiencing its implementation during science lessons. Teachers' experiences and practices are crucial in determining the effectiveness of the curriculum implementation process. Generally, science teaching is considered challenging in Ghana due to a number of factors such as lack of equipment and teachers' overly reliance on traditional didactic instructional approaches (Adu-Gyamfi, 2014; Adofu, 2017; Humphrey-Darkeh et al.,

2022). Teaching science to Deaf and Hard of Hearing (DHH) pupils and pupils in inclusive classes can be particularly challenging, and the curriculum's effectiveness and success require an exploration into teachers' practices during science lessons.

Pupils from Regular, Inclusive, and Deaf school settings are expected to achieve the same standards, making it essential to investigate and compare teachers' practices during science lessons in these school settings. Not many studies have been conducted into DHH learning science in special schools. Most studies focus on other forms of SEN and issues of inclusivity in mainstream classroom settings (Thwala, 2018; Anyetei, Kwarteng & Hanson, 2019). While there is a general assertion that DHH students can perform as well as their peers in mainstream classrooms, evidence shows that they continue to perform comparatively low, especially in standardized tests (Mantey *et al.*, 2017). A 2023 study on science education in Ghana's basic schools highlighted serious challenges: in one analysis of the national Basic Education Certificate Examination (BECE) results, only 9.38% of deaf pupils achieved a proficient score (aggregate 1–6) in Integrated Science, out of over 200 DHH candidates (Dosoo, 2023).

Teachers in Inclusive and Deaf schools require a range of competencies, such as the use of sign language, assistive technologies, and inclusive teaching strategies to carry out their instructions effectively. However, Mprah (2022) asserts that the majority of teachers in Deaf schools in Ghana cannot use sign language. Therefore, it is important to find out the qualification of teachers teaching science in Deaf and Inclusive schools.

The standards-based curriculum is envisaged to bring hope to the Ghanaian educational system since it embraces inclusive teaching practices that consider the

individual needs and interests of various learners in the science classroom. It is expected that science teacher practices will be adaptive enough to meet these curriculum implementation demands. The standards-based curriculum was rolled out in 2019 at the primary school level and extended to junior high school in subsequent years. With its implementation, science teachers are expected to engage in practices aligned with the constructivist theory of teaching. However, since the implementation, no studies have been conducted on science teacher instructional practices at the basic school level. Therefore, it was significant to conduct this study into the current instructional practices in selected Regular, Inclusive, and Deaf schools in Ghana.

1.3 Purpose of Study

The purpose of this study was to examine the instructional practices of science teachers in selected Regular, Inclusive and Deaf basic schools in Ghana.

1.4 Research Objectives

This thesis explored science teacher practices in regular, inclusive and special schools during science lessons. The research objectives were:

- a. To determine the academic and professional qualifications of the personnel facilitating science lessons in the selected basic schools.
- b. To explore the current instructional practices of science teachers in basic regular, inclusive and deaf schools.
- c. To identify similarities and differences in science' teachers' instructional practices among regular, inclusive and deaf basic schools.
- d. To explore the extent to which science instructional approaches are differentiated for learners in inclusive classrooms

- e. To identify the types of assistive technologies which are utilized for science lessons in inclusive and deaf schools and the rationale for using them
- f. To identify the types of capacity enhancing activities that are organized for the science teachers to beef up their professional

1.5 Research Questions

The following research questions guided the study:

1. To what extent are the personnel in the selected schools academically and professionally qualified to facilitate science instructions?
2. What are the current instructional practices of science teachers in terms of planning, delivery, and assessment in the selected schools?
3. What are the similarities and differences in science teachers' instructional practices among Regular, Inclusive, and Deaf Basic schools?
4. To what extent are the science instructional approaches differentiated for learners in inclusive classrooms?
5. Which type of assistive technologies are utilized for science lessons in inclusive and deaf classrooms?
6. Which type of differentiated capacity-enhancing activities are organized for science teachers in the selected schools?

1.6 Significance of the Study

The findings of the study would be significant to a number of bodies and institutions such as school administrators and teachers, educators, policy formulators and researchers. The results of the study could give teachers and school authorities in the chosen schools a better understanding of their own methods, which would benefit their students. The study findings could also be used by the education directorates of

the chosen schools to guide the planning of professional development programmes for their teachers through baseline studies.

The study findings could also influence educational policies, especially issues concerning educating people with special needs. The findings could influence the implementation of Ghana's inclusive policy. Again, the findings could inform curriculum designers to make appropriate curriculum plans for special education needs curriculum. It could also inform universities about the training of special education needs teachers to modify their programmes for pre-service science teachers meant for special schools. The findings could further inform science teachers of the selected schools to build their capacity in order to effectively carry out their mandate to effectively carry out science instructions to diverse needs of learners.

The results of the study can serve as a foundational study for future research, encouraging further exploration into effective teaching strategies and their impact on student learning in various educational contexts

1.7 Delimitations of the Study

With the inclusive education policy, there are some schools that have both hearing and special needs education children. Currently, there are about 20 public and private institutions that offer either deaf only or inclusive education (Asonye & Edwad, 2022). These schools are spread throughout the country which would require that the research had to travel across the country to satisfy the demands of the study. This study was, however, limited to the School for the Deaf at Bechem, The University Practice Basic School-Winneba, which is an inclusive school and St. Joseph R/C school, a regular school in the Tano South District.

1.8 Operational Definitions of Key Words

Basic School: Level of the school where pupils aged between four and fifteen are educated. It ranges from kindergarten to junior high school

Deaf School: A segregated school where children with deafness and hard of hearing are educated

Inclusive school: A school that is designated by the GES, where learners with SEN and those without SEN are both educated in the same class. In this study, an inclusive has both regular learners and learners with deafness and hard-of-hearing receiving instructions in the same classroom

Instructional Practices: Activities that teachers carry out to bring lessons to their students. These are considered under the indicators of planning, delivery, and assessment.

Regular School: A school where it is assumed that learners have no SEN

Teacher Qualification: Teacher qualification includes pursuing an accredited programme in education and having a teacher's license issued by the NTC

Teaching Experience: The number of years of teaching

Teacher Knowledge: Refers to content knowledge and pedagogical content knowledge of the teacher.

1.9 Organization of the Study Report

This thesis is organized into three sections. Chapter one deals with the introduction which comprises the background to the study, statement of the problem, purpose and objectives of the study, research questions, significance of the study, delimitations and limitations. Chapter two is a review of related literature which presents the main concepts and theories in the study, and presented under various themes. The data collection process is detailed in chapter three. Research design, population, sample

and sampling procedure, instruments of data collection, data collection procedures and data processing analysis procedures are discussed in this chapter. The fourth chapter presents the findings and discussion of the data obtained. Chapter five concludes the study with a summary, conclusion, and recommendations based on the study's findings, after which recommendations for further research are made.



CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

This section discusses the theories upon which the study is grounded. The section further looks at review of related literature under various themes. Some of the themes are nature of science instruction, teachers' curriculum adaptation for SEN learners, hearing impairment as disability, deaf and hard-of-hearing learning and performance in science and barriers to effective science teaching to DHH learners.

2.1 Theoretical Framework

This study is grounded in the theory of constructivism and the theory of symbolic interaction. While constructivism theories on how learners construct their own knowledge and the need for teachers thus to facilitate learning among pupils in science, the theory of symbolic interaction examines the interaction between learners and their teacher through symbols to create meaning.

2.1.1 Constructivism

From a constructivist perspective, learning is an individual process that involves linking new ideas and experiences with what the learner already knows. A fundamental assumption of constructivism is that learners construct understanding. It is an innovative approach to building a better understanding of fundamental science concepts (Liang & Gabel, 2005)

Social interaction among individuals plays an integral part in how they learn and it has proven to be quite effective in assisting the learner to organize their thoughts, reflect on their understanding, and find gaps in their reasoning (Okita, 2012).

Student–student and student-teacher interactions are important ingredients of learning from a constructivist perspective. For example, according to Piaget’s (1970) cognitive development theory, peer interaction is a source of experience that evokes cognitive conflict (disequilibrium) in children, and human beings all have a tendency to reduce this conflict and re-establish an equilibrium at a higher level. For Vygotsky (1978), cognitive development begins with an interaction between the child and a more knowledgeable other, and the social processes are then transformed into the child’s internal mental processes. The role of ‘scaffolding’ provided in guiding social interaction thus becomes central to the Vygotskian view. Based on Vygotsky’s theory, one important step in designing instruction to develop complex mental functions is the analysis of the ‘zone of proximal development—the distance between the actual developmental level that is reflected in the child’s independent problem-solving process and the problem-solving level that is accomplished with guidance. Most importantly, the zone of proximal development is created in the interaction between students and the instructor or in the cooperative problem-solving with peers.

Assessing the instructional practices of science teaching in selected Regular, Inclusive, and Deaf basic schools in Ghana can be closely related to constructivist theory, which posits that learning is an individual process involving the linking of new ideas and experiences with prior knowledge. Constructivism, as highlighted by Liang and Gabel (2005), emphasizes that learners actively construct their understanding, which is crucial for grasping fundamental science concepts.

From a constructivist perspective, the effectiveness of science teaching practices hinges on how well they facilitate this process of constructing knowledge. In Regular, Inclusive, and Deaf basic schools, this assessment can reveal whether instructional

practices are fostering environments that encourage individual exploration, reflection, and the integration of new knowledge with existing cognitive frameworks.

In Inclusive and Deaf schools, where students may have diverse learning needs and varying levels of prior knowledge, constructivist principles are particularly vital. Effective science teaching in these settings would involve differentiated instruction and the use of assistive technologies, ensuring that each student can engage with the material in a meaningful way. This aligns with the constructivist view that learning should be tailored to the individual's current understanding and experiences.

Social interaction is another crucial aspect of constructivist learning, as noted by Okita (2012). In the context of Ghanaian schools, student-student and student-teacher interactions are essential for helping learners organize their thoughts, reflect on their understanding, and identify gaps in their reasoning. For example, Piaget's (1970) theory emphasizes the role of peer interaction in creating cognitive conflict, which prompts students to resolve discrepancies and achieve a higher level of understanding.

Vygotsky's (1978) theory further underscores the importance of social interaction, particularly through the concept of scaffolding. In science classrooms, teachers act as the "more knowledgeable other" who guide and support students as they navigate complex concepts. Assessing instructional practices in these schools would involve examining how teachers scaffold learning experiences, thereby supporting students' movement through their zone of proximal development. This means providing the appropriate level of challenge and support to help students progress from their current level of understanding to more advanced levels of cognitive development.

2.1.2 Symbolic Interaction Theory

The study is grounded in Herbert Blumer's (1969) Theory of symbolic interaction. This theory claims that facts are based on and directed by symbols. The foundation of this theory is meanings. Symbolic interaction examines the meanings emerging from the reciprocal interaction of individuals in social environment with other individuals and focuses on the question of "which symbols and meanings emerge from the interaction between people.

Schenk and Holman (1980) state that symbolic interaction is a dynamic theory because according to this theory objects feature meanings within themselves and individuals formulate their activities in the direction of their evaluation of themselves and also people and objects around them. Thus, it is the social actors that attribute meaning to objects according to this perspective

Learners with DHH learn through sign language which is about symbolic interaction among the communicators. During the science lesson, the teacher-learner interaction and learner-learner communication occur through symbolic language. It is therefore imperative that the teacher in a science lesson for DHH is wielded with adequate signs and symbols to promote effective communication of scientific concepts and vocabulary.

Assessing the instructional practices of science teaching in selected Regular, Inclusive, and Deaf basic schools in Ghana can be closely related to Symbolic Interaction Theory, which emphasizes the importance of social interactions and the meanings individuals derive from these interactions in the learning process. This theory is highly relevant to understanding how instructional practices impact student engagement and learning in science education across different school settings.

In the context of Regular, Inclusive, and Deaf basic schools in Ghana, Symbolic Interaction Theory highlights several key aspects. First, it emphasizes meaning-making through interaction. Learning science involves not just the transmission of factual knowledge but also the interpretation and internalization of scientific concepts through interaction. In Regular schools, the interaction between teachers and students, as well as among peers, helps students to construct meanings and understand scientific ideas. The quality of these interactions can significantly influence how well students grasp and retain scientific knowledge.

Effective communication is another critical component highlighted by Symbolic Interaction Theory, especially in Inclusive and Deaf schools. In these settings, the use of sign language, visual aids, and other communication tools are essential for ensuring that all students can participate in the learning process. Symbolic Interaction Theory suggests that these communicative symbols must be effectively used and interpreted by both teachers and students to facilitate learning. Assessing how well teachers use these tools can provide insights into the effectiveness of science instruction.

Additionally, Symbolic Interaction Theory underscores the importance of identity formation in the learning process. Students' identities as learners of science are shaped through their interactions with teachers and peers. Positive reinforcement, encouragement, and the symbolic recognition of students' efforts and achievements can foster a strong science learner identity. Conversely, negative interactions or lack of support can hinder students' confidence and interest in science. This aspect is particularly important in Inclusive and Deaf schools, where students might already face challenges that impact their self-esteem and identity as learners.

Finally, the social context of learning, as emphasized by Symbolic Interaction Theory, plays a crucial role in shaping students' learning experiences. The social environment of the classroom, including the norms, values, and expectations set by the teacher and the school, significantly influences students' engagement and learning. In Inclusive and Deaf schools, creating an inclusive and supportive social environment is essential for effective science teaching. This includes understanding and addressing the unique needs of each student and fostering an atmosphere of mutual respect and collaboration.

2.2 Conceptual Framework for Science Teachers' Instructional Practices

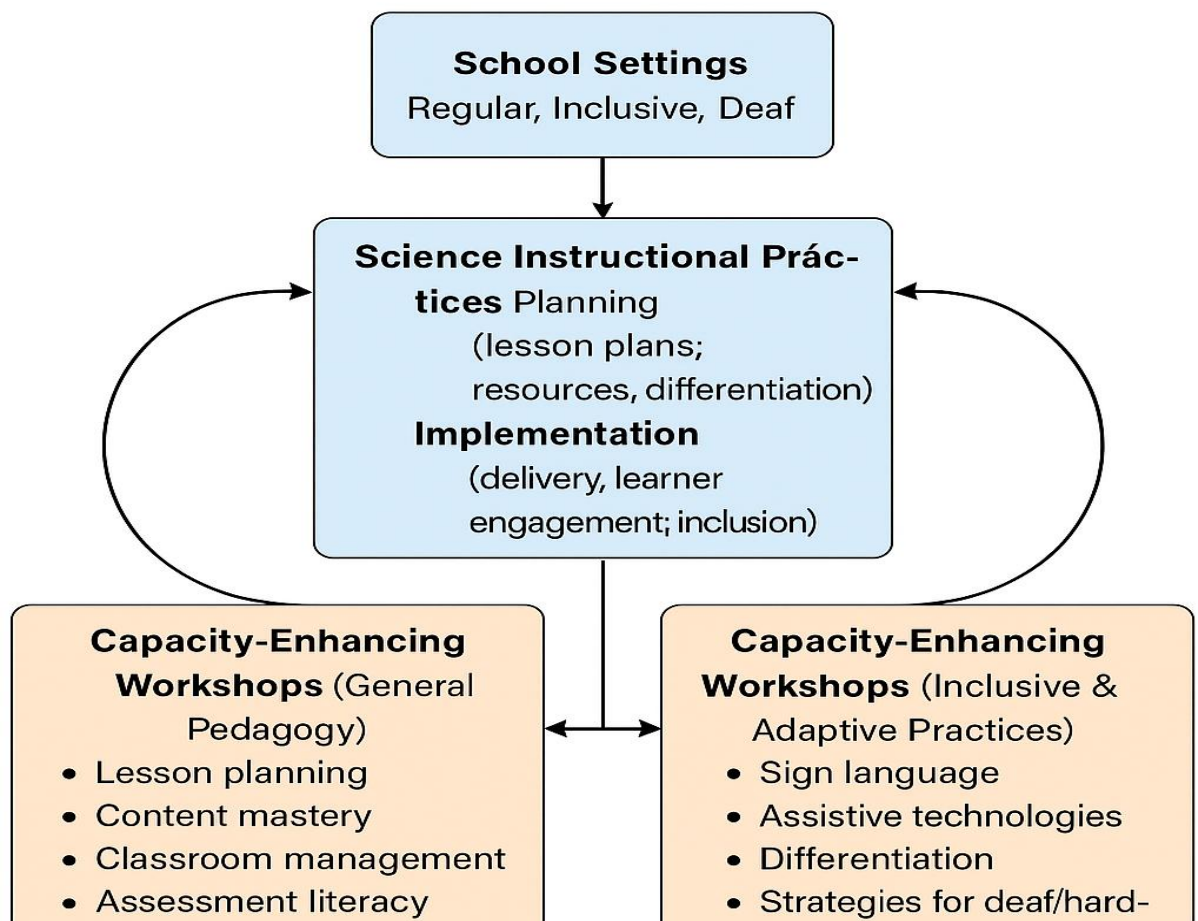


Figure 1: Conceptual Framework for Science Teacher Instructional Practice

(Author's

The conceptual framework depicted in Figure 1 provides a structured approach to understanding and assessing the instructional practices of science teaching in selected regular, inclusive, and deaf basic schools in Ghana. This framework is essential for comprehending how various components interact to enhance the quality of science education within these diverse educational settings.

At the core of the framework are the science instructional practices, which encompass three critical aspects: Planning, Delivery, and Assessment. planning involves establishing clear learning objectives while considering the unique characteristics of learners, ensuring that instructional goals are tailored to meet diverse student needs. delivery refers to the implementation of teaching strategies, the utilization of educational resources, and the nature of interactions and discourse within the classroom. Effective delivery ensures that the teaching methods are engaging and accessible to all students, including those with special needs. assessment includes different types of assessments, namely Assessment of Learning (AoL), Assessment for Learning (AfL), and Assessment as Learning (AsL), along with various modes of assessment to evaluate and support student learning continuously.

To support and enhance these instructional practices, capacity-enhancing workshops play a pivotal role. These workshops provide professional development opportunities for teachers, enabling them to stay updated with the latest educational trends and innovations. They offer a platform for localized problem-solving and idea sharing among educators. The diagram indicates that these workshops directly influence science instructional practices by equipping teachers with new strategies and methodologies, such as inquiry-based learning and the integration of digital tools. This professional growth fosters a collaborative and supportive community of

educators, ultimately leading to improved teaching practices and better student engagement and comprehension.

The framework also highlights the importance of School Settings, which include regular, inclusive, and deaf schools. Each of these settings presents unique challenges and requirements that must be addressed to ensure effective science instruction. The diagram shows that these school settings influence the design and implementation of capacity-enhancing workshops. Tailoring these workshops to the specific needs of each school setting is crucial for addressing particular challenges and ensuring that professional development activities are relevant and impactful.

The flow of the diagram demonstrates a cyclical process where the specific needs of the school settings inform the development of capacity-enhancing workshops, which in turn improve science instructional practices. These enhanced practices feed back into the school settings, creating a continuous loop of improvement and adaptation. This cyclical nature ensures that the educational strategies remain responsive and effective in meeting the evolving needs of students and teachers.

In conclusion, the conceptual framework underscores the interconnectedness of school settings, professional development, and instructional practices. By focusing on tailored capacity-building programs that address the specific needs of different educational environments, the framework aims to improve the overall quality of science education in Ghana's regular, inclusive, and deaf basic schools.

2.3 Science Teachers' Instructional Practices

Various methods have been prescribed for teaching science. While some of these strategies and techniques are more appropriate than others, Das (2009) asserts that any

method of instruction selected by the science teacher should be pivoted on the learner, the teacher, and the nature of the subject. Hence for the nature of science as a subject, NaCCA (2019) recommends that science teaching should adopt the constructivist and inquiry approaches to the subject. In this vein, learners will benefit more from the instructions.

In general, when we talk about instructional practices, we are talking about the activities that teachers carry out to create lessons for their learners. The traits and actions of the teachers are what guide their classes and are constantly applied throughout time. Many academics have variously characterized instructional practices as teaching approaches, teaching styles or teaching methods. The framework developed by Dancy and Henderson (2017) distinguishes between two categories of instructional practices: traditional instructional practices and alternative instructional practices.

In traditional instructional practices, lessons are usually teacher-centered; the teacher decides what, when and how students should learn (Hassidov, 2019). Students are usually passive in classroom interaction because they just receive packaged knowledge from the teacher, who is the primary source of information. In traditional instructional practices, there is little attention to student needs and interests since the primary goal is to help them perform on national and standardized examinations (Zohrabi et al., 2012). Traditional science instruction has relied heavily on lectures and the use of science textbooks as methods of teaching (Brigham, et. al., 2011), and students do not receive the instruction necessary to promote a strong understanding of expository text laced with complex vocabulary and the expectation that learners have prior knowledge of the subject matter (Mason and Helin, 2011).

Contrary to traditional instructional practices, alternative instructional practices are student-centered. Alternative instructional practices are a form of instruction that is adaptable, collaborative, problem-centered, and democratic and in which the teacher and the students together determine what, how, and when learning takes place (Dupin-Bryant, 2004; Dancy & Henderson, 2007; Hassidov, 2019). Teachers who use alternative instructional methods do not just rely on textbooks; they also promote dynamic commitment and place an emphasis on understanding the subject matter rather than mindless memorizing of facts. According to research, pupils who participated actively in their learning had superior academic results (Hassidov, 2019; Skilling, 2023), suggesting that alternative instructional practices are superior to traditional instructional practices in terms of quality of student learning.

The use of the traditional or alternative type of instructional practice in science lessons is not exclusive even in advanced countries. In a comparative study of instructional practices in Science Education in German and Malaysian Secondary Schools, Saleh and Jing (2020) noted that current instructional practices used in German science lessons at the secondary school are more towards the alternative practices where the teacher facilitates the students in the science lesson whereas the current instructional practices in Malaysian secondary school are still the traditional method which is teacher-centered where most of the lessons are taught by the teacher without the involvement of the students. Thus, the results obtained showed the same findings as the past research where Malaysian instructional practices were still dominated by the teachers and German science teachers used varied styles of teaching strategies.

Analysis of PISA (2015) results indicates that science teachers in top science-performing countries neither use didactic nor constructivist teaching practices in their science lessons. They use an integration or amalgam of the two that allows for efficient learning of science content while addressing student concerns. Such approaches are in between the traditional-alternative pedagogy continuum (Lau & Lam, 2017). The integrated approach encourages students to see the interconnectedness and interrelationships between the different curriculum areas. Instead of focusing on learning in isolated curriculum areas, an integrated approach is based on skill development around a particular theme that is relevant to students of a particular class. The use of the integrated approach which incorporates varied strategies allows learners to explore, gather, process, refine and present information about the topics they want to investigate without the constraints imposed by traditional subject barriers (Antonio & Prudente, 2024).

Whatever strategies and techniques adopted by the teacher in science lessons should ensure that learners get involved in the learning process and the scientific method. This ensures that learners generate knowledge based on their past and present experiences rather than being given facts and ideas by the teacher.

Learners with or without disability face challenges during science instruction. Therrien, et al. (2011) contend that students with disability have greater challenges and difficulties. Students with disability have difficulty with vocabulary knowledge and reading comprehension. This characteristic puts students with disability at a greater disadvantage and the likelihood of not benefitting from quality instructions. Therefore, science teachers need to adapt practices that leverage the challenges that these learners face during science lessons.

Science teachers in Ghana do not organize lesson time for effective classroom practices and they usually form lesson goals on knowing science information (Beccles, 2012). It is therefore not surprising that science teachers do not engage their learners in practices that will enable them to construct their own knowledge through scientific processes. In analyzing Ghana's poor performance in Trends in International Mathematics and Science Study (TIMSS), Fredua-Kwarteng and Ahia (2005) noted that in Ghana, science teachers employ direct and teacher-centered instructional practices which demand that learners pay attention throughout the lesson. This, according to the authors reduce the learners to rote learning and mere receivers of facts and information rather than active constructors of knowledge.

Indeed, learner-centered instruction has been found to be superior to teacher-centered or traditional instruction in achieving learning outcomes among learners (Felder & Brent, 2016), however, the idea of embracing learner-centered instruction does not imply throwing away everything about traditional teaching strategies.

Felder and Brent (2016) state:

We won't be telling you, for example, to abandon lecturing and make every class you teach an extravaganza of student activity. We will tell you to avoid making lecturing the only thing that happens in your class sessions. Introduce one or two activities in the first few sessions so you and the students can get used to them, and gradually increase their frequency. As you continue to use the method your confidence will rise, and your use of active learning will probably rise with it (p.4)

Thus on the premise of Felder and Brent (2016), this study is not intended to pass judgment on various instructional practices. The goal is to understand and compare teachers' practices in regular, inclusive and deaf science lessons.

Table 1: Framework for Science Teacher Practices

S/N	General Dimension	Practices consistent with traditional instruction	Practices consistent with alternative instruction
1.	Interactivity	One-sided discourse, passive students	Conversation, active students
2.	Instructional decisions	Decision made by teacher	Decisions shared by teacher and students
3.	Knowledge Source	Students receive expert knowledge	Students develop their own knowledge
4.	Student success	Success measured against preset standards	Success measured by individual improvement
5.	Learning mode	Competitive or individualistic learning mode	Cooperative learning mode
6.	Motivation	External motivators	Internal motivators
7.	Assessment	Knowledge-based assessment	Process-based assessment
8.	Content	Explicitly teach only science facts and principles	Explicitly teach learning, thinking and problem-solving skills in addition to science content
9.	Instructional design	Knowledge-driven instruction based on the structure of science	Student-driven instruction based on understanding of student learning within the discipline of science
10.	Problem-solving	Formulaic problem solving: Problems assigned to students are well-defined and similar to problems students have previously seen	Creative problem solving: Problems assigned to students are novel to solve and may have unknown or open-ended solution.

Adapted from Dancy (2007)

2.3.1 Planning

Effective planning is foundational for successful science instruction, especially in diverse educational settings such as Regular, Inclusive, and Deaf basic schools in Ghana. In the planning stage, teachers need to align their lesson objectives with the curriculum requirements and consider the varying needs of their students. For Regular schools, planning might involve leveraging a wealth of resources and standardized curricula to create lesson plans that are engaging and informative (Darling-Hammond et al., 2020; Mensah, 2021). Teachers often have the flexibility to integrate a variety

of teaching aids and technologies, which can enrich the learning experience and cater to different learning styles. However, the planning process in Inclusive and Deaf schools requires a more nuanced approach. Teachers must prepare materials that are accessible to students with special educational needs (SEN), incorporating assistive technologies and differentiated instruction techniques (Engelbrecht et al., 2020; Nketsia, 2022). This might include visual aids, tactile resources, and interactive models that can help make abstract scientific concepts more tangible. Additionally, for Deaf students, lesson plans need to be designed with the inclusion of sign language interpreters or visual instructions to support comprehension (Iroegbu, 2021; Mprah, 2022). Therefore, effective planning in these settings not only involves creating detailed lesson plans but also anticipating and addressing the unique challenges that might arise in the classroom.

Furthermore, planning in Inclusive and Deaf schools involves setting realistic and attainable goals that reflect the diverse capabilities of the students. Teachers need to be adept at identifying the individual learning needs of their students and tailoring their instructional strategies accordingly. This could involve setting differentiated learning objectives and creating individualized education plans (IEPs) that outline specific goals and the steps needed to achieve them (Engelbrecht et al., 2020; Mprah, 2022). In Regular schools, while the planning might be less individualized, it still requires a strategic approach to ensure that all students are engaged and can achieve the set objectives. Teachers need to prepare for a range of activities that can cater to various learning styles, ensuring that visual, auditory, and kinesthetic learners all find something in the lesson that resonates with them (Mensah, 2021; Nketsia, 2022). This comprehensive planning helps in creating a conducive learning environment where all students can thrive.

Moreover, planning in these diverse educational settings must also consider the availability and allocation of resources. In many cases, Inclusive and Deaf schools might face resource constraints that Regular schools do not. Teachers need to be resourceful and innovative, often improvising with the materials they have or seeking out additional resources through grants and community support (Iroegbu, 2021; Mprah, 2022). This aspect of planning requires teachers to be not only educators but also effective managers and advocates for their students' needs. Ensuring that the necessary resources are available and properly utilized can make a significant difference in the quality of education delivered.

Lastly, effective planning includes continuous reflection and adaptation. Teachers should regularly assess the effectiveness of their lesson plans and make necessary adjustments based on feedback and observed outcomes. This reflective practice helps in identifying what works well and what needs improvement, ensuring that the instructional strategies remain effective and relevant (Darling-Hammond et al., 2020; Engelbrecht et al., 2020). In Inclusive and Deaf schools, this might involve regular consultations with specialists such as SEN coordinators and speech therapists, ensuring that the plans are aligned with best practices and the latest research in special education (Nketsia, 2022; Mprah, 2022). Overall, planning is a dynamic and critical component of instructional practices, setting the stage for effective teaching and learning in science education.

2.3.2 Delivery

The delivery of science lessons is where the planned instructional strategies are put into action, and this stage is crucial for student engagement and comprehension. In Regular schools, teachers often employ a range of teaching methods to keep students

interested and motivated. Interactive methods such as inquiry-based learning, hands-on experiments, and group activities are particularly effective in helping students understand scientific concepts (Darling-Hammond et al., 2020; Nketsia, 2022). These methods allow students to explore concepts, ask questions, and engage in problem-solving activities that are essential for learning science. However, the delivery of lessons in Inclusive and Deaf schools requires additional considerations to ensure that all students can participate fully.

In Inclusive classrooms, teachers must use differentiated instruction strategies to cater to the diverse learning needs of their students (Engelbrecht et al., 2020; Nketsia, 2022). This involves varying the content, process, and product of the lessons to ensure that each student can access and engage with the material. For example, while some students might benefit from visual aids and demonstrations, others might need written instructions or tactile learning tools. Using a variety of instructional strategies not only helps in reaching every student but also makes the lessons more dynamic and interesting. In Deaf schools, the use of sign language and visual communication is paramount. Teachers need to ensure that their instructions are clear and accessible, often employing visual aids such as diagrams, videos, and written instructions alongside verbal explanations (Iroegbu, 2021; Mprah, 2022). This dual-mode of communication helps in reinforcing the learning material and ensures that Deaf students can follow along without missing critical information.

Moreover, the delivery of science lessons in these settings involves creating an inclusive classroom environment that encourages participation from all students. Teachers need to be mindful of the classroom dynamics and actively promote an atmosphere of respect and collaboration (Nketsia, 2022; Engelbrecht et al., 2020). In

Inclusive classrooms, this might involve setting up group activities that encourage students to work together, leveraging each other's strengths and learning from diverse perspectives. For Deaf students, teachers might need to facilitate communication among peers by teaching basic sign language to all students or using technology that supports communication (Iroegbu, 2021; Mprah, 2022). Creating such an inclusive environment helps in building a sense of community and belonging, which is essential for effective learning.

Furthermore, effective delivery also involves ongoing assessment and feedback. Teachers need to continuously monitor students' understanding and adjust their teaching methods accordingly. Formative assessments such as quizzes, class discussions, and hands-on activities provide immediate feedback and help in identifying areas where students might be struggling (Darling-Hammond et al., 2020; Nketsia, 2022). This allows teachers to address misconceptions and provide additional support where needed. In Deaf and Inclusive schools, teachers might need to use alternative assessment methods to ensure that all students can demonstrate their understanding. For example, instead of a written test, a Deaf student might be assessed through a hands-on project or a visual presentation (Engelbrecht et al., 2020; Mprah, 2022). This flexibility in assessment is crucial for providing an accurate picture of each student's progress and ensuring that all students have the opportunity to succeed.

2.3.3 Assessment

Assessment is a critical component of instructional practice, providing essential feedback on student learning and informing instructional decisions. Effective assessment practices in science education include both formative and summative

assessments, each serving a unique purpose (Darling-Hammond et al., 2020; Nketsia, 2022). Formative assessments, such as quizzes, class discussions, and hands-on activities, provide immediate feedback that can be used to guide instruction and support student learning. Summative assessments, like tests and projects, evaluate student learning at the end of an instructional period, helping to measure the overall effectiveness of the teaching strategies used. In Regular schools, teachers can utilize a variety of assessment methods to gauge student understanding and progress. However, in Inclusive and Deaf schools, assessments must be adapted to be fair and accessible to all students.

In Inclusive classrooms, teachers need to employ differentiated assessment strategies to cater to the diverse needs of their students (Engelbrecht et al., 2020; Iroegbu, 2021). This might involve providing additional time for tests, using alternative formats for questions, or allowing students to demonstrate their knowledge through projects or presentations instead of written exams. For example, a student with a learning disability might be given more time to complete a test or might be allowed to take the test in a quiet room with fewer distractions. Similarly, a student who struggles with writing might be allowed to give an oral presentation or create a visual project to demonstrate their understanding. These adaptations ensure that assessments are fair and that all students have the opportunity to succeed (Nketsia, 2022; Mprah, 2022).

For deaf students, assessments should be designed in a way that does not disadvantage them due to language barriers (Iroegbu, 2021; Mprah, 2022). This might involve using sign language interpreters during tests or providing written instructions alongside oral explanations. Teachers might also need to use visual or hands-on assessments to better accommodate the needs of Deaf students. For example, instead

of a traditional written test, a deaf student might be assessed through a hands-on science experiment or a visual project that demonstrates their understanding of the material. These adaptations help to ensure that Deaf students are assessed fairly and that their true understanding of the subject matter is accurately measured (Engelbrecht et al., 2020; Nketsia, 2022).

Moreover, assessment practices in regular, inclusive and deaf basic school settings should also include opportunities for self-assessment and reflection. Encouraging students to reflect on their own learning and assess their own progress helps to develop metacognitive skills and fosters a sense of ownership over their learning (Darling-Hammond et al., 2020; Nketsia, 2022). In inclusive and deaf schools, teachers might need to provide additional support and guidance to help students develop these skills. This might involve teaching students how to set learning goals, monitor their own progress, and reflect on their learning experiences. Providing opportunities for self-assessment and reflection helps students to become more independent learners and better understand their own strengths and areas for improvement (Engelbrecht et al., 2020; Mprah, 2022).

Finally, effective assessment practices also involve using the data collected to inform instructional decisions. Teachers need to analyze assessment results to identify patterns and trends, determine areas where students are struggling, and adjust their teaching strategies accordingly (Darling-Hammond et al., 2020; Engelbrecht et al., 2020). In inclusive and deaf schools, this might involve working with special education coordinators and other specialists to develop targeted interventions and support plans for students who need additional help. By using assessment data to

inform instruction, teachers can ensure that their teaching strategies are effective and that all students have the support they need to succeed (Nketsia, 2022; Mprah, 2022).

2.4 Teacher Characteristics and Science Teacher Instructional Practices

Effective teaching is predicated on the teacher's ability to design and implement lessons effectively. This ability of the science teacher is hinged on several teacher characteristics. Some outstanding teacher characteristics that influence teacher practices leading to effective teaching include teaching experience and teacher qualification. These two are usually an indication of teacher quality (Darling-Hammond, 2000).

Effective teaching and learning cannot occur without a congenial learning environment and appropriate teaching practices. Research suggests that teacher quality and experience have a significant impact on instructional practices, and sound learning environment, and ultimately affect student learning outcomes. On her part, Darling-Hammond (2000) recognized a number of variables to be indicative of teachers' competence which have been examined for their relationship to student learning. These include measures of academic ability, years of education, teacher knowledge, and years of teaching experience, certification status, and teaching behaviours in the classroom.

A teacher's knowledge base, including their subject-matter knowledge, curricular knowledge, and pedagogical knowledge, and technological knowledge can impact their instructional effectiveness (Burroughs et al., 2019). These variables have been discussed extensively earlier in this chapter

Teaching Experience: Science teachers' teaching experience have been found to influence teachers' knowledge and practices and studies have found a relationship between teachers' effectiveness and their years of experience (Darling-Hammond, 2000). Many of those studies have shown that while inexperienced teachers (those with less than three years of experience) are less effective than more experienced teachers, the benefits of experience appear to level off after about five years (Rosenholtz, 1986)

Kini and Podolsky (2016) reviewed the literature from 30 studies on the relationship between teaching experience and teacher effectiveness. They reported that teachers' effectiveness improves as they gain experience in the classroom. It was discovered that teaching experience is, on average, positively associated with student achievement gains throughout a teacher's career. Of course, there is variation in teacher effectiveness at every stage of the teaching career; not every inexperienced teacher is less effective on average, and not every experienced teacher is more effective. The review further revealed that teaching experience positively associated with student achievement gains while their students performed better on other measures beyond test scores such as school attendance (Kini & Podolsky, 2016).

Teaching experience is usually linked to self-efficacy and teachers with higher self-efficacy tend to have better classroom management skills, are more adept at identifying student needs, and can provide more individualized instruction. This leads to a more positive classroom environment and increased student engagement, which in turn leads to stronger literacy skills. Teachers with lower self-efficacy may struggle to maintain a positive classroom climate, leading to lower student achievement. Therefore, teaching experience is positively associated with student achievement

gains throughout a teacher's career (Kini & Podolsky, 2016). With this research knowledge more experienced science teachers are in a better position to provide more appropriate instructional practices.

Teacher Qualification; Teacher qualification leads to effective mastery of subject matter and hence plays a significant role in improving the academic performance of students (Casian, Mugo & Claire, 2021).

Qualified teachers employ varied strategies of teaching to impact their student learning and to improve the academic performance of students, while they design and implement instructions that sustain an inclusive classroom (Darling-Hammond, Schachner et al., 2024).

The assumption that teacher quality impacts student performance has been validated by various studies (Darling-Harmond, 2000; Casian, Mugo & Claire, 2021). In a study of the impact of teacher qualification on student academic performance in public secondary schools in the Gasobo district in Rwanda, Casian et al., (2021), concluded that improvement in teacher qualification will lead to improvement in student performance.

In Ghana, the Education Act, 2008 (Act 778) provides for the implementation of teacher licensure. According to Act 778, the National Teaching Council (NTC) is to "register teachers after they have satisfied the appropriate conditions for initial licensing and issue the appropriate license. Teacher qualification is based on two attributes; certification and licensing. To be certified, teachers are expected to have pursued and graduated from an accredited teacher education programme. Certification is a prerequisite for licensing. Certified teachers are then required to pass national

teacher licensure examinations to be qualified to teach in any pre-tertiary public school. However, whether or not the qualified teacher is placed to teach his/her area of specialization during the pre-service training is currently a subject of debate.

The Ghana Teacher Licensure Examination (GTLE) was introduced in 2018 as part of a national effort to professionalize teaching and ensure teacher quality. It was conceived by the National Teaching Council (NTC) under the Education Act of 2008 (Act 778) to serve as a standardized benchmark for assessing whether newly trained teachers possess the requisite knowledge and skills for effective teaching. By implementing a common licensing exam across both public and private teacher training institutions, policymakers aimed to uphold high professional standards and “sieve for quality teachers” entering Ghana’s basic education classrooms (NTC, 2021). The licensure policy was also expected to help evaluate and harmonize teacher education programs nationwide, using exam performance data to inform curriculum improvements and enforce adherence to the National Teachers’ Standards (NTS).

A recurring critique is that there is a misalignment between what teacher trainees learn in their programmes and what the licensure exam demands. Many candidates who excelled in their college or university coursework have struggled with the GTLE, raising “concerns about how they managed to pass their final exams in college” yet failed the external test. The Ministry of Education’s analyses found “poor alignment between teacher education courses and the GTLE” content (UEW, 2023).

Hence, a science teacher may have the qualification to teach but may not have been trained to teach science. In this case, that teacher may be deficient in some teacher knowledge such as content or pedagogical content knowledge. Similarly, a teacher may have qualified to teach science but had no prior training in any special needs

education so will have challenges in teaching special education needs learners or participating effectively in an inclusive class.

The teacher licensing examination is a type of paper test completed by qualified teachers in order to acquire the opportunity to join a broader network of accomplished educators shaping the teaching profession (Darling-Hammond and Snyder, 2000). The license when issued demonstrates that a teacher has met all of the profession's requirements and elevates the teacher to a properly educated professional (National Board for Professional Teaching Standards, 2015). This means that certification is a key factor in ensuring the quality of the teaching workforce. It draws clear lines between individuals who have the necessary degree of competency to begin practicing and those who do not. Many professions employ licensing systems to select persons and prevent those deemed incompetent from practicing. The licensing system assesses basic abilities, subject matter, and teaching methods (Feuer, Floden, Chudowsky & Ahn, 2013).

According to Kent (2015), teacher licensure is recognized by institutions and their clients, governments, and the general public as an assurance of dedication, expertise, and quality. It may be concluded from the foregoing that teacher licensure examinations are very important in enhancing the quality of basic education in Ghana. This is because such a license allows basic education teachers to express themselves with the highest levels of professionalism while maintaining amicable relationships with their students.

By understanding how teacher qualifications are most strongly related to academic success, it is imperative that educators meet all standards required for the profession through the acquisition of a professional license. Therefore, Putman and Walsh

(2019), have stated that since licensure tests are designed to set minimum teaching proficiency standards, potential teachers who fall above the pass mark are deemed to have obtained the minimum competencies in their instructional practices. Hence passing the licensure examination for teachers is an effective indicator of teacher quality in achieving quality basic education in Ghana.

2.5 Teacher Knowledge

Teacher education equips would-be teachers with the necessary knowledge and skills to practice and influence their students' lives. One of such competency is the teacher's subject matter knowledge which is necessary for effective teaching. Though strong subject matter knowledge is necessary, it is insufficient for a teacher to transact his instructions effectively. The teacher needs another category of knowledge that blends subject-matter knowledge and pedagogy (Ball & Bass, 2000). Thus, Shulman's (1986) framework gave an answer to this missing link, pedagogical content knowledge. Mishra and Koehler (2006), appreciating technology's critical influence in education, extended Shulman's framework to another knowledge dimension- technological pedagogical content knowledge (TPACK). Thus, to do an assessment of how science teacher knowledge influences science teaching, it is important to consider it from the dimensions of content knowledge, pedagogical content knowledge, and technological pedagogical content knowledge. It is the integration of these knowledge dimensions that positions the science teacher well to carry out science instructions effectively.

2.5.1 Subject Matter Knowledge

Teachers' content or subject matter knowledge could relate to teacher effectiveness. Evidence from the research shows that subject matter knowledge has a positive influence on student performance (Jadama, 2014; Bartos & Lederman, 2014). If good

student performance results from effective teaching, then it stands to reason that a teacher with sufficient subject matter knowledge is likely to present effective teaching.

In the pre-service years, teachers who are trained to teach in basic schools in Ghana were trained as generalist teachers; that is, they are trained to teach a number of subjects. However, the training is done to expose them to sufficient subject matter to enable them to teach in basic schools.

Teachers must conceptualize content knowledge from multiple perspectives and at levels deeper than what must be presented to students in order to communicate adequate understanding of scientific knowledge (Ghazi et al., 2013; Bartos et al., 2014). It is very important for teachers to have deeper content knowledge because when teachers have a shallow depth of science content knowledge they will fail to help facilitate students learning and fail to deal with their misconceptions in science (Abd-El-Khalick & Lederman, 2023).

Teachers' ability to plan and deliver meaningful science lessons with appropriate practices is frequently hampered by a lack of science content knowledge. When science teachers have a shallow understanding of the subject matter, they may deliver incorrect information, leading to some students developing misconceptions (Ghazi et al., 2013).

2.5.2 Pedagogical Content knowledge (PCK)

Scholars appear to be divided on what a teacher's PCK should consist of as they view PCK differently. For instance, the proponent of the concept, Shulman (1986) defined PCK as teachers' ways of representing and formulating the subject-matter knowledge

in the context of facilitating student learning, Miller described Pedagogical content knowledge as that teacher knowledge that allows teachers to assist students to access specific content knowledge in a meaningful way. The differences in what constitutes PCK notwithstanding, the theorists seem to agree on one thing ‘possessing PCK enables teachers effectively plan and implement their instructions.

Pedagogical Content Knowledge is essential in classroom instruction and teacher practices. A PCK in the teaching and learning process involves teachers' competence in delivering the conceptual approach, relational understanding, and adaptive reasoning of the subject matter (Filgona et al.,2020)

2.5.3 Technological Pedagogical Content Knowledge (TPACK) of Science Teachers

TPACK describes the kind of knowledge required by teachers for effective technology integration. TPACK emphasizes how the understanding of subject matter, pedagogy, and technology interact with one another to give effective teaching. Shulman (1986) proposed that effective teaching requires a special type of knowledge, pedagogical content knowledge (PCK), that blends content and pedagogy into an understanding of how particular topics or problems are organized, represented and adapted to the varied needs, interests and abilities of learners. Mishra and Koehler (2006) extended Shulman’s (1986) framework of pedagogical content knowledge (PCK) to consider the role that knowledge about technology can play in effective lesson instruction. This led to technological pedagogical content knowledge (TPACK). However, Bruce (1997) and Koehler and Mishra (2008) noted that TPACK was an emergent form of knowledge that went beyond knowledge of content, pedagogy, and technology taken individually but rather existed in a dynamic transactional relationship.

While much research is focused on the integrative perspective, that is, teachers' knowledge of technology integration (Kafyuililo et al., 2016), Yeh et al., (2017) emphasized that researchers should rather be focusing on what happens in teachers' classrooms. For Yeh et al., examining teaching in practice has significant implications for understanding teachers' TPACK when the focus is on teachers' simultaneous instructional decision making-processes that are built around classroom management and assessment but noted however, that little is known about observed indicators of teachers' TPACK in science classrooms (Yeh, et al., 2017). It is therefore significant that any study into science teachers' TPACK should consider instruments that can measure both the integrative and transformative perspectives.

2.6 Teachers' Curriculum Adaptation for Special Education Needs Learners

In today's world, several nations want affiliation with inclusive education. According to the Norwegian Education Act, instruction must be customized to each student's unique abilities and aptitudes (Buli-Holmberg et al. 2014). In this instance, Norway follows the philosophy of personally tailored education, which is administered in an inclusive setting to all students. This indicates that instruction needs to be differentiated in accordance with the diversity of the student body, despite the fact that Buli-Holmberg et al. (2014) note that "special education entails a more extensive adaptation than that normally provided for in ordinary education with regard to the input of resources and expertise as well as differentiation of content." According to Pierangelo and Giuliani (2008), adaptation, particularly for learners with special education needs (LSEN), considers a number of factors, such as a combination of teaching strategies, flexible scheduling, individualized instruction, mastery learning, large- and small-group instruction, individualized tutorials, and cooperative learning.

With regard to content, instructional resources, and the responses required from students, Mitchell (2008) outlined four approaches to curricular accessibility: accommodation (computer responses instead of oral responses); substitution (e.g. braille for written works) omission (for example, omitting particularly complex work), and compensation (e.g. self-care, vocational skills). Pierangelo and Giuliani (2008) assert that if students with disabilities are to meet or exceed the curriculum's learning objectives, curriculum adaptation is essential. These modifications include those to the surroundings, how the information is presented, how quickly activities are completed, how the content is used, how students are helped, and how the evaluation process is modified. According to King-Sears (2001), adaptations are a type of alteration to the way instruction is delivered and the objectives for students' performance that doesn't modify the curriculum's content but somewhat alters the conceptual complexity.

Another term used to describe the various ways SEN students might access the curriculum is accommodation. According to Hunt and Marshall (2022), many kids with disabilities can study the same subject matter, curriculum, or standard as other students, but they require extra assistance to master it. As a result, some students require accommodations. There must be accommodations made to ensure that students in the inclusive classroom understand the same material as their peers, even if they learn it at a different pace. The ultimate result is that both learners with disabilities and those without impairments succeed in achieving the curriculum's objectives. Accommodations, according to Hunt and Marshall (2022), are changes that aid a student in overcoming or navigating a disability. For instance, they might permit a student who struggles with writing to provide responses verbally. According to Wilson and Blendnick (2011), accommodations can alter the venue or mode of a

presentation or response but they cannot change the curriculum or learning objectives. This implies that there should be the tools and other supports required for students to access the curriculum in a manner comparable to that of students without disabilities. Different teaching and learning pedagogies and approaches must be used so that students with impairments can access the curriculum. Providing audiovisual materials, projectors, pictorial presentations or modifying any amount of input allows learners with disabilities to access the curriculum with the conceptual level of difficulty remaining the same.

Ghana has embraced the inclusive education idea but the policy is yet to be rolled out nationwide and SEN students continue to receive education mostly in special schools. However, the undeniable fact is that learners with disabilities in special schools and even those in inclusive classrooms require more time to master content than the other learners without disabilities. Thus, an adapted curriculum and necessary accommodations that support the achievement of the curriculum goals should be provided by teachers engaged with educating SEN learners like the DHH.

Many science education programmes do not include inclusive instructional practices. As a result of this, many science teachers do not have the competencies in adapting their lessons to suit inclusive classroom practices. To mitigate this challenge, some science teachers resort to co-teaching where special education and science teachers collaborate to develop lessons and curricular accommodations to teach in inclusive classrooms (Scruggs et al., 2007). However, Eisenman et al., (2011) found that there were co-teaching issues of promoting collaboration and facilitating open communication between pairs of teachers that persisted which have affected the

learning of their students. It is therefore important that teachers are given the necessary training to enable them to carry out effective co-teaching.

On this basis, what this study seeks to establish is how teachers adapt their instructional practices to meet the needs of students with DHH during science lessons.

2.6.1 Factors Influencing Teacher Knowledge

Teacher knowledge is a cornerstone of effective science instruction, influencing how teachers plan, deliver, and assess their lessons. In science education, teacher knowledge encompasses content knowledge, pedagogical knowledge, and knowledge of students' diverse needs. Understanding the factors that shape teacher knowledge is essential for improving educational outcomes, particularly in diverse educational settings such as Regular, Inclusive, and Deaf basic schools in Ghana. This discussion explores various factors that influence teacher knowledge in these settings, including initial teacher education, professional development opportunities, classroom experience, access to resources, and the supportive school environment.

2.5.1.1 Initial Teacher Education

Initial teacher education provides the foundational knowledge and skills that teachers need to begin their careers. The quality and comprehensiveness of teacher education programs significantly impact teachers' content knowledge and pedagogical skills. In Ghana, teacher education programs vary in quality, with some institutions offering more rigorous training than others (Asare, 2020). High-quality teacher education programs provide pre-service teachers with a strong understanding of scientific concepts and effective teaching strategies, preparing them to meet the diverse needs of their students.

For teachers in Regular schools, initial teacher education programs typically include coursework in science content, pedagogy, and classroom management. These programs aim to equip teachers with the knowledge and skills needed to deliver effective science instruction. However, for teachers in Inclusive and Deaf schools, initial teacher education programs must go beyond the basics to include specialized training in special education needs (SEN) strategies and the use of assistive technologies (Forlin & Chambers, 2019). Programs that offer comprehensive training in these areas can better prepare teachers to address the unique challenges of Inclusive and Deaf classrooms.

Moreover, initial teacher education programs should emphasize reflective practice and the development of critical thinking skills. Teachers need to be able to analyze their teaching methods and adjust based on student feedback and performance. Reflective practice helps teachers to continually improve their instructional techniques and better meet the needs of their students (Mansour et al., 2020). In addition, pre-service teachers should be exposed to a variety of teaching environments, including Regular, Inclusive, and Deaf schools, to gain a broader understanding of different educational settings and the unique challenges they present.

1.5.1.2 Professional Development Opportunities

Professional development is crucial for enhancing teacher knowledge and ensuring that teachers stay current with the latest educational practices and research. Ongoing professional development helps teachers to expand their content knowledge, refine their pedagogical skills, and learn new strategies for meeting the needs of their students (Desimone & Garet, 2015). However, the availability and quality of

professional development opportunities can vary widely between Regular, Inclusive, and Deaf schools.

In Regular schools, teachers often have more access to professional development opportunities, such as workshops, conferences, and in-service training programs (Darling-Hammond et al., 2020). These opportunities allow teachers to stay updated on new scientific discoveries and pedagogical innovations. Workshops and conferences often focus on new science curricula, innovative teaching methods, and the integration of technology in the classroom. These sessions provide teachers with hands-on experience and practical tools that they can implement in their classrooms (Desimone & Pak, 2019). In-service training programs typically offer ongoing support and follow-up sessions to help teachers integrate new strategies into their teaching practice effectively.

In contrast, teachers in Inclusive and Deaf schools may have fewer opportunities for specialized professional development. This limitation can significantly impact their ability to meet the diverse needs of their students effectively (Nketsia, 2022). Inclusive and Deaf schools require teachers to have specialized knowledge and skills, such as differentiated instruction, the use of assistive technologies, and strategies for creating inclusive classroom environments (Florian, 2019). However, the lack of targeted professional development opportunities can hinder teachers' ability to acquire these essential skills.

To address this gap, educational systems need to provide targeted professional development opportunities that focus on the unique needs of teachers in Inclusive and Deaf schools. This could include training on differentiated instruction, which involves tailoring teaching methods and materials to accommodate the varied learning styles

and needs of students (Tomlinson & Murphy, 2020). For example, professional development sessions could demonstrate how to modify science experiments to be accessible to students with physical disabilities or how to use visual aids to support Deaf students' learning.

For teachers in Deaf schools, professional development should also include training in sign language and other visual communication tools. This training is crucial for ensuring that Deaf students can fully participate in science lessons and understand the content being taught (Marschark & Knoors, 2020). Additionally, professional development should address the social and emotional needs of Deaf students, providing teachers with strategies to support their overall well-being and academic success.

Continuous learning and reflection are integral components of professional development. Teachers should be encouraged to engage in ongoing self-assessment and reflection to identify areas for improvement and to develop their skills further (Schön, 2019). This reflective practice can involve seeking feedback from colleagues, participating in professional learning communities, and staying current with the latest research and best practices in education (Hattie & Hamilton, 2020).

1. Professional learning communities (PLCs) provide a collaborative environment where teachers can share experiences, discuss challenges, and develop solutions together. These communities foster a culture of continuous learning and improvement, helping teachers to stay motivated and committed to their professional growth (Stoll et al., 2020). In Inclusive and Deaf schools, PLCs can be particularly valuable, providing a support network for teachers

who may feel isolated or overwhelmed by the unique challenges of their teaching environments.

1.5.1.3 Classroom Experience

Classroom experience is another critical factor that influences teacher knowledge. Experience allows teachers to apply their theoretical knowledge in real-world settings, refine their teaching practices, and learn from their interactions with students. Experienced teachers often develop a deeper understanding of how to effectively teach scientific concepts and manage classroom dynamics (Hattie & Hamilton, 2020).

In Regular schools, teachers with more years of experience tend to have a better grasp of effective instructional strategies and classroom management techniques. They are more adept at identifying students' needs and adapting their teaching methods accordingly. For example, experienced teachers are better at differentiating instruction to cater to the diverse learning styles within their classrooms, using a variety of teaching methods to engage all students (García-Lopez, et al., 2019).

For teachers in Inclusive and Deaf schools, classroom experience can be particularly valuable as it allows them to develop specialized skills for working with students with diverse needs. For example, experienced teachers in Deaf schools often become more proficient in sign language and more adept at using visual aids to support student learning (Marschark & Knoors, 2020). Similarly, teachers in Inclusive schools develop a deeper understanding of how to create inclusive learning environments that accommodate students with a wide range of abilities and learning styles (Florian, 2019).

Classroom experience also helps teachers to develop effective classroom management strategies. Managing a classroom can be particularly challenging in Inclusive and Deaf schools, where teachers must balance the needs of students with diverse abilities and ensure that all students can participate fully in the learning process. Experienced teachers are better equipped to create a positive and inclusive classroom environment that supports student learning and engagement (García et al., 2019).

1.5.1.4 Access to Resources

Access to resources is a significant factor that affects teacher knowledge and instructional effectiveness. Resources can include textbooks, teaching materials, technology, and support services. Teachers who have access to a wide range of resources are better equipped to provide high-quality science instruction and to address the diverse needs of their students (Jensen et al., 2020).

In Regular schools, teachers often have better access to resources compared to their counterparts in Inclusive and Deaf schools. This disparity can impact the quality of education that students receive. For example, teachers in Regular schools may have access to up-to-date textbooks, laboratory equipment, and digital learning tools that enhance their teaching and help students to better understand scientific concepts (Darling-Hammond et al., 2020).

In contrast, teachers in Inclusive and Deaf schools may face significant resource constraints. These schools often lack the specialized resources needed to support students with disabilities, such as assistive technologies, adaptive teaching materials, and specialized support services (Florian, 2019). For example, Deaf schools may lack sufficient sign language interpreters, visual aids, and other resources that support Deaf students' learning (Marschark & Knoors, 2020). Similarly, Inclusive schools may lack

the necessary resources to accommodate students with physical disabilities, learning disabilities, and other special needs (Nketsia, 2022).

Educational systems must ensure that all teachers have the resources they need to effectively teach science, regardless of the educational setting. This includes providing access to up-to-date textbooks, laboratory equipment, digital learning tools, and specialized resources for students with disabilities. By addressing resource disparities, educational systems can help to level the playing field and ensure that all students receive high-quality science education (Jensen et al., 2020).

1.5.1.5 Supportive School Environment

A supportive school environment can significantly influence teacher knowledge and effectiveness. Schools that foster a culture of collaboration, continuous learning, and professional growth provide a conducive environment for teachers to develop their skills and knowledge (Stoll et al., 2020). In such environments, teachers are encouraged to share best practices, seek feedback, and engage in reflective practice.

In Regular schools, supportive environments might include access to professional learning communities (PLCs), mentoring programs, and regular professional development opportunities. For example, teachers might participate in PLCs where they collaborate with colleagues to discuss instructional strategies, share resources, and analyze student data to inform their teaching practices (Vangrieken et al., 2017). Mentoring programs can also provide valuable support for new teachers, helping them to navigate the challenges of the classroom and develop their teaching skills (Ingersoll & Strong, 2011).

For teachers in Inclusive and Deaf schools, a supportive environment might also involve access to special education experts, sign language interpreters, and other support staff who can assist in meeting the needs of students with disabilities (Mastropieri & Scruggs, 2020). For example, teachers in Deaf schools might work closely with sign language interpreters to ensure that Deaf students can fully participate in classroom activities and understand the content being taught (Marschark & Knoors, 2020). Similarly, teachers in Inclusive schools might collaborate with special education coordinators and other support staff to develop individualized education plans (IEPs) and adapt their teaching methods to accommodate students with diverse needs (Florian, 2019).

Creating a supportive school environment is crucial for enabling all teachers to provide high-quality science instruction. Schools should foster a culture of collaboration, where teachers are encouraged to work together and share their expertise. This collaborative culture can help to break down silos and ensure that all teachers have access to the knowledge and resources they need to support their students effectively (Vangrieken et al., 2017).

1.5.1.6 Teacher Attitudes and Beliefs

Teacher attitudes and beliefs about teaching and learning can also influence their knowledge and instructional practices. Teachers who hold positive attitudes towards science and believe in their ability to teach it effectively are more likely to engage in practices that promote student learning and engagement (Bandura, 1997). Conversely, teachers who lack confidence in their science teaching abilities may struggle to deliver effective instruction and support their students' learning.

In Regular schools, teachers' attitudes and beliefs about science teaching can be influenced by their initial teacher education, professional development experiences, and classroom interactions. For example, teachers who have had positive experiences with science during their own education and who have received strong support and training in their teacher education programs are more likely to feel confident in their ability to teach science (García et al., 2019).

In Inclusive and Deaf schools, teachers' attitudes and beliefs can be influenced by their experiences with students with disabilities and the support they receive from their schools and colleagues. Teachers who have had positive experiences working with students with disabilities and who feel supported by their schools are more likely to hold positive attitudes towards inclusive education and feel confident in their ability to meet the diverse needs of their students (Forlin & Chambers, 2019).

Professional development can play a crucial role in shaping teachers' attitudes and beliefs about science teaching. By providing teachers with the knowledge and skills they need to teach science effectively, professional development can help to build their confidence and enthusiasm for the subject (Desimone & Garet, 2015). Additionally, professional development that focuses on inclusive education and the needs of students with disabilities can help to foster positive attitudes towards inclusive teaching practices and build teachers' confidence in their ability to support all students (Florian, 2019).

1.5.1.7 Socio-Cultural Context

The socio-cultural context in which teachers work can also influence their knowledge and instructional practices. Factors such as cultural beliefs, community expectations, and socio-economic conditions can impact how teachers perceive their roles and

responsibilities and how they approach teaching and learning (Banks, 2020). In Ghana, the socio-cultural context can vary significantly between urban and rural areas, influencing teachers' experiences and the resources available to them.

In urban areas, teachers may have access to more resources and professional development opportunities, as well as greater support from their communities and educational authorities. This can positively impact their knowledge and instructional practices, allowing them to provide high-quality science education to their students (Jensen et al., 2020). In contrast, teachers in rural areas may face significant challenges, such as limited access to resources, professional development opportunities, and support services. These challenges can impact their ability to effectively teach science and support their students' learning (Asare, 2020).

Cultural beliefs and community expectations can also influence teachers' knowledge and instructional practices. In some communities, there may be strong support for science education and a recognition of its importance for students' future success. In such contexts, teachers may feel more motivated and supported in their efforts to provide high-quality science instruction (Banks, 2020). Conversely, in communities where there is less emphasis on science education, teachers may struggle to gain the support they need and may face challenges in engaging students and their families in the learning process (Asare, 2020).

Educational systems need to consider the socio-cultural context in which teachers work and provide targeted support and resources to address the unique challenges they face. This might include offering professional development opportunities that are tailored to the specific needs of teachers in different regions and providing additional resources and support for teachers in rural areas (Jensen et al., 2016). By addressing

the socio-cultural factors that influence teacher knowledge and instructional practices, educational systems can help to ensure that all students receive high-quality science education, regardless of their location or background.

Teacher knowledge is influenced by a variety of factors, including initial teacher education, professional development opportunities, classroom experience, access to resources, the supportive school environment, teacher attitudes and beliefs, and the socio-cultural context. Understanding these factors is essential for improving educational outcomes in Regular, Inclusive, and Deaf basic schools in Ghana. By addressing disparities in professional development opportunities and access to resources, fostering supportive school environments, and considering the socio-cultural context, educational systems can enhance teacher knowledge and ensure that all students receive high-quality science education.

2.7 Hearing Impairment as Disability

Hearing impairment may be defined severally or categorized variously. For instance, cultural, medical, or educational. Medically and clinically speaking, one is considered to be ‘deaf’ whenever hearing loss is so severe that one is unable to process linguistic information through hearing alone. On the other hand, one is considered to be ‘hard-of-hearing’ when there is a hearing loss, whether permanent or fluctuating, which adversely affects an individual’s ability to detect and decipher some sounds. In other words, despite the hearing loss, there is still some residual hearing (Rodda and Grove, 2013).

According to WHO (1980), hearing impairment is a broad term that refers to hearing losses of varying degrees from hard-of-hearing to total deafness. The Individuals with Disabilities Education Improvement Act (IDEIA, 2004) in the United States defines

Deaf and hard-of-hearing as “a disability that, with or without amplification, adversely affects the student's ability to use hearing for developing language and learning, educational performance, and developmental progress.” The definition also includes permanent or temporary, mild to severe or profound, and unilateral or bilateral hearing loss, and those who have hearing loss may use either spoken language or sign language, and, in many cases, a combination of both languages.

The implication of these definitions is that persons with hearing impairment will require assistance if their potentials are to be tapped and made useful citizens of their communities. Therefore, teachers in charge of learners of such disabilities will have to adapt their teaching and assessment strategies to suit their needs, especially during science lessons.

2.8 Deaf and Hard-of-Hearing Learning and Performance in Science

Research findings on the performance of deaf students compared to their hearing peers in science is not conclusive. For instance, Akram, et al. (2013) indicate that teachers and some parents believe that deaf students cannot learn scientific concepts because of their hearing loss, whereas other studies showed that they can learn scientific concepts when they are involved in first-hand exploration and investigation. Some of these studies have suggested that deaf individuals have a variety of visual-spatial advantages over hearing individuals, although some of those differences are the functions of sign language fluency rather than auditory deprivation (Bellugi et al., 2010; Dye & Bavelier, 2013).

A study conducted by Roald and Mikalsen (2000) revealed that there is no difference between younger deaf children and their hearing peers in terms of conceptions of scientific facts. However, scientific knowledge of deaf high school students deviates

significantly from their hearing counterparts and this, according to Atika et al., (2018), might have resulted from deaf students' lack of experience with scientific reasoning and the mental models necessary for understanding and integrating new scientific facts.

Science classrooms do not adequately cater for the needs of deaf and hard-of-hearing (DHH) students. Teachers are not well-equipped to deliver teaching that satisfies the needs of DHH students. There are few science curricula for DHH kids, and there is little support tailored to their needs. Typically, science language learning for DHH students consists of fingerspelling difficult scientific terms (Hagevik et al. 2011). Because of this, data from standardized tests demonstrate that DHH children are unable to stay up with their peers. DHH youngsters have also been generally disregarded in educational research and policy.

2.9 Strategies for Teaching Science to DHH Learners

Teaching science to Deaf and Hard of Hearing (DHH) learners presents unique challenges that require the use of specialized, evidence-based instructional strategies. Effective science instruction for DHH students involves using appropriate resources and adapting teaching methods to meet their specific needs.

2.9.1 Visual Aids and Non-Projected Visual Art Forms

Visual aids are essential tools in teaching science to DHH learners. They help bridge the gap between abstract scientific concepts and students' understanding by providing tangible, visual representations of the material being taught. Obosu et al. (2013) highlighted the significance of using non-projected visual art forms, such as charts and flashcards, in teaching deaf students. These visual aids allow kindergarten pupils to engage in hands-on learning experiences, which help them create lasting memories

that they can later refer to. Despite their effectiveness, the use of visual aids tends to diminish at the upper primary, junior high school (JHS), and senior high school (SHS) levels.

To maximize the benefits of visual aids, teachers should consistently incorporate them across all educational levels. This includes using diagrams, flowcharts, and models to illustrate scientific processes and concepts (Boone et al., 2019; Kossyvaki, Jones & Guldborg, 2020). For example, a teacher might use a model of the solar system to explain planetary motion or a flowchart to depict the steps of the scientific method. These visual tools can make abstract ideas more accessible and enhance students' comprehension. Research by Harris et al., (2021) also supports the use of visual aids, indicating that they can improve retention and understanding of scientific concepts among DHH learners.

2.8.2 Pre-Teaching and Sign Language

Pre-teaching scientific concepts using sign language before introducing textbook materials can significantly improve DHH students' understanding. *Roald and Mikalsen (2000)* found that comprehensive discussions of a topic using sign language prior to reading the textbook promote better scientific comprehension among deaf students. This approach allows students to grasp key concepts and vocabulary in their preferred language before encountering them in written form.

In addition to pre-teaching, incorporating sign language throughout science instruction is crucial. Teachers should be proficient in sign language or work with qualified sign language interpreters who have a strong understanding of scientific terminology (Crowe et al., 2019; Knoors & Marschark, 2020). This ensures that DHH students can fully participate in class discussions and activities. Moreover, using

sign language helps create an inclusive learning environment where students feel valued and understood. McKee and Smiler (2019) emphasize the importance of sign language proficiency for teachers in enhancing the learning outcomes for DHH students.

2.8.3 Multimedia and Interactive Learning

The use of interactive multimedia and web-based curriculum materials has been shown to yield significantly greater knowledge gains in science for DHH students compared to traditional classroom experiences (Land & Steely, 2003). Multimedia resources, such as videos, animations, and interactive simulations, can make science lessons more engaging and accessible. For instance, animations that illustrate cellular processes or chemical reactions can help students visualize and better understand these complex phenomena.

Interactive learning approaches, such as student-based problem-solving activities, are particularly effective in developing critical thinking and problem-solving skills among DHH students (Brown et al., 2002; Wolbers, Dostal & Graham 2021). These activities encourage active participation and allow students to apply scientific concepts in real-world scenarios. For example, teachers can design experiments or projects that require students to work collaboratively to solve scientific problems, thereby enhancing their understanding and retention of the material. Studies by Easterbrooks and Lederberg (2020) further highlight the benefits of interactive learning in improving cognitive skills in DHH learners.

2.8.4 Dynamic Visual Displays

Dynamic visual displays that accompany verbal descriptions are especially helpful for teaching scientific principles or processes that need to be visualized to be understood.

Studies involving hearing students have shown that simultaneous presentation of verbal and non-verbal materials facilitates information integration, resulting in faster learning, better retention, and a greater likelihood of application (Iding, 2000; James, 2008). For DHH learners, this means incorporating dynamic visuals such as animations, videos, and interactive simulations alongside verbal explanations.

For example, when teaching about the water cycle, a teacher might use an animated video that shows the process of evaporation, condensation, and precipitation while explaining each step in sign language or through captions. This multi-sensory approach helps students to integrate and retain information more effectively (Paivio, 2019; Mayer, 2021). Research by Smith and Levitt (2021) supports the use of dynamic visuals in enhancing understanding and retention of scientific concepts among DHH students.

2.8.5 Graphic Organizers and Visual Representations

Graphic organizers, maps, pictures, and illustrations are valuable tools for advancing learning among DHH students. Raven and Whiteman (2019) found that these visual representations help students organize information, making it easier to understand and recall. Graphic organizers, such as Venn diagrams and concept maps, can help students visualize relationships between different scientific concepts and organize their thoughts.

However, Raven and Whiteman (2019) also cautioned that an over-reliance on visuals might diminish students' literacy skills. To address this, teachers should balance the use of visual aids with activities that promote reading and writing skills (Trussell et al., 2019; Marsicano et al., 2020). For instance, after using a graphic organizer to outline a scientific concept, teachers might have students write a summary or

explanation of the concept in their own words. Research by Shaw and Dyce (2020) also emphasizes the importance of balancing visual aids with literacy development activities to ensure comprehensive learning.

2.8.6 Repetition and Reinforcement

Repetition and reinforcement are crucial strategies for ensuring that DHH students understand and retain scientific concepts. This involves revisiting key ideas and vocabulary multiple times and in various contexts. Teachers can use strategies such as repeated exposure to new terms, revisiting previously taught concepts in different lessons, and providing opportunities for students to apply their knowledge in new situations.

For example, a teacher might introduce the concept of photosynthesis in one lesson, then revisit it in subsequent lessons through different activities such as experiments, discussions, and multimedia presentations. This repeated exposure helps reinforce students' understanding and retention of the concept (Hallahan et al., 2020; Lutz & Huitt, 2020). Studies by *Dillon and Larkin (2021)* indicate that repetition and reinforcement significantly improve the retention of scientific concepts among DHH students.

2.8.7 Use of Sign Language Interpreters

The use of sign language interpreters can significantly enhance the learning experience for DHH students, provided that the interpreters have a strong understanding of scientific content. Raven and Whitman (2019) emphasized that interpreters' content knowledge is crucial for effectively communicating scientific concepts to learners. If an interpreter lacks sufficient knowledge of science, they may

not be able to accurately convey the material, which can hinder students' understanding.

To ensure effective communication, teachers should collaborate closely with interpreters, providing them with lesson plans and materials in advance (Napier et al., 2019; Jambor & Elliott, 2020). This allows interpreters to familiarize themselves with the content and prepare to accurately convey it to students. Additionally, professional development opportunities for interpreters in scientific content can enhance their ability to support DHH students' learning (Andrews et al., 2020). Studies by Smith (2018) support the importance of professional development for interpreters in enhancing educational outcomes for DHH students.

2.8.8 Student-Based Problem-Solving Approaches

Student-based problem-solving approaches are particularly effective in developing thinking skills and problem-solving abilities in DHH students (Brown, et al., 2002). These approaches involve presenting students with real-world scientific problems and guiding them through the process of finding solutions. This method encourages active learning, critical thinking, and collaboration.

For example, a teacher might present a scenario where students need to design a water filtration system using limited resources. Students would work in groups to brainstorm ideas, conduct experiments, and refine their designs based on their findings. This hands-on, inquiry-based approach helps students develop a deeper understanding of scientific concepts and improves their problem-solving skills (Easterbrooks & Lederberg, 2020; Johnson et al., 2021). Research by O'Brien and Kosslyn (2020) highlights the effectiveness of problem-based learning in enhancing cognitive skills and scientific understanding among DHH learners.

2.8.9 Incorporating Technology and Assistive Devices

Incorporating technology and assistive devices into science instruction can greatly benefit DHH students. Technologies such as captioned videos, speech-to-text applications, and interactive whiteboards can make science lessons more accessible and engaging. Assistive devices, such as hearing aids and FM systems, can also enhance students' ability to hear and understand spoken instructions.

For instance, teachers can use interactive whiteboards to display visual aids, videos, and simulations that illustrate scientific concepts. Captioned videos provide visual representations of spoken content, making it easier for DHH students to follow along (Stinson & Liu, 2020; Mayer, 2021). Speech-to-text applications can transcribe spoken instructions in real-time, allowing students to read what the teacher is saying. Studies by Marschark and Knoors (2020) and Linder and Powers (2019) further emphasize the positive impact of technology and assistive devices on the learning experiences of DHH students.

2.8.10 Creating an Inclusive Classroom Environment

Creating an inclusive classroom environment is essential for the success of DHH students in science education. This involves fostering a classroom culture that values diversity and promotes equal participation. Teachers should be mindful of the specific needs of DHH students and implement strategies to ensure they are fully included in all classroom activities.

One way to create an inclusive environment is to arrange the classroom seating in a way that facilitates visual communication. For example, arranging desks in a circle or U-shape allows DHH students to see their peers and the teacher, making it easier to follow discussions and participate in group activities (Smith & Levit, 2019;

Easterbrooks & Lederberg, 2020). Teachers should also establish clear communication norms, such as raising hands to speak and using visual signals to get attention.

Additionally, teachers can create a supportive learning environment by encouraging collaboration and peer support. Group activities and projects can provide opportunities for DHH students to work with their hearing peers, fostering mutual understanding and cooperation. Teachers should also provide positive reinforcement and recognition for students' efforts and achievements, creating a motivating and inclusive atmosphere (Johnson et al., 2021; Wolbers et al., 2021).

2.8.11 Collaboration with Special Education Professionals

Collaboration with special education professionals, such as speech therapists, audiologists, and special education teachers, can enhance the effectiveness of science instruction for DHH students. These professionals can provide valuable insights and support in developing and implementing instructional strategies that meet the specific needs of DHH learners.

For example, speech therapists can work with teachers to develop activities that promote language development and communication skills. Audiologists can provide guidance on the use of hearing aids and other assistive devices to improve students' access to auditory information. Special education teachers can offer strategies for differentiating instruction and creating individualized education plans (IEPs) that address the unique needs of DHH students (Marsicano et al., 2020; Kossyvaki et al., 2020).

Teaching science to DHH learners requires the use of specialized, evidence-based strategies that accommodate their unique needs and promote their engagement and understanding. By incorporating visual aids, sign language, multimedia resources, interactive learning approaches, and technology, teachers can create an inclusive and supportive learning environment. Additionally, collaboration with special education professionals and the creation of a positive classroom culture are essential for the success of DHH students in science education. By implementing these strategies, teachers can enhance the learning experiences of DHH students and help them achieve their full potential in science.

2.10 Barriers to Effective Science Teaching to DHH Learners

Educating Deaf and Hard of Hearing (DHH) students presents numerous barriers that can impede their academic achievement. These barriers include challenges related to language and communication, curriculum, instruction and assessment, expectations, and technology. Identifying and addressing these barriers is crucial to improving the educational outcomes for DHH learners. This discussion explores these barriers in detail and examines their impact on the effectiveness of science teaching for DHH students.

2.10.1 Language and Communication Barriers

Language and communication barriers are among the most significant challenges in teaching science to DHH learners. Proficiency in scientific vocabulary and the ability to understand and use complex language structures are critical for success in science education (Lemke, 1990). However, many DHH students have lower language skills compared to their hearing peers, which can make it difficult for them to grasp scientific concepts that are often conveyed through complex language.

Szymanski et al., (2013) identified language and communication as critical needs for DHH students. Their survey revealed that the educational needs of DHH students vary greatly, and finding appropriate programs to meet these needs is challenging due to the low-incidence nature of the population. Furthermore, the notion held by some teachers that DHH learners are low academic achievers can negatively affect their performance, as these low expectations can become a self-fulfilling prophecy.

Language proficiency is essential in science because it involves the precise use of terminology and the ability to comprehend and produce complex explanations, arguments, and descriptions. DHH students often struggle with acquiring this proficiency due to their reduced access to incidental learning opportunities and natural language development that their hearing peers experience. This gap can result in difficulties with reading comprehension, written expression, and understanding spoken or signed instructions in the classroom.

To overcome language and communication barriers, it is essential to provide DHH students with access to high-quality language instruction and support. This includes the use of sign language interpreters who are proficient in scientific terminology, as well as visual aids and other tools that can help convey complex concepts (Knoors & Marschark, 2020). Additionally, integrating language development into science instruction can help DHH students build their language skills while learning scientific content (Crowe et al., 2019). Teachers can use strategies such as pre-teaching key vocabulary, using visual representations of complex terms, and providing opportunities for students to engage in scientific discourse through both spoken and signed languages.

2.10.2 Curriculum, Instruction and Assessment Barriers

The curriculum, instruction, and assessment practices used in many schools are often not adequately adapted to meet the needs of DHH learners. Szymanski et al. (2013) highlighted that DHH students face significant challenges related to the mainstream curriculum, which is typically designed for hearing students. The lack of professional competencies among teachers, such as the ability to use sign language effectively, further exacerbates these challenges.

Ntinda et al., (2019) emphasized the need for curriculum developers to ensure that teacher training programs include deaf education. This would prepare teachers to handle DHH learners more effectively. Currently, many teachers lack innovative methods and strategies for teaching DHH students, which hinders their ability to provide an inclusive and effective science education. Traditional science curricula often fail to consider the unique learning styles and needs of DHH students, leading to their marginalization in the classroom.

Assessment practices also pose a significant barrier for DHH students. Standardized tests and traditional assessment methods often do not accommodate the unique needs of DHH learners, leading to inaccurate representations of their abilities and knowledge. For example, written tests may not accurately reflect a DHH student's understanding if they struggle with reading and writing in English. Similarly, oral assessments may not be suitable for students who communicate primarily through sign language.

Alternative assessment strategies, such as performance-based assessments and portfolios, can provide a more accurate picture of DHH students' understanding and skills (Easterbrooks & Lwdermab, 2020). These methods allow students to

demonstrate their knowledge in ways that are more aligned with their strengths and communication preferences. For example, a performance-based assessment might involve conducting a scientific experiment and explaining the results through a signed presentation. Portfolios can showcase a student's work over time, including written reports, projects, and visual representations, providing a comprehensive view of their learning progress.

2.10.3 Expectations and Attitudinal Barriers

Teachers' expectations and attitudes towards DHH learners can significantly impact their educational outcomes. Szymanski et al. (2013) found that teachers often hold the view that DHH learners are low academic achievers. This belief can lower teachers' expectations for these students, leading to a lack of challenging and engaging instruction. When teachers have low expectations, they may provide less rigorous instruction, fewer opportunities for critical thinking, and limited feedback, which can hinder DHH students' academic growth.

Expectations play a crucial role in shaping students' self-perceptions and motivation. When teachers hold high expectations for all students, including those who are DHH, students are more likely to be motivated to achieve and to engage in learning (Rosenthal & Jacobson, 2020). Conversely, low expectations can lead to a lack of effort and engagement from students, perpetuating a cycle of low achievement. Teachers' attitudes towards DHH students can also influence how they interact with these learners, including the type and quality of feedback they provide, the instructional strategies they use, and their willingness to modify lessons to meet students' needs.

To address these attitudinal barriers, it is essential to provide professional development for teachers that focuses on fostering high expectations and positive attitudes towards DHH learners (Hattie & Hamilton, 2020). This training should include strategies for creating an inclusive classroom environment where all students feel valued and supported. Professional development can also help teachers understand the impact of their expectations on student achievement and equip them with the tools to set and maintain high standards for all students.

2.10.4 Technological Barriers

Technology can play a significant role in enhancing the learning experiences of DHH students. However, the lack of access to appropriate assistive technologies and resources is a major barrier. Mprah (2022) noted that the absence of assistive devices in deaf schools in Ghana hampers the education of DHH students. Additionally, many teachers lack the skills and knowledge to effectively integrate technology into their instruction.

Assistive technologies, such as hearing aids, FM systems, captioned videos, and speech-to-text applications, can significantly improve access to auditory information and enhance learning for DHH students (Stinson & Liu, 2020). However, these technologies are often expensive and may not be readily available in all educational settings. Schools in low-income areas or developing countries may struggle to provide these resources due to financial constraints and lack of infrastructure.

Technological barriers can be addressed by providing schools with the necessary resources and training to implement assistive technologies. This includes devices such as hearing aids, FM systems, and captioned videos, as well as training for teachers on how to use these tools effectively. Professional development programs can help

teachers integrate technology into their lessons, making science instruction more accessible and engaging for DHH students. Additionally, ensuring that all classrooms are equipped with the necessary technological infrastructure, such as internet access and interactive whiteboards, can enhance the learning experiences of DHH students (Marschark & Knoors, 2020).

2.10.5 Professional Competency Barriers

The competency of teachers in using sign language and adapting the mainstream curriculum to meet the needs of DHH students is crucial for their educational success. However, many teachers lack this competency, which negatively impacts their ability to provide effective instruction. Mprah (2022) highlighted the need for educational reforms to address barriers to communication and improve the competency of teachers in deaf schools.

Teachers' lack of proficiency in sign language and their reliance on inappropriate strategies can hinder DHH students' learning. To address this, it is essential to include deaf education as part of teacher training programs and to provide ongoing professional development for current teachers (Jambor & Elliott, 2020). This training should focus on developing teachers' sign language skills and equipping them with innovative instructional strategies tailored to the needs of DHH learners (Andrews et al., 2020).

Professional development should also include training on the use of assistive technologies and strategies for differentiating instruction. Teachers need to be equipped with the knowledge and skills to modify their teaching methods to accommodate the diverse needs of DHH students. This might involve using visual aids, hands-on learning activities, and alternative assessment methods. By improving

teachers' competencies in these areas, schools can create a more inclusive and effective learning environment for DHH students (Ntinda et al., 2019).

2.10.6 Resource and Material Barriers

Inadequate instructional materials and resources are significant barriers to effective science teaching for DHH learners. Ndhlovu and Matafwali (2020) found that barriers to teaching integrated science to learners with hearing impairment include a lack of instructional materials and resources. Without access to appropriate materials, teachers are unable to provide engaging and effective science instruction.

To overcome this barrier, schools need to be equipped with a variety of instructional materials that cater to the needs of DHH students. This includes visual aids, hands-on learning tools, and digital resources that can enhance the learning experience. For example, visual aids such as diagrams, charts, and models can help DHH students understand complex scientific concepts. Hands-on learning tools, such as science kits and laboratory equipment, allow students to engage in experiments and explore scientific principles through direct experience.

Digital resources, such as interactive simulations, videos, and online learning platforms, can also play a crucial role in making science instruction more accessible and engaging for DHH learners. These resources can provide visual representations of scientific phenomena, interactive activities that reinforce learning, and opportunities for students to practice and apply their knowledge in a variety of contexts (Harris et al., 2021).

Additionally, providing teachers with the necessary training to effectively use these materials can help improve the quality of science education for DHH learners.

Professional development programs should focus on equipping teachers with the skills to integrate visual aids, hands-on learning tools, and digital resources into their instruction. This training can help teachers create more engaging and effective lessons that meet the diverse needs of DHH students (Easterbrooks & Lederberg, 2020).

Educating DHH students in science is met with numerous barriers, including language and communication challenges, curriculum and assessment issues, low expectations, technological limitations, professional competency gaps, and inadequate instructional materials. Addressing these barriers requires a comprehensive approach that includes enhancing teacher training, providing access to appropriate resources and technologies, fostering high expectations, and creating an inclusive learning environment. By addressing these barriers, educators can improve the educational outcomes for DHH students and help them achieve their full potential in science.

2.11 Social Interaction of Deaf Learners in Inclusive Schools

Interaction is described as a social transaction between two individuals that can be of any length and in which the participants' conduct is interdependent (Batten et al., 2014). Furthermore, any attempt to capture an audience's attention or communicate using language and/or non-linguistic means that refer to the meaning of interaction. As a result, social exchange can include any trading relationships, non-linguistic or language communication, and social play. Social contact is the desire to communicate with, make friends, and be accepted by peers. In inclusive classrooms, deaf children frequently have few acquaintances, have less contact with learners without hearing impairments, and are frequently disallowed or disregarded compared to learners without hearing impairments (Yu-Han et al., 2014). However, research on the social interactions of deaf and hard-of-hearing children in inclusive environments is limited.

Inclusion of children with impairments, particularly deaf children, is a major aspect of educational policy in many nations. Children with impairments in general, and deaf children in particular, are taught in inclusive settings as a result of the development of comprehensive educational policies (Rebecca, 2015). While children with mild and severe hearing impairments and hearing children associate more with peers of the same hearing status, there has been increased interaction between children with mild and severe hearing impairments and children without hearing impairment. Children with mild and severe hearing impairments, on the other hand, appear to be ignored more often than children without hearing impairments in the classroom and make fewer friends (Rebecca, 2015). The proportion of learners with mild and severe hearing impairments pursuing their education in conventional classes with learners without hearing impairment has increased quickly (Eriks-Brophy & Whittingham, 2013; Alasim, 2018;). The percentage of learners with mild and severe hearing impairments in the general education classroom and integration of them in the general education system is increasing as a result of early detection and intervention methods, financial stresses, parental demands, technological advances, and the development of legislation promoting inclusive schools for learners with special educational needs (Alasim, 2018).

The inclusive educational benefits of social interaction and communication with children with regular hearing include access to conventional verbal and behavioral models of learners without hearing impairment and social recognition of children by learners without hearing impairment (Yu-Han et al., 2014). However, placing deaf and hard-of-hearing children in regular classrooms does not instantly result in expressive social contact, recognition of colleagues, constructive inclusion, or progress in children's social and communication abilities (Bobzien et al., 2013; Yu-Han et al.,

2014). Children with mild to severe hearing impairment encounter significant challenges in social contact, communication, promoting interaction and communication, and maintaining these connections and communication with listening peers in inclusive schools. Effective communication and social skills of deaf children and children with mild hearing impairment, as well as the impact of an inclusive educational environment, are critical components of social communication. Educating children with mild and severe hearing impairments in inclusive school environments with classmates who do not have hearing impairments can improve social communication and foster a pleasant inclusive environment in the classroom (Yu-Han et al., 2014).

While there is an increase in the placement in the general teaching classroom of mild and severe hearing impairment learners in many countries, numerous researches have revealed that these children face problems in engaging and communicating with teachers of ordinary schools and learners without hearing impairment (Fan, 2014). The presence in standard education classes of mild and severe hearing impairment learners leads to their alienation and social exclusion from the families of the listening school. For this cause, deaf learners' alienation and social isolation from the hearing community have a detrimental effect on their ability to connect and engage, as well as on their academic achievements (Yakundi et al., 2016). It is therefore vital that the community in inclusive education system, especially educators that instruct in a classroom of inclusive education, establish circumstances and establish a diversity of approaches that remove obstacles to the participation and social interaction of learners with mild and severe types of hearing impairments (MoE, 2015). In addition, educators in schools must build a regulatory structure that assists learners in facilitating meaningful contact between learners with mild to severe hearing

impairment and learners without hearing impairment (Sentayehu, 2015). Furthermore, in order to improve their understanding and enable them to speak and communicate with one another, teachers in mainstream schools and teachers who teach learners with different types of impairments can provide knowledge about hearing impairment and features learners with mild and severe types of hearing impairment (Alasim, 2018).

Staff members have critical responsibilities in creating a pleasant environment for disadvantaged students in the school setting. Many professors appear to unintentionally create these barriers despite their desire to communicate with deaf students (Tewodros, 2014). Teachers and peers of deaf learners evaluate deaf learners more positively on characteristics such as intelligence, achievement, and personality due to a phenomena known as the impacts of hearing aids (Bobzien et al., 2013). The cultural attitudes and beliefs of its citizens influence deaf learners' meaningful engagement in schools and society. If a culture disregards and discriminates against children with disabilities, oppressive practices will be perpetuated.

2.12 The Concept of Inclusive Education

Creating an inclusive learning environment in science is crucial to ensure that all students feel safe and respected in the classroom, regardless of their background, identity, or abilities. Inclusive education used to focus largely on learners with SEN due to behaviour or learning difficulties. However, in its current form, it is aimed at meeting the diverse learning needs of all learners. Inclusive education enables both learners with and without disabilities can learn together by attending schools with sufficient support services (UNESCO, 2015).

Inclusive education means ensuring that all children have equal access to learning opportunities. Inclusion begins with acknowledging the uniqueness in all children rather than labeling them. It is also vital to concentrate on people who are vulnerable, underprivileged, or underachieving. Inclusion is concerned with providing suitable solutions to varied learning needs across the curriculum (UNICEF, 2014). Everyone is encouraged to engage in an inclusive school. Peers and other school community members embrace and support it to meet their educational needs.

The goal of inclusive education is to offer the necessary resources so that all children can engage meaningfully in current classroom activities. Additionally, assistance may necessitate the employment of new resources or the provision of enhanced training to present personnel. Inclusive education is a method of giving learning to all children, including learners with disabilities and children without disabilities, in the same class by designing or arranging instruction based on individual learners' interests and skills (Kirschner, 2015).

Before preparing a lesson in inclusive education, a teacher must first assess the qualities, abilities, and interests of the pupils. The next duty is to organize and select various activities and instructional materials for children with varying needs, abilities, and interests. Inclusive learning is a method of changing both the regular and special education systems and raising the educational standards for all students. The pursuit of inclusive education demands a systemic process of launching school reforms in order to develop quality, participatory, and socially equitable educational communities for learner variety (Liasidou & Antoniou, 2023)

2.13 Deaf Learners in Inclusive Schools

The basic purpose of inclusive education is to integrate disabled children into regular educational settings. This inclusion of children with disabilities with those without impairments in the inclusive educational environment improves the replacement of special schools and classes in comprehensive schools. Inclusive schools are regular schools in which students with disabilities, in whole or in part, are placed in regular classes with children without impairments (UNICEF, 2014).

The accommodation and inclusion of children with hearing impairments in regular schools has become a point of contention among teachers, practitioners, and parents because it is difficult to satisfy the special desires of children with hearing disabilities, particularly those who are integrated with learners without hearing impairment in regular schools (Sentayehu, 2015). Inclusion is successful when students with hearing impairments fully engage and participate in the classroom, when the teacher collaborates with the special needs education teacher in the classroom, and when the classroom environment and curriculum can be tailored to the learners' educational needs. According to Antia and Kreimeyer (2015), one of the primary goals of an inclusive classroom is to provide a means of communication that allows learners with hearing impairments to communicate directly with one another. However, learners with hearing impairments speak differently than those around them (Sentayehu, 2015), which may limit their social contact and growth.

2.14 Differentiated Instructional Strategies

There is so much diversity in the classroom especially in an inclusive class. In this respect, Aldossari (2018) states that students come to the classroom with different abilities, readiness, and interests, indicating “the multi-level differences among

learners” (2018). To produce effective teaching in such an educational environment, a teacher needs to adopt an approach beyond the ‘one-fit-all’ type which considers the average interest of the learners rather than their differences. While there are different approaches to this, literature has suggested differentiated instruction as one very effective approach (Tomlinson, 2020).

Teachers must therefore value the diversity of learners in their science classrooms, accept responsibility for each student's achievement, and recognize that there are various paths to that accomplishment. However, creating multiple learning alternatives or different learning pathways for difficult learners without "watering down" the material is a significant issue for teachers. According to research, classroom teachers are hesitant to adopt adaptive instruction due to a lack of experience and familiarity with changing instruction to cater to challenging students

In educational practice, differentiation is characterized by Sondergeld and Schultz (2008) as trying to address learners' talents, interests, and both perceived and genuine needs. Differentiation allows students to approach material from their strengths, no matter how diverse they may be. Limitations can thus be addressed in differentiated instructions without forming negative opinions of one's own ability or value. A differentiated classroom is one in which the teacher creates and implements a variety of approaches to material, and process, and results in anticipation of and reaction to student variances in readiness, interest, and learning requirements (Tomlison, 2020). She added that student readiness, interest, or preferred learning styles are key considerations for teachers when exploring differentiated instructions.

Strogilos (2018) argued that differentiated instruction is useful for teaching in inclusive settings because differentiated instruction provides a learning environment

that takes into consideration the individual characteristics of all students. Thus, though effective teachers rely on different approaches to achieve desired instructional objectives, the most appropriate approaches are those that consider individual learner differences and help them accomplish learning. For teachers to be accomplished in differentiated instructions, they should design lessons based on individual learner differences in terms of their backgrounds, and learning styles, and hence group learners by ability, and shared interest, among others. When teachers become aware of the differences among their learners, they can then plan and manage instructional activities that will take advantage of their natural skills and inclinations to enhance learning.

Differentiated Instruction involves responding effectively to the individual differences among learners in the classroom. Teachers carry out differentiated teaching when they reach out to an individual or small group by varying their teaching in order to create the best learning experience possible (Tomlinson, 2020). Differentiated instruction is considered as one of the essential means to effective education for all students including those with disabilities. As Tomlinson argues, differentiation is not associated with “one size fits all” teaching but mainly with responsive teaching. Thus, when teachers differentiate they ‘proactively plan varied approaches to what students need to learn, how they will learn it, and/or how they will show what they have learned in order to increase the likelihood that each student will learn as much as he or she can, as effectively as possible’ (Tomlinson 2020).

Teachers need to modify and adapt their curriculum implementation approaches to carry out differentiated instructions. However, Strogilos et al., (2015), identified limited curriculum modifications for students with SEN in their descriptive

observation in mainstream classrooms. The study thus suggests that teachers in inclusive classrooms do not carry out differentiated instructions or do so to a limited extent.

In an effective differentiated classroom, the teacher strives to have a better understanding of the student's readiness levels, interests, and learning preferences. The teacher then adapts the content, process, and product, so as to develop instruction that increases each student's opportunity for academic success (Tomlison & Imbeau, 2014). The authors assert that the elements of differentiation are interdependent and a teacher needs to give equal attention to all since a weakness in one affects the other. For instance, assessment that students perceive to be judgmental will have a negative impact on the learning environment. A classroom in which the curriculum is specified, with no or few opportunities for the instructor to make professional decisions on behalf of pupils, restricts the teacher's instructional alternatives.

To ensure effective implementation of differentiated instruction, researchers and educators have recommended a number of strategies. Such strategies when integrated into differentiated instruction are likely to record positive learning outcomes. In a study of differentiated instructional strategies of junior high school science teachers, Gayeta and Ramos, (2019) found flexible grouping, adjusting questions and rubrics were the most frequently used differentiated instructional strategies by science teachers.

Teachers adjust questions to enable students to get the concept under study. To make this strategy impactful in differentiated instruction, Gayeta and Ramos (2019) suggests that open-ended questions prepared ahead should be used while students are

given enough time to reflect in order to provide the appropriate response. This will result in meaningful student engagement.

Another differentiated instructional strategy adopted by science teachers is rubrics. Rubrics help distinguish different levels of quality in students' work with reference to a coherent set of criteria which includes descriptions of levels of performance (Gayeta, 2019). Rezaei and Lovorn (2010) assert that rubrics is a 21st-century assessment skill that enhances and enriches the assessment of student work, making it more popular in US classrooms.

2.15 Classroom Equipment in Inclusive Setting

Deaf learners' communication skills can be appropriately developed if instructional materials and approaches adequately target their needs and abilities. These items should include relevant linguistic, environmental, psychomotor, and other components. In terms of teaching methods, children with congenital hearing impairments have unique requirements (Mohamed, 2015). Teachers who use instructional materials to teach students with hearing impairments in inclusive settings while accommodating their needs reduce emotions of sadness and frustration while increasing academic accomplishment. This has demonstrated the importance of educators in sustaining an effective communicative, efficient, promising, and pleasurable schoolroom (Matthews, 2016). They also stated that during lectures and other teaching sessions, students with hearing impairments frequently rely on their sight as the primary means of obtaining educational services. Lesson knowledge is provided as useful teaching resources in a visual format such as chalkboard, overheads, power point slides, handouts, captioned images, diagrams, and other visual aids, with acceptable seating arrangements in the room so that learners with hearing

impairments can see everyone in the class. Deaf students know where to seat, which is always near the front and somewhat to the instructor's side (Colclasure et al., 2016).

For a teacher who have learners with a hearing impairment in the class, audiovisual equipment and staff are of special significance. They can put important notes or main vocabulary terms or phrases on the overhead projector while the instructor lectures. An overhead projector enables the instructor, when writing on the projector, to maintain eye contact with learners. The trainer should be sure that there is enough light when using slides or movies to allow the learner with hearing impairments to see faces clearly while the teacher makes remarks. In general, as much as possible, complementary graphs and pictures should be used (Colclasure et al., 2016). Teachers of deaf students must be versatile and have adapted educational materials and equipment designed for use by students with hearing impairments. Teaching tactics might differ depending on the diagnosis of the learning problems and the opportunity for interaction accessible to the teacher and learner. Instruction must be set at a level that allows understanding while also challenging the learner to learn and develop academically and socially (Hidayat et al., 2017).

While there are many resources available for learners without hearing impairments and their teachers, there are very few resources available for deaf learners and deaf teachers. The availability of technology, materials, and educational resources is critical for teaching deaf students. These include a sign language dictionary that deaf learners and teachers can use as a reference to improve their sign language skills, as well as interpreters from support workers who can access spoken languages. Deaf students should be able to read written languages when they are taught in inclusive education settings (Mohamed, 2015). According to Usman (2016), every level of

hearing impairment affects a learner's capacity to navigate their surroundings in a variety of ways. Learners with hearing loss may have fewer possibilities to learn incidentally through television, radio, audiotapes, films, and theatrical performances that will help them acquire proper speech and language patterns. All instructors, families, and students in the school community play a significant part in creating a healthy and inviting environment and providing adequate materials and facilities to promote deaf learners' learning.

2.16 Assistive Technology Devices in Deaf Education

Assistive technologies encompass a wide range of assistive, adaptive, and rehabilitative devices for people with special needs. For the past two decades, there has been a huge development in the area of deafness and hearing loss assistive technologies. Assistive technologies are grouped into hardware, software and prosthetic implants. Assistive technologies allow people who are deaf, hard of hearing, or speech impaired to communicate through a communications assistant (CA) with people who use a standard telephone (Abdallaha & Fayyumi, 2016).

Assistive technology devices and equipment are meant to help persons with disability in several ways depending on the nature of the disability. For instance, for DHH, the devices may help enhance their hearing abilities. The devices may also help in enhancing many skills of the learner with disabilities.

The use of assistive technology can significantly improve a student's performance by correcting and compensating for performance limitations they may have. It can also ensure accurate testing accommodations and provide sufficient answers when a longer evaluation is required. Therefore, through the provision of necessary support and an equally accessible learning environment to all, effective technology integration in

education can aid in addressing the functional barriers experienced by students with disabilities, providing them with equitable learning opportunities and a level playing field to appropriately exhibit their differential abilities (Ahmad, 2015).

The development of writing skills in hearing-impaired kids may be assisted by word processing and instructional software. The usage of alternatives to audio output can help the computer user who has hearing loss instead of a normal keyboard and mouse. Advanced speech synthesizers can serve as substitute voices, giving children who struggle with verbal communication a compensatory tool. Once modified computers give students with portable systems audible speaking voices, they can join in class discussions. With the development of appropriate speech and language patterns using supportive aids like recorded tapes, speech trainers, photo albums, articulation charts, concrete objects, and other visual cues, students with hearing and/or speech impairments can use standard written or on-screen documentation without difficulty (Ahmad, 2015).

There are technologies that combine visual and auditory content into a single device, such as an iPad to tablet PC, which can avoid the juggling act that many deaf students go through during a class. The use of transparent video and overlay digital ink can help lessen the visual distance between the student and the interpreter and the student's notes. A tablet displaying the instructor, the presentation, and the interpretation on one screen would be ideal (Cavender, 2008). This synchronous participation in the activity helps to alleviate some of the emotions of isolation that deaf learners frequently experience.

'Transcense' is a new programme that has been developed to enable the deaf to communicate effectively with the hearing, designed for use with smartphones and

other mobile devices. The application transcribes speech into written words that show up on a smartphone screen. Conversely, a deaf person can use the same application to speak for them in a digital voice or to get the attention of hearing people present. Transcense works by using a newly devised voice recognition algorithm to separate individual voices in a group; then assigns each voice a color on their smartphone screen so the deaf person can determine who is speaking, and thus can be actively involved as a participant in the conversation. This is the first mobile application that has made it possible for the deaf to engage in synchronous conversations with their peers (Shepherd and Apert, 2015).

In recent years, the usage of technology by DHH students has increased steadily. For example, Harding and Tidball (1982) discovered that 42% of the schools assessed used computers for instruction, whereas Rose and Waldron (1984) discovered that 52% of the programs surveyed used computers for instruction. Again, Melikian's (1994) research revealed the increased use of computers for instructions by teachers of deaf children. While these were studies conducted in the United States of America, in Ghana, the use of technology for classroom instruction by DHH has its attendant challenges.

With the use of assistive technology, learners are provided with greater opportunities to participate fully during lessons. They are therefore motivated for higher performance. Unfortunately, the availability and accessibility due to cost; and the attitude of teachers and school heads are barriers to using assistive technology (Szymanski, et al., 2013; Ahmad, 2015).

Adeoye (2022) cites accessibility issues, adoption and acceptance of technology, parental attitude and users' attitude as some of the challenges limiting the use of

assistive technology for deaf education in Ghana. According to Maiorana-Basas and Pagliaro (2014), as society becomes more reliant upon technology, information about, preference for, and accessibility of frequently used devices and services among individuals who are Deaf and hard of hearing is critical. Developing functional and appropriate access to technologies allows people who are Deaf and hard of hearing to fully participate in society, education, and business, and provides opportunities for advancement. The issue of how to acquire the device is another accessibility challenge which Adeoye (2022) places at the doorstep of poverty.

It is also obvious that many science teachers, schools, and students own various types of technology that they use in their daily lives, but not all of them are deemed suitable for academic or instructional purposes. Many of these technologies are also considered assistive if teachers know how to model them as such. Having access to technology is frequently regarded as merely a first step. Even more crucial is learning how to effectively integrate it in a classroom setting for pedagogical purposes. As a result, the fundamental foundation for technology use is familiarization, modeling, and integrative techniques used by science teachers in the lesson, or unconventional personal tryouts that can prove workable or otherwise disastrous (Kalonde, 2019).

Therefore, this study partly seeks to identify the kind of available assistive technology devices and how teachers use them during science lessons.

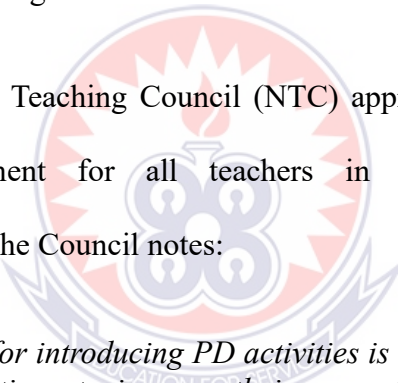
2.17 Capacity –Enhancing In-Service Training for Teachers of Deaf and Inclusive Education

There are not many teacher training institutions in Ghana to train pre-service teachers for special needs learners. Julka (2012) and Ahmed (2018) is the lack of in-service or pre-service training to address the diverse and specific learning needs of children with

disabilities, especially in inclusive classrooms. Due to this lack of training, a teacher, despite a positive attitude and good intentions often feels unprepared to educate SEN learners in his/her classroom. In addition a general observation is the lack of candidates with a science background who apply for the pre-service training in special education. Special educators are thus generally not able to suggest inclusive strategies for learning of science.

In-service education and training for special education teachers according to Golder, et al. (2005) is significant because special education needs elements are limited in initial teacher training. Continuous professional training therefore will fill the gaps from initial teacher training.

Generally, the National Teaching Council (NTC) appreciates the role of continuous professional development for all teachers in improving their skills and professionalism. Thus, the Council notes:



“The rationale for introducing PD activities is to provide guidance for teachers to continue to improve their competencies to maintain the integrity of the teaching profession and improve their professional status. It is envisaged that going through the listed accredited PD activities would help maintain and enhance the knowledge, skills, attitudes and experiences gained after the initial training. It is essential for teachers as professionals to preserve their professional integrity by updating their knowledge and skills to keep them abreast of contemporary issues and approaches in education.” (NTC, 2020 p. 13)

The National teachers' Standards reinforce the purpose of IE by mandating that teachers be enabled to consistently enhance their learning and to instill effective learning in the learners they teach (MoE, 2017). This means that teachers must continue to improve their personal and professional learning in order to construct knowledge and skill architecture for improved IE. Ensuring teachers develop

professional values and attitudes, professional knowledge, and professional practice to promote equality and inclusivity in Ghanaian early childhood and school settings is critical (MoE, 2017).

Though the continuous professional development framework (CPD) for teachers by the NTC has made in-service training as a prerequisite for teacher license renewal, there is no evidence to show that priority is given to teachers in charge of SEN students in specialized and inclusive schools. Hence teachers in such designated schools may well be engaged in CPD activities which might not help them to better handle SEN students.

In a study to investigate the availability of in-service training to teachers of the deaf in Ghana, Issaka (2018) revealed that teachers of the deaf did not have uniform access to in-service training programmes. The absence of these training activities meant teachers would not have the opportunity to equip themselves with new skills required for coping with emerging trends and demands of teaching,

Teachers who attend more in-service training programmes have better conceptual understanding, improved skills, better pedagogic knowledge and develop positive attitudes towards inclusive education (Salim, 2018; Achah-Jnr, 2020). The results of a study carried out in Indonesia by Salim (2018) concluded that there is a significant difference in the pedagogical competence of teachers based on their participation in inclusive education In-Service Training programmes that have been attended. Teachers, who attended more training frequently, had better pedagogic competence.

2.18 Empirical Studies

2.18.1 Academically and Professionally Qualified to Facilitate Science Instructions in Schools

Koirala et al., (2020) conducted a significant study to understand the influence of teacher qualifications on students' science achievements in Gorkha district. This mixed-method research, which included surveys, classroom observations, and student interviews across 15 public schools with diverse teacher training backgrounds, aimed to compare science achievement among students taught by teachers with varying levels of education and professional development training. The findings indicated that teachers with higher qualifications and targeted training were more adept at employing effective teaching methods, materials, and evaluations, leading to better student engagement and understanding, resulting in notably higher science achievement compared to their less qualified counterparts. This study underscores the vital role of teacher qualifications and ongoing professional development in enhancing educational outcomes in science.

Mat-Salleh et al., (2020) explored the perceptions of trainee teachers regarding a STEM Facilitator Training Program and its impact on their personal growth as future educators. Through a mixed-method design, incorporating surveys and group interviews with 125 trainee teachers, the study aimed to evaluate the effectiveness of the training program in enhancing trainee teachers' confidence and instructional skills in science and mathematics. Participants reported significant improvements in their ability to deliver content, manage classrooms, and engage students effectively. This research highlights the critical influence of structured training programs in preparing future teachers by equipping them with the necessary skills and confidence to excel in their teaching careers.

Shana and Abulibdeh (2020) conducted a quasi-experimental study to evaluate the impact of practical work on students' science achievement. The study involved dividing tenth and eleventh-grade students into control and experimental groups, with the latter participating in intensive practical work. Results from pre and post-tests showed a significant improvement in the achievement scores of students engaged in practical activities, suggesting that active engagement in experiments and practical tasks substantially boosts science learning.

Fitzgerald et al., (2020) examined the discrepancies between student and teacher perceptions of teaching practices in high school science classrooms. Through a survey of 86 teachers and 2512 students, the study aimed to explore how these different perspectives influence evaluations of teaching effectiveness. Findings revealed a significant gap between how teachers viewed their performance and how students perceived their classroom experiences. Teachers tended to overrate their effectiveness, which was starkly contrasted by student responses that suggested a need for improvement in teaching practices.

Pringle et al., (2020) analyzed the effects of a comprehensive professional development program on middle school science teachers' knowledge and instructional practices. This mixed-methods study included classroom observations and assessments to measure improvements in teachers' disciplinary content knowledge and their ability to implement reform-based science curricula. The program significantly enhanced teachers' understanding and application of scientific concepts in teaching, leading to more effective and engaging science instruction. The findings suggest that well-structured professional development programs are essential for

empowering teachers to adopt and implement contemporary educational reforms in science education.

Akilli and Kingir (2020) focused on the effects of high-level teacher questioning on sixth-grade students' science achievement and retention. The study utilized a quasi-experimental pretest-posttest control group design to assess whether advanced questioning techniques could enhance cognitive engagement and learning outcomes in science. The experimental group experienced a significant increase in science achievement and retention compared to the control group, which was subjected to standard questioning practices. This research emphasizes the critical role of cognitive stimulation through questioning in promoting deeper understanding and long-term retention of scientific knowledge.

Lee et al., (2021) conducted a study to explore the differential impacts of cooperative flipped learning (CFL) on student motivation and achievement in science education. By employing a mixed-methods research design that included both experimental and control groups, the researchers were able to offer a comprehensive analysis of how this innovative educational approach influences learning outcomes. The study's findings revealed that while CFL significantly boosted students' motivation towards learning, its effects on academic achievement were more nuanced, demonstrating variability based on individual learning abilities. This suggests that while flipped learning environments can enhance engagement and interest, their effectiveness in improving academic performance may depend on adaptive teaching strategies that cater to diverse student needs.

Chen et al., (2020) aimed to dissect the correlation between teachers' knowledge—both of the subject matter and of students' misconceptions—and the resulting impacts

on students' learning outcomes. Their method involved a detailed analysis of performance data from both teachers and students, providing a unique insight into the educational process. The study revealed a positive correlation between teachers' deep subject matter knowledge and their ability to predict students' misconceptions with students' overall performance. This highlights the critical role that a teacher's understanding of common misconceptions plays in effectively addressing and correcting these misunderstandings, leading to better student outcomes in science.

Hanley et al., (2020) evaluated the effectiveness of a professional development program designed to enhance primary school teachers' ability to deliver science education. Utilizing a Randomized Controlled Trial, one of the most stringent study designs, the research assessed the impact of this training on enhancing student science attainment and attitudes. The results were compelling, showing significant improvements in both areas, with the most pronounced benefits observed among female students and those with lower initial science attainment. This indicates that targeted teacher professional development can not only elevate educational outcomes but also help bridge achievement gaps in science education.

Zahra et al. (2019) explored whether consistency in who facilitates small group learning impacts dental students' performance. Through a retrospective study, they compared performance outcomes between groups with consistent facilitators and those with varying facilitators throughout the academic year. Contrary to what one might expect, the study found no significant differences in student performance based on facilitator consistency. This suggests that the quality of training and the pedagogical approaches employed by facilitators are more crucial than simply having

a consistent facilitator, thus emphasizing the need for quality in educational methods over consistency in personnel.

Hasanah (2020) focused on examining the efficacy of STEM instruction over traditional teaching methods in enhancing students' reasoning skills. The study juxtaposed a group receiving integrated STEM instruction against a traditional instruction group, with both sets of students taught by the same teacher. The findings from this comparative study highlighted a significant enhancement in reasoning abilities among students in the STEM instruction group, demonstrating the potential of interdisciplinary approaches to foster higher-order cognitive skills in students. This study lends support to the growing advocacy for STEM education as a means to improve critical thinking and problem-solving skills in students.

Preston-Smith et al., (2020) investigated high school students' perceptions of co-teaching in science classrooms, an instructional strategy where two teachers, often one general and one special education specialist, collaborate. Utilizing both surveys and qualitative analyses, the study illuminated students' mixed feelings about the distribution of tasks between co-teachers but highlighted the perceived benefits of having support from both teachers, especially in inclusively designed classrooms. The findings suggest that while co-teaching can be beneficial, it requires careful planning and role-definition to ensure that all students benefit equitably from the shared expertise of the teachers involved.

2.18.2 Instructional Practices of Science Teachers in Terms of Planning, Delivery and Assessment

2.18.2.1 Planning

Yacap (2022) conducted a comprehensive investigation into the lesson preparation practices of pre-service high school science teachers. Employing a mixed-methods approach encompassing questionnaires, documentary analysis, and semi-structured interviews, the study revealed a systematic method of lesson preparation among pre-service teachers, characterized by detailed plans. However, areas such as affective domain objectives and motivational techniques were identified as needing further development to enhance instructional effectiveness.

Rutt and Mumba (2020) concentrated on enhancing the instructional planning abilities of secondary pre-service science teachers for language- and literacy-integrated science instruction. Utilizing open-ended survey questions, interviews, and analysis of lesson plans, the study demonstrated that post-intervention, more teachers integrated language and literacy practices into their instructional materials, indicating positive progress in instructional planning skills.

Windschitl et al., (2020) delved into the learning experiences of pre-service teachers regarding planning for equitable and ambitious instruction during clinical placements. Through analysis of interview and survey responses, the study elucidated that opportunities for learning varied depending on the alignment between visions of teaching and instructional practices in host classrooms, highlighting the importance of congruence between theory and practice in teacher preparation programs.

Dlamini and Ramnarain (2023) provided insights into teachers' formative assessment practices in inquiry-based teaching, with a specific focus on lesson planning.

Employing lesson observations, interviews, and analysis of plans, the study revealed that teachers tended to emphasize epistemic dimensions over conceptual ones in their questions, shedding light on the complexities of integrating formative assessment into inquiry-based instruction.

2.18.2.2 Delivery

Areepattamannil et al., (2020) investigated the impact of teacher-directed and inquiry-based science instruction on students' science dispositions. Through multilevel path analyses of data from a vast cohort of students across multiple countries, the study demonstrated that both instructional approaches positively influenced students' enjoyment of science, suggesting the potential benefits of adopting a blended approach to science instruction.

Bumagat et al. (2023) explored the practices and challenges of science teachers teaching online during the COVID-19 pandemic. Utilizing a descriptive research approach with a questionnaire, the study uncovered various strategies employed by teachers, such as printed modules and technology integration, while highlighting challenges related to academic workload and laboratory experimentation in an online environment.

Supeno et al. (2022) focused on enhancing the instructional abilities of science teacher candidates through the lesson study approach. By observing candidates teaching a common lesson in diverse classrooms, the study demonstrated that lesson study facilitated improvements in candidates' subject matter knowledge and the quality of their lesson plans, emphasizing the efficacy of collaborative professional development approaches.

Ntuli et al., (2022) investigated how instructional strategies influenced the teaching practices of natural science teachers. Through a qualitative case study incorporating interviews and observations, the research revealed that instructional strategies significantly impacted teaching practices, with traditional methods like rote-learning still prevalent, contributing to poor student performance and underscoring the need for pedagogical reform.

2.18.2.3 Assessment

Wilsey et al., (2020) explored middle school science teachers' conceptions of assessment practice as part of a professional development intervention. Using drawn conceptual models and interviews, the study demonstrated a shift in teachers' perspectives towards iterative conceptions of assessment, where frequent assessment informed future instruction, highlighting the evolving nature of assessment practices among teachers.

Saka and Inaltekin (2023) examined the types and quality of questions asked by a science teacher in class and their impact on student learning. Through a case study involving classroom observation and video evaluation, the study revealed that many questions were partially appropriate, indicating a need for professional development to enhance questioning practices and promote deeper student engagement.

Bibon (2022) documented teachers' instructional practices and their correlation with learners' academic achievement in science. Through a survey study involving a substantial number of teachers and learners, the research identified instructional practices emphasizing differentiation for planning and assessment as closely related to academic achievement, underlining the importance of tailored instruction in promoting student success.

Tay and Saleh (2019) compared science teachers' instructional practices in Malaysian and German secondary schools. Through a qualitative study incorporating classroom observations and interviews, the research identified similarities in knowledge sources and definitions of success, with differences observed in classroom interactivity, instructional decisions, and assessment practices, highlighting the influence of cultural and contextual factors on teaching approaches.

2.18.3 Similarities and Differences in Science Teachers' Instructional Practices

Kelly et al., (2020) conducted a comprehensive study to analyze the divergent instructional practices among elementary and middle schools. Utilizing data from the Measures of Effective Teaching Study, their research focused particularly on behavioral management within schools. Through observational protocols and variance decomposition analysis, the study uncovered that a significant portion of instructional variance around 30% or more was attributed to disparities between schools. Notably, demographic characteristics, such as the racial composition of schools, played a substantial role in explaining these differences. The findings suggested that teacher sorting, where educators are distributed across schools based on certain characteristics, significantly contributed to these variations. This research underscores the critical influence of both internal school environments and external social settings on educational inequality. It emphasizes the necessity for teacher accountability frameworks and instructional improvement efforts to critically consider these factors to promote equitable education.

In their 2019 study, Anyetei et al., examined the practical challenges associated with implementing inclusive education in a basic school in Winneba, Ghana. Using questionnaires, informal interviews, and observations, the researchers focused on how

teachers and interpreters prepared for and conducted science classes in an inclusive setting. Despite intentions to accommodate students with special needs, the study revealed a critical gap in the expertise required to effectively manage these classes. Approximately half of the respondents lacked the necessary skills to organize inclusive science classes proficiently. The study recommended enhancements such as the utilization of multimedia technologies and further professional development for teachers. This research underscores the significant disparity between the theory and practice of inclusive education, highlighting the urgent need for structured teacher training and resources to bridge this gap and enhance educational outcomes for all students.

Lindner and Porres (2019) provided insights into the perceptions and implementation of inclusive practices, such as differentiation and personalization, in inclusive classrooms in Germany. Their study surveyed both students and teachers from 47 inclusive classes to assess the frequency and effectiveness of these practices. Despite legislative advancements, the research identified a discrepancy between teachers' self-perceptions of their inclusive teaching practices and students' experiences. While teachers believed they were effectively applying inclusive practices, students did not observe them being implemented to the expected extent. This discrepancy underscores the need for ongoing professional development and a reassessment of how inclusive practices are communicated and evaluated in educational settings. The findings highlight the complexities of implementing inclusive education and emphasize the importance of aligning teacher perceptions with student experiences to enhance educational effectiveness.

Atika et al. (2023) focused on instructional practices in special schools for deaf and hard-of-hearing (DHH) students in Indonesia. Through interviews, field observations, and artifact analysis involving principals and teachers from five DHH schools, the researchers examined the strategies used by teachers in these specialized settings to improve science education. Despite tailored strategies, the study highlighted significant challenges, such as the need for more professional development and better support for teachers in collaboration and instructional strategy development. The research underscored the importance of governmental support and targeted training programs to equip teachers with the skills needed to effectively teach DHH students and integrate inclusive education principles across the educational spectrum.

Tay and Saleh (2019) conducted a comparative analysis of science teachers' instructional practices in Malaysian and German secondary schools. Through classroom observations and semi-structured interviews, the study explored core aspects of instructional practices and identified similarities and differences between the two educational contexts. While both settings emphasized student success and learning modes, significant disparities were noted in classroom interactivity, instructional decisions, and assessment methods. This research provides valuable insights into how different cultural and educational frameworks influence teaching practices, emphasizing the importance of understanding these differences to develop effective educational strategies and promote cross-cultural teacher exchange programs.

Raven and Whitman (2019) conducted a pivotal study on the instructional strategies employed for deaf and hard-of-hearing (DHH) students in a U.S. urban school. Their research provided an in-depth analysis of the challenges and inconsistencies within

this specialized educational setting. The study revealed a broad spectrum of teaching strategies, ranging from visual aids to hands-on activities, which were unevenly applied across different classrooms. This inconsistency pointed to a larger systemic issue within the educational training of teachers for DHH students. Raven and Whitman highlighted the crucial need for a more standardized approach to teacher training that specifically addresses the unique needs of DHH students. They advocated for comprehensive training programs to equip teachers with a consistent set of skills and methodologies to effectively engage and educate DHH students. This study underscores the significant impact that tailored and consistent instructional strategies can have on the educational outcomes of students with hearing impairments, advocating for strategic educational reforms that ensure all teachers are well-prepared to handle the diverse needs of their students.

Adu-Boateng and Goodnough (2021) explored the practical application of Universal Design for Learning (UDL) in an inclusive science classroom, highlighting the complexities and challenges that arise when theoretical educational frameworks are implemented. Their study focused on a single high school science teacher with a special education background, providing a detailed case study of the integration of UDL principles in a setting that included students with diverse learning needs. Despite the teacher's efforts to employ multiple means of engagement, representation, and expression core components of UDL the study identified significant obstacles such as limited resources and a rigid curriculum that hindered effective implementation. These tensions illustrate the gap between educational policy and classroom reality, where teachers often struggle with insufficient support and inflexible structures that impede truly inclusive education. Adu-Boateng and Goodnough's work calls for systemic changes to provide teachers with the necessary tools and flexibility to

implement UDL effectively, emphasizing the need for educational systems to adapt to the methodologies they promote.

Lindner and Powers (2021) conducted a comprehensive study on the implementation of differentiation and grouping practices across various types of German schools, including regular, inclusive, and special education settings. Utilizing data from the German National Educational Panel Study (NEPS), the research focused on teachers' practices in secondary school German classes. The findings indicated that differentiation practices were most extensively used in special school classes, catering specifically to students with special educational needs. Various factors, such as class size and the presence of students with a migration background, were identified as significant predictors of the extent to which teachers employed these practices. This study sheds light on the complexities of inclusive education in a stratified school system, highlighting the necessity of tailored teaching strategies that address the diverse needs of all students. It also emphasizes the need for ongoing professional development and support for teachers to ensure that differentiation strategies are effectively and consistently applied across all educational settings.

D'Intino and Wang (2021) reviewed the state of teacher education in Canada, focusing specifically on inclusive education practices for pre-service elementary school teachers. Their study critically evaluated the curricular offerings across Canadian university programs that prepare future teachers, identifying a general introduction to inclusive and differentiated teaching practices within these programs. Despite this foundational training, D'Intino and Wang highlighted a significant gap in the preparation of teachers to meet the needs of diverse classrooms, emphasizing the need for additional professional development once teachers enter the workforce. Their

findings point to a disconnect between the theoretical knowledge provided during teacher training and the practical skills needed in actual classroom settings, suggesting that ongoing support and training are crucial for the development of effective inclusive teaching practices. This research provides valuable insights into the challenges of preparing teachers for the realities of modern, diverse classrooms and underscores the importance of lifelong learning and professional development in the education profession.

Spektor-levy and Yifrach (2019) delved into the challenges faced by science teachers in inclusive classrooms, particularly in the context of teaching students with learning disabilities. Their study, grounded in the theory of planned behavior, surveyed and interviewed 215 junior high school science teachers to assess their attitudes, perceived norms, and perceived control over inclusive teaching practices. Despite generally positive attitudes and a willingness to adapt teaching methods, the teachers reported significant barriers to effective implementation, including a lack of support and resources. This gap between teachers' intentions and their ability to execute inclusive practices highlights the critical need for comprehensive support systems, including professional training and suitable instructional materials. Spektor-Levy and Yifrach's work underscores the complex interplay between teacher attitudes, school policies, and the practical challenges of inclusive education, suggesting that addressing these factors holistically is key to improving educational outcomes for students with learning disabilities.

2.18.4 Extent to which Science Instructional Approaches Differentiated

Bacosa and Caballes (2022) conducted a comprehensive study that analyzed the pedagogical approaches of science teachers in a public high school during the

COVID-19 pandemic, utilizing a descriptive-correlation quantitative research design. They specifically looked into how the teachers' highest educational attainments correlated with their general practices in curriculum design and instructional methods. The results revealed a strong correlation, suggesting that the level of education attained by teachers significantly influenced their ability to adapt and effectively manage instructional strategies and classroom environments during the pandemic. This relationship is particularly vital, as it points to the need for a well-educated teaching workforce capable of adapting to emergency situations, ensuring the continuity and quality of education. The study is crucial as it underscores the role of teacher qualifications in delivering effective education under challenging circumstances, advocating for continued professional development and educational advancement for teachers

Atika et al. (2023) explored the specific educational approaches for teaching science to deaf and hard-of-hearing (DHH) students in Indonesia. Their research highlighted the effective use of visual aids and hands-on activities, which are essential in engaging DHH students who might not benefit from traditional auditory learning methods. The study stressed the importance of these strategies in facilitating deeper understanding and retention of scientific concepts among DHH students. Additionally, the researchers called attention to a significant gap in professional development for teachers working with DHH students, emphasizing that enhancing teachers' skills through targeted training in specialized instructional strategies could lead to substantial improvements in educational outcomes for this group. This work provides important insights into the customized educational needs of DHH students and underscores the critical role of teacher training in specialized educational practices to ensure that these students are not disadvantaged

Anyetei et al., (2019) conducted a case study to examine inclusive education practices in a basic school in Ghana, focusing on the preparedness of teachers and interpreters to meet the needs of students with special educational requirements. Their findings indicated a notable deficiency in the expertise necessary to organize and conduct inclusive science classes effectively. This lack of expertise highlights a critical area for improvement in professional development and resource allocation to enable teachers to manage diverse classrooms more effectively. The study further illuminates the broader challenges faced by inclusive education systems, especially in settings constrained by resources, emphasizing the essential role of targeted professional development and adequate resources to build teacher competencies for inclusive education

Lindner et al., (2019) utilized the Inclusive Classroom Practices Scale to evaluate the application of differentiation and personalization in inclusive classrooms across Germany. Their research identified a uniform understanding and implementation of inclusive teaching strategies among both educators and students. This uniformity is crucial as it facilitates a cohesive educational environment where students with varying needs can thrive. The findings suggest that consistent training and a clear grasp of inclusive strategies among teachers and students are pivotal for the successful integration of diverse learners. This study underscores the significance of consistent and well-understood educational practices in promoting successful inclusive education, which benefits all students by creating a supportive and adaptive learning environment

Adu-Boateng and Goodnough (2021) carried out a qualitative case study in Canada to investigate the instructional practices of a science teacher who embraced inclusive

pedagogy within the framework of Universal Design for Learning. Their study revealed several tensions that affect the implementation of inclusive science pedagogy, such as the balance between meeting individual needs and maintaining general classroom order. These findings emphasize the challenges educators face in applying inclusive education practices and highlight the need for frameworks that support practical and adaptable teaching methods. Such frameworks can help accommodate the diverse learning needs of students, ensuring that all students receive quality education tailored to their individual needs

Raven and Whitman (2019) delved into the educational methodologies tailored for deaf and hard-of-hearing students, uncovering a range of inconsistent instructional strategies, including the use of visuals and physical models. This inconsistency, while seemingly a drawback, actually reflects the adaptive and versatile approaches required to cater to the diverse sensory engagement methods needed by deaf students. Their study advocates for a fundamental reconsideration of the educational framework for science teaching to effectively include deaf learners, emphasizing the unique cultural and educational requirements of these students and suggesting that a more flexible and inclusive approach to education is necessary to truly meet their needs

Le Hanie et al., (2023) investigated the specific impacts of the COVID-19 pandemic on mathematics education for oral hearing impaired students, reflecting on the compounded challenges these students faced during the transition to remote learning. The study highlights the technological, pedagogical, and social barriers that were exacerbated by the rapid shift to online formats, emphasizing the critical gaps in existing educational practices that failed to accommodate the unique needs of hearing-impaired students effectively. The findings point to an urgent need for inclusive

digital education strategies that are robust enough to consider all students' needs, ensuring that transitions to remote learning do not disproportionately disadvantage any student group (Le Hanie et al., 2023).

Alsalem and Alzahrani (2023) offered a critical analysis of the institutional practices in Saudi Arabian schools concerning the inclusion of deaf and hard of hearing students. They argued for the need to enhance support services and clarify regulations governing inclusive education, highlighting the systemic barriers that hinder effective inclusion. Their study underscores the need for policy and practice changes that can facilitate a more integrated approach to educating hearing-impaired students in mainstream educational settings, advocating for a more supportive and well-regulated framework to ensure equitable educational opportunities for all students

Torigoe (2019) described a unique co-enrollment project in a Japanese primary school that included both deaf and hearing students. This project involved teaching sign language to all students and making necessary environmental modifications to support inclusive learning. Torigoe's study showcases how these intentional modifications can significantly enhance educational access and equity, addressing communication barriers while fostering an inclusive culture that benefits all students. The project not only met the immediate communication needs of deaf students but also prepared all students to operate effectively in a more diverse world, highlighting the long-term benefits of such inclusive educational practices.

2.18.5 Types of Assistive Technologies (AT)

Taylor et al., (2020) explore the use of assistive technology (AT) in elementary science lessons, highlighting its importance under the Individuals with Disabilities Education Act (IDEA). They discuss how AT can enhance curriculum access for

students with disabilities through a vignette of an inclusive classroom, aiming to show how teachers can embed various AT tools to improve educational outcomes. The study emphasizes the critical need for ongoing teacher education in AT to better support students with disabilities, suggesting that future technologies could significantly enhance curriculum access. This perspective is essential for educators seeking to integrate more effective tools in their teaching practices, potentially transforming the educational landscape for students requiring additional support.

Sugiman et al., (2022) examine the development and use of sign language video lectures as assistive technology in inclusive higher education settings. Motivated by the enrollment of a deaf student, their study uses a mixed-method approach to create and test PowerPoint lecture videos that incorporate sign language. The findings from their research indicate that these videos significantly enhance engagement and comprehension among deaf students, thus underlining the effectiveness of video lectures in facilitating learning for deaf students. The study advocates for the broader adoption of such technologies to improve accessibility in education, which could have profound implications for inclusive teaching practices across various disciplines.

Caldwell (2019) introduces various types of assistive and instructional technologies for students with disabilities, categorized under the thirteen disabilities defined by IDEA. The paper aims to inform parents and educators about the technology tools available to aid students' access to education, emphasizing the critical role of technology in facilitating educational access. Caldwell discusses each disability briefly and aligns them with specific technologies that can best support affected students. This comprehensive overview is aimed at helping overcome educational

barriers, highlighting the necessity for educators to be well-versed in these technologies to better support their students.

Zilz and Pang (2019) review the integration of assistive technology in inclusive K-12 classrooms, identifying trends and outcomes from a decade's worth of literature. Their study confirms the benefits of AT for students with disabilities and highlights the need for better teacher preparation for effective technology integration in education. They point out the significant gap in teacher preparation, which often hinders the effective use of AT in classrooms. The study suggests that while AT is beneficial, educational institutions must also focus on training teachers to utilize these technologies effectively to maximize their impact, thereby enhancing the learning experience for all students.

Evmenova (2020) delves into the practical implementation of assistive and mainstream technology in inclusive classrooms, discussing necessary factors for successful integration. The study emphasizes the need for coordination and collaboration among service providers and the importance of situated training and fidelity in technology integration. Evmenova outlines various models and resources that provide guidance for both general and special education teachers on effectively using assistive technology to support students with disabilities. The findings advocate overcoming barriers and enhancing teacher efficacy to ensure equitable learning opportunities, which is pivotal for the inclusive educational practice.

Chambers (2020) explores existing and emerging trends in assistive technology within the framework of inclusive education, describing how AT aids in the inclusion of students with disabilities in mainstream educational settings and enhances both social interaction and curriculum access. The research highlights the dual function of AT in

promoting both social interaction and curriculum access, which can significantly enhance inclusivity in educational settings. Chambers' insights aim to inform educators and policymakers on the potential of AT to transform learning experiences and outcomes for students with disabilities, proposing a future where technology is seamlessly integrated into educational practices to support diverse learning needs.

Stinson and Nikolarazi (2020) focus on technologies that assist individuals who are deaf or hard of hearing in various environments, including educational settings. They discuss how specific technologies, like captioning and enhanced auditory devices, enable fuller participation in educational and social activities. The study underscores the importance of technology in bridging communication gaps and enhancing the educational and social integration of deaf or hard of hearing individuals. Stinson and Nikolarazi advocate for continued innovation and implementation of tailored technological solutions to support the deaf and hard of hearing community, emphasizing the transformative potential of these technologies.

Park et al., (2021) evaluate the effectiveness of integrating assistive technology training in teacher preparation programs. Their research highlights the positive impact of AT training on preservice teachers' attitudes and confidence in using AT to support students with disabilities. The findings suggest that comprehensive training in AT can significantly improve the quality of education that students with disabilities receive, proposing an essential shift towards more inclusive educational practices. This approach not only prepares teachers better but also ensures that educational systems become more accommodating and responsive to the needs of all students.

Pinheiro et al., (2022) investigate the challenges faced by teachers in adapting to hybrid teaching modes for deaf students during the COVID-19 pandemic. Conducted

in Brazil, the study uses qualitative analysis to assess the effectiveness of training programs for teachers in hybrid and online teaching modalities. The findings highlight significant gaps in teacher training for dealing with the unique needs of deaf students, particularly in remote learning scenarios. The paper calls for innovative educational practices and further research to better prepare teachers for the evolving educational landscape, emphasizing the need for targeted training and resources to ensure effective teaching in hybrid settings.

Albalhareth and Saleem (2023) assess teacher satisfaction with the availability and use of assistive technologies for students with sensory impairments in inclusive schools in the Najran region of Saudi Arabia. Their findings indicate a need for improved provision and implementation of AT, as well as teacher training on using these technologies effectively. The study underscores the critical role of AT in enhancing educational access and success for students with sensory impairments, calling for strategic efforts to bolster technology integration and teacher proficiency in using these tools to foster an inclusive learning environment.

2.18.6 Types of Differentiated Capacity-Enhancing Activities

Abonyi et al., (2020) conducted a detailed investigation into the factors that influence the application of teacher professional development in Ghana's basic schools. By using a qualitative research design, they interviewed 15 teachers from a single educational district. Their findings highlight that support from headteachers and peers, facilitated by shared norms and values, along with student interest and the availability of teaching materials, significantly contributed to the effectiveness of professional development. However, they also identified several challenges, including rigid timetables, high teacher workloads, and a general lack of resources, which hindered

the successful implementation of professional development programs. The study advocates for INSET programs that comprehensively address both supportive and limiting factors within the educational environment, calling for enhanced infrastructures to enable headteachers to provide the necessary support and resources (Abonyi et al., 2020).

Pasman (2023) conducted school action research aimed at evaluating the impact of school-based INSET on improving teachers' skills in lesson preparation and planning at SDN 41/X Sungai Jambat. The research utilized a cyclical process consisting of planning, implementing, observing, and reflecting, which was repeated across two cycles and involved five teacher subjects. The findings showed significant enhancements in teachers' abilities to prepare and plan lessons, thus proving the effectiveness of localized, hands-on training approaches. This study emphasizes the importance of tailored INSET programs that cater directly to the specific needs of teachers within their teaching environments (Pasman, 2023).

Azewara et al., (2021) critically examined the distribution of teachers in Ghana's primary and junior high schools, with a particular focus on rural areas in the Sekyere Central District. Utilizing data from the District Education Office, the study identified significant disparities in teacher deployment, which adversely impacted the quality of education in rural areas. The researchers recommend the adoption of differentiated INSET approaches at the district level to address these disparities and improve teacher distribution. Such targeted professional development could help tackle the specific challenges and needs of teachers in under-resourced rural schools.

Bukari et al., (2023) assessed the effectiveness of Ghana's TVET curriculum in meeting the basic skills needs of students for job creation. Through collecting

quantitative data from 126 technical teachers across various districts, the study revealed that the existing TVET curriculum does not adequately prepare students for the demands of the job market. The research suggests the necessity of regional INSET workshops focused on curriculum development to better align TVET education with industry needs and enhance job readiness among students. This study points towards the need for curriculum reforms that are informed by the actual skill requirements of the job market

2.19 Summary of Literature Review

Literature reviewed show that that while teachers have different approaches to science instruction, these approaches may generally be classified into traditional instructional practices and alternative instructional practices (Dancy and Henderson, 2017). The NaCCA (2019) recommends that science teaching should adopt the constructivist and inquiry approaches to the subject, which fall under the alternative practices. While traditional instructional practices are not entirely detrimental to student learning, literature suggests that alternative methods impact more positively on student learning. However, since the introduction of the Standards-based curriculum, no research has been carried out to find out science teacher's instructional practices, which is a gap to be filled by this research.

Literature further revealed that teachers' adoption of certain instructional practices are influenced by teacher characteristics such as teacher qualification, teaching experience and teacher knowledge (Darling-Harmond, 2000). The National Teaching Council, mandated by the Education Regulatory Bodies Act, 2008 (Act 778), license all teachers before they are employed by the Ghana Education Service. It is however,

not known from literature if teachers teaching science have the qualification to teach science, making the current research relevant.

The DHH students in both deaf and inclusive schools require special teachers who can customize instructions to meet their needs (Buli-Holmberg et al. 2014). Such teachers need knowledge and skills such as inclusive teach practices and sign language. Some of these skills are absent in the teachers who rely on interpreters. What is missing in available literature is however, whether or not the interpreters have science content knowledge to ensure accurate interpretation.

Again, pre-service teachers have limited training in special education during initial teacher training and will need in-service training programmes to help them improve their delivery. What is however, not known in literature is if teachers in deaf and inclusive schools in Ghana have access to the appropriate professional development activities to enhance their instructional practices.

Related literature was extensively reviewed on thematic areas under the research problem to guide the current research. There are, however, gaps in the reviewed literature which this research seeks to cover.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter examined the methodologies that were used for the study. This chapter included philosophical assumption, research approach, research design, Research site, population, sample size, sampling technique and instrumentation. The procedure for data collection, method of data analysis, method for verification/ trustworthiness, data analysis procedures, limitations and ethical considerations were also looked at.

3.1 Philosophical Assumption

Interpretivism served as the philosophical foundation for this investigation into assessing the instructional practices of science teaching in selected regular, inclusive, and deaf basic schools in Ghana. This approach emphasized understanding the meanings, purposes, and intentions that educators and students attributed to their teaching and learning interactions (Brinkmann & Kvale, 2015; Denzin & Lincoln, 2017; Smith & Levit, 2021). Consequently, the researcher examined these instructional practices in their natural school environments, striving to interpret or understand them based on the meanings ascribed by the participants. This methodology enabled the researcher to delve into the nuances of science teaching methods within diverse educational settings, fostering a deeper comprehension of the instructional phenomenon in Ghanaian schools.

3.2 Research Approach

The study employed a qualitative research methodology to investigate the instructional practices of science teaching in selected regular, inclusive, and deaf basic schools in Ghana. Qualitative research places emphasis on the analysis and

interpretation of verbal expressions, descriptive narratives, conceptual frameworks, and abstract notions. This approach allowed the researcher to concentrate on maximizing the amount of data obtained from a comparatively limited sample size, aiding in acquiring a comprehensive understanding of the instructional practices within these diverse educational settings. According to Creswell and Poth (2018), qualitative studies are valuable for examining the quality of activities and situations and serve as a primary means for researchers to obtain information.

The utilization of a qualitative approach was deemed suitable for this study due to its focus on investigating a phenomenon that prompted participants to display distinct characteristics in relation to their instructional practices in science education. As Brinkmann and Kvale (2015) noted, the researcher's values and their relationship with the respondents could influence the interpretation of the data. The researcher effectively employed their personal knowledge, experience, and comprehension to derive meaning from the subject matter.

Qualitative data are characterized by their complexity, impressionistic nature, personal subjectivity, softness, and richness, making it unsuitable for numerical representation. While the findings may lack generalizability, they are still applicable to analogous contexts and are of interest to individuals in seemingly disparate environments. This study aimed to employ a qualitative approach to gain a more comprehensive understanding and interpretation of the instructional practices of science teaching in regular, inclusive, and deaf basic schools in Ghana.

3.3 Research Design

According to Saunders Sierpe et al., (2023), research design is the systematic arrangement of conditions for the collection and analysis of data in a manner that

ensures the relevance of the research purpose while maintaining economy in procedure. Creswell and Poth (2018) elaborate that research design encompasses the specific procedures involved in the research process, including data collection, data analysis, and report writing. This structure helps to enhance the researcher's understanding of a particular topic or issue. Essentially, research design addresses the when, why, and how of the research.

For this study, the researcher adopted a phenomenological research design. Phenomenological research design, a qualitative approach, seeks to understand and describe the universal essence of a phenomenon by focusing on the lived experiences of individuals. This method is particularly effective for exploring complex human behaviors and social phenomena in-depth.

Within the framework of phenomenological design, the researcher chose the interpretive phenomenological approach. Interpretive phenomenological design (IPA) is a qualitative methodology that aims to provide detailed examinations of personal lived experiences, presenting them in their own terms (Smith & Levit, 2021). This approach investigates everyday experiences while deliberately suspending the researcher's preconceived notions about the phenomenon, allowing for a more authentic and nuanced understanding. In other words, IPA studies lived experiences to gain deeper insights into how individuals comprehend those experiences.

The interpretive phenomenological approach was particularly suitable for this study as it assisted the researcher in gaining a richly detailed understanding of the instructional practices of science teaching in selected regular, inclusive, and deaf basic schools in Ghana. This methodology enabled the researcher to explore the unique and shared experiences of teachers and students in these diverse educational settings. By

bracketing any a priori assumptions, the researcher could engage more deeply with participants' perspectives, uncovering the subtle and often complex dynamics at play in science education within these schools.

This design was considered appropriate because it provided a comprehensive framework for investigating the instructional strategies employed by teachers and how these strategies impacted student learning and engagement in different types of schools. The phenomenological approach also facilitated a deeper exploration of the contextual factors influencing science teaching practices, including cultural, social, and institutional variables. By employing IPA, the researcher was able to capture the richness and diversity of experiences, offering valuable insights into the effectiveness and challenges of science education in regular, inclusive, and deaf basic schools in Ghana.

3.4 Research Site

The study was conducted in selected regular, inclusive, and Deaf basic schools in Ghana. These institutions were carefully chosen to represent the diversity of educational environments in the country. The research required extensive travel to different regions to ensure a comprehensive understanding of the instructional practices across varied contexts.

The institutions selected for this study included the School for the Deaf at Bechem, the University Practice Basic School in Winneba, St. Joseph's Basic School and Roman Catholic Basic School, Bechem, in the Tano South Municipality. The Bechem School for the Deaf was purposefully selected due to its specialization in educating Deaf students. This setting provided critical insights into instructional practices tailored to meet the needs of Deaf learners. According to MOE (2015), inclusive

education policies in Ghana emphasize the integration of special needs students into mainstream educational settings, making such institutions pivotal for this study.

The University Practice Basic School in Winneba was chosen for its unique status as the only public basic school (at the time of the research) implementing inclusive education for deaf and hard-of-hearing students. This school provided a rare, information-rich case of inclusive education in practice— essentially a one-of-a-kind example in Ghana’s basic education system.

As highlighted by IIEP-UNESCO (2023), inclusive schools in Ghana strive to provide equal learning opportunities for all students, making them essential for studies on instructional practices. The St. Joseph and Roman Catholic Basic Schools in the Tano South District were conveniently chosen due to their proximity to the Bechem School for the Deaf. These regular schools served as a comparative site to analyze instructional practices in a typical educational environment. By including a regular school, the study aimed to capture a holistic view of science teaching practices across different types of schools.

The study focused on teachers from Basic School (BS) levels 4, 5, and 6, as well as Science teachers at the Junior High School (JHS) level. In addition, interpreters at the Deaf and inclusive schools were included to provide comprehensive insights into the instructional practices. This approach ensured that the selected schools and participants were representative of the diverse educational contexts in Ghana, as described by Asonye and Edwad (2022).

The strategic selection of these schools and participants enabled the researcher to gather rich, contextual data. Access was a key consideration in the selection of schools; the schools were chosen in part because the researcher could obtain

permission and cooperation to conduct in-depth observations and interviews there (which is crucial in qualitative research). The selections were also influenced by feasibility; for instance, two of the schools (Bechem School for the Deaf and St. Joseph R/C in Bechem) are in the same town and close to each other, which made fieldwork logistics more manageable.

3.5 Population

Kumekpor (2002) explained population as the total number of all units of the phenomenon to be investigated that existed in the area of investigation. Thus, population is related to all possible observations of the same kind.

The target population of the study consists of regular public primary schools and special schools in the Ahafo Region and inclusive public basic schools in the Central Region of Ghana. Thus, the pupils and teachers in these schools formed the study population.

3.6 Sample Size and Sampling Technique

The selection of the sample size for assessing the instructional practices of science teaching in selected regular, inclusive, and Deaf basic schools in Ghana was influenced by several factors. Key considerations included the anticipated level of representativeness and the methodologies employed for data collection and analysis (Creswell & Creswell, 2018). This study employed a saturation approach in data collection to determine the appropriate sample size. Data saturation involves adding participants until the data set is complete, indicated by replication or redundancy (Saunders et al., 2023). Saturation is achieved when additional data no longer provides new insights, indicating that the collected data sufficiently address the research questions. Saunders et al. (2018) emphasize that while there is no one-size-

fits-all number, they recommend using a sample size of 10-20 interviews as a general rule of thumb for most qualitative studies, particularly when exploring new or complex phenomena.

For this study, the sample size consisted of 30 individuals, who were selected from science teachers and interpreters in the targeted schools. Sixteen teachers were selected from St. Joseph and R/C Basic Schools in Bechem, nine science teachers and interpreters were selected from the School for Deaf in Bechem, and five science teachers and interpreters were selected from the University Practice Inclusive School at South Campus, Winneba. This breakdown was context-driven. It reflects, in part, the relative sizes and teacher availability in each type of school.

In a multi-site or cross-cultural qualitative research, researchers have recommended on the order of 20 to 40 interviews to ensure that themes cutting across sites are fully captured (Vasileiou, et al., 2018). A total sample of 30 teachers falls within this range, lending confidence that the study has enough participants to uncover both site-specific insights and overarching patterns.

Determining the saturation point can be complex and varies significantly from one study to another. Vasileiou et al., (2018) noted that disciplinary and publishing norms often influence how researchers justify the adequacy of their sample sizes, impacting the design and acceptance of qualitative research. Moreover, the concept of data saturation and its impact on sample size determination is an ongoing topic of debate and analysis within the qualitative research community. Mwita (2022) argued that factors beyond the absence of new data should influence the determination of data saturation, such as the quality and richness of the data collected, the scope of the study, and the complexity of the phenomenon being investigated. This broader view

acknowledges the multifaceted nature of qualitative research and the varied contexts in which it is applied. Supporting this perspective, Bekele and Ago (2022) emphasized the criticality of sample size determination in interview studies, offering practical guidance to novice researchers on balancing the depth and breadth of data collection with available resources.

Turner-Bowker et al. (2018) introduced an innovative approach by utilizing data simulations to predict the minimum sample size needed for qualitative research. This method considers various sampling scenarios and purposive sampling methods, providing a more empirical approach to understanding and planning sample size.

Based on these explanations, the researcher conducted interviews and observations with participants until reaching a data saturation point at a sample size of 30. Out of the 30 participants 18 participants were involved in face-to-face interviews, when the researcher considered that data saturation point had been reached. Twenty-seven participants were engaged in sit-in lesson observations.

The study employed purposive and convenience sampling approaches to select participants. Purposive sampling was used to carefully choose teachers and interpreters from the school for the deaf and inclusive school who could provide comprehensive insights into teachers' instructional practices because these individuals are most likely to produce the useful results for the study (Awanta & Asiedu-Addo, 2008). Convenience sampling was employed to enlist participants who were readily accessible, from two basic schools close to school for the deaf at Bechem. This structured approach allowed for a diverse range of perspectives and in-depth discussion, facilitating a rich understanding of the instructional practices in science teaching.

Descriptions of participants for the study are presented in table 2. For the purposes of anonymity and confidentiality, pseudonyms have been used to protect the identities of the participants.

Table 2: Description of Participants

Pseudonym	School
PP1	Deaf
PP2	Deaf
PP3	Deaf
PP4	Deaf
PP5	Deaf
PP6	Deaf
PP7	Deaf
PP8	Deaf
PP9	Deaf
PP10	Regular
PP11	Regular
PP12	Regular
PP13	Regular
PP14	Regular
PP15	Regular
PP16	Regular
PP17	Regular
PP18	Regular
PP19	Regular
PP20	Regular
PP21	Regular
PP22	Regular
PP23	Regular
PP24	Regular
PP25	Regular
PP26	Inclusive
PP27	Inclusive
PP28	Inclusive
PP29	Inclusive
PP30	Inclusive

3.7 Instrumentation

A research tool or instrument is a specific mechanism or strategies that a researcher employs to collect, manipulate, or interpret data (Creswell & Creswell, 2021). In this study, Semi-structured interviews and observations were utilized to gather information from participants.

3.7.1 Semi-structured Interviews

An interview is a primary data generation technique in which the interviewee verbally gives the necessary details in a face-to-face or non-face-to-face situation. In design or structure, interviews differ. An interviewer can interview one person at a time (individual interview) or a group of individuals simultaneously (focus group interview) in some circumstances. While the latter appears cost-effective in certain situations, in groups with the involvement of others, interviewees may refuse to disclose those information or experiences (Kabir, 2016).

To manage the interviews properly, interview guide questions were prepared separately for each category of the interviewees. The Teacher Instructional practices and processes system–TIPPS, was adapted for the interview (Seidman et al., 2014). The interviews with the teachers focused on how they presented lessons, how they assessed learners how they communicated with deaf learners, and how they assessed deaf learners in the case of inclusive and deaf schools). The interviews with interpreters focused on their subject matter knowledge and their competencies in sign language.

3.7.2 Observation

The primary purpose of conducting observation is to identify the existing instructional practices of teachers, opportunities, and challenges of learners in the three settings, viz. regular, deaf, and inclusive schools. Direct or participant type of observation and classroom observation was conducted. In the inclusive and deaf schools, the observation checklist focused on teachers and principals. The classroom observation was focused the teachers' use of appropriate resources, assessment methods, and instructional strategies.

Observation is a structured mechanism used to detect, document, and classify the occurrence of some hidden or apparent activity in a real-world situation according to an expected scheme (Creswell, 2014). Observation can take either a participatory or a non-participatory approach. In the participant process, the researcher becomes a member of the classes to be examined. In observing with varying degrees of participation (as a visiting stranger, as an attentive listener, as an avid listener or in a broader role as a participating observer), the researcher can play one of several roles. The person takes on the role of an observer in a disinterested observation, but in a way that ensures their presence does not disturb the group (Creswell, 2014).

In this study, the researcher used direct observation with the intention to see the participation of deaf learners in the classrooms, the instructional approaches used in the schools, and teachers and how effective communication was facilitated for learners with hearing impairment inside the classrooms in the deaf and inclusive schools.

Observation can also be classified as unstructured and structured. Unstructured observation basically relates to the observation of participants and is also an exploratory technique. With unstructured observation, it may not be possible to explain and categorize the behaviours to be observed in detail in advance. In this research, the researcher used the structured observation type since the observation is formal in nature and provides a systematic explanation of the observed data. Furthermore, the observation was conducted in controlled situations in classrooms during science lessons and the time within which the observation was carried out was limited (Creswell, 2014).

The observation protocol was adapted from BARBADOS Science teaching observation instrument.

3.8 Validity and Reliability/Trustworthiness

Validity is the degree to which an instrument measures what it is supposed to measure. The researcher tested both the face and content validity of the interview questions. Face validity refers to the likelihood that a question may be misunderstood or misinterpreted. Content validity refers to whether an instrument provides adequate coverage of a topic. Expert opinions, literature searches, and pre-testing of the question helped to establish its face and content validity. Through this, the validity of the instrument was ascertained. Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials. Reliability is the extent to which the measuring instruments produce consistent results when the same groups of individuals are repeatedly measured under the same conditions.

In establishing trustworthiness, Lincoln and Guba (1986) as cited in Enworo (2023) created stringent criteria in qualitative research, known as credibility, dependability, confirmability and transferability. To ensure dependability of the results, the researcher developed a detailed track record of the data collection process and measure coding accuracy and reliability of data collected.

3.9 Trustworthiness of the Data

The credibility, transferability, dependability, and confirmability of the research findings were evaluated to determine their quality and trustworthiness.

3.9.1 Credibility

Credibility refers to the level of confidence in the truthfulness of research findings. It is essential for assessing the accuracy of study conclusions and ensuring that the data collected from participants genuinely reflect their perspectives (Anney, 2014). To ensure the rigor of the qualitative investigation, the researcher employed various strategies to enhance credibility.

These strategies included engaging in extensive and diverse field experiences, using time sampling techniques, maintaining self-awareness through a field journal, applying triangulation methods, conducting member checks, subjecting the research to peer review, employing effective interview techniques, establishing the researcher's credibility, and ensuring a structured approach (Creswell & Poth, 2021). Triangulation, specifically data triangulation, was a key technique used in this study to strengthen the credibility of the findings.

Triangulation involves using multiple methods, investigators, sources, and theoretical perspectives to gather corroborating evidence (Donkoh & Mensah, 2023). It helps reduce bias and verify the reliability of participants' responses. There are three primary types of triangulation: investigator triangulation, data triangulation, and methodological triangulation.

Investigator triangulation involves multiple researchers examining the same phenomenon, allowing for the integration of different viewpoints, which enhances the robustness and reliability of the results (Grant et al., 2023). Data triangulation, which was used in this study, leverages various data sources or research tools, such as interviews and observations, to improve data quality and reliability (Carter et al., 2022). Methodological triangulation involves using multiple research methods to

study a single phenomenon. By employing data triangulation through interviews and observations, the researcher aimed to augment the credibility of the study and achieve a comprehensive understanding of the phenomena (Patton, 2023).

2.9.2 Transferability

Transferability, in the realm of qualitative research, refers to the degree to which the conclusions and results of a study can be extrapolated and applied to various environments and groups. The concept might be seen as the interpretive equivalent of generalizability. The researcher assisted the future user in making transferability judgments by employing 'thick description' and intentional sampling procedures. Travers (2008) argues that providing a thorough description of the research issue and carefully selecting participants improves the transferability of the study. By incorporating detailed and comprehensive descriptions in a study report, one can evaluate how well the research setting can be applied to different situations. It is crucial to include a thorough and extensive compilation of information, referred to as thick descriptive data, regarding the technique and context. Anney (2014) argues that the notion of thick description entails a thorough explanation of several research methodologies, such as data collection, contextualization of the study, and the creation of the final report.

A comprehensive and precise description enhances the ability of other researchers to replicate the work, allowing them to duplicate the experiment in similar conditions in different settings. Therefore, to guarantee the applicability of qualitative research, it is crucial for the researcher to collect extensive and meticulous data that enables the comparison of the present situation with other possible situations that could be considered for transfer. This involves creating a comprehensive depiction of the

situation, allowing for an evaluation of its suitability in comparison to other situations. Therefore, it was essential for the qualitative researcher to provide thorough and complete descriptions of the study in order to increase its potential for being applied to other contexts.

The study utilised member checking and reflexivity as methods to augment the confirmability of the research. This was accomplished by the careful synchronisation of the researcher's recorded data with the verbal and behavioural reactions of the participants during the interview sessions, along with a thorough analysis of my own biases. The study explicitly addressed and excluded these biases. Member checking was deemed the most appropriate approach as it enabled the validation of whether the transcribed text accurately reflected the participants' responses. The participants were given the chance to carefully analyse the interview data to confirm the truthfulness and coherence of their remarks made during the interview.

3.9.3 Dependability

To improve the research's dependability, an audit trail was developed. Dependability refers to the evaluation of the study's findings, interpretations, and recommendations to ensure that they are supported by the data collected from the study's informants (Anney, 2014). Travers (2008) defines an audit trail as a comprehensive assessment of the process and result of an investigation to verify the authenticity of the data. Within this framework, a researcher diligently recorded and rationalised all study decisions and activities, offering a thorough explanation of how the data were collected, documented, and assessed. In order to establish a thorough record of the audit, it is crucial for auditors to retain the specified documentation for the purpose of verifying the inquiry process. This includes raw data, notes from interviews and

observations, field-collected papers and records, test results, and any other pertinent materials. Evaluating the credibility of an inquiry requires a thorough examination of the sources over a long period of time to determine any changes and provide explanations for such revisions. Moreover, the acquired outcomes must undergo a verification process to guarantee their authenticity. Therefore, the researcher incorporated the audit trail to ensure a thorough documenting of the sequential activities and procedures utilised throughout the study undertaking.

3.9.4 Confirmability

Confirmability, as defined by Anney (2014), refers to the degree to which the results of a research work may be corroborated or substantiated by other scholars. Confirmability is an essential element in research as it seeks to guarantee that the facts and interpretations offered are not subjective fabrications, but rather are genuinely derived from the acquired data. Confirmability can be attained by using a reflexive journal. A reflexive journal is a written document kept by the researcher to engage in self-reflection, provide first interpretations, and plan data collection strategies. The researcher must keep a comprehensive reflexive journal, documenting all events that took place in the field and personal reflections related to the study. Reflexivity involves assessing the researcher's own background, perspectives, and interests and how these influence the qualitative research process, including the researcher's personal past. Confirmability was attained by a meticulous process of introspection, where personal prejudices were thoroughly examined and deliberately avoided throughout the data gathering and processing stages. The study's results were presented with a genuine and straightforward approach, with the intention of maintaining the research's integrity and accuracy. To ensure a high degree of

objectivity during the process of gathering and interpreting data, the researcher chose to engage in self-reflection to examine her own biases.

3.10 Data Collection Procedure

The research aimed to study science teaching practices in regular, deaf and inclusive school settings. Data were gathered through observation and interviews. To achieve this, a letter of introduction was taken from the Department of Science Education to the Municipal Directorates where the selected schools are located. The Education Directorates gave permission notes which were sent to the schools selected for the study. Before the actual data collection, the researcher paid familiarization visits to the selected schools to establish a rapport with school heads, science teachers and to study their teaching time tables and other schedules.

Two lessons each were observed in the selected classes, while teachers were observed after the first observation.

In this research, individual interviews were conducted by the researcher with teachers and sign language interpreters. The participants in the interviews and the researcher agreed on the interview venues, dates and times. The interview venues, dates, and times were chosen in collaboration with the heads of the chosen schools based on ease of access and their convenience.

On the day of each interview, the researcher visited the selected schools where participants were greeted and briefed on the study's details, emphasizing the voluntary nature and confidentiality of their participation. Sessions typically lasted about 30 minutes, during which the researcher took comprehensive notes, including non-verbal cues, ensuring to capture the depth of each response. Upon conclusion, participants

were thanked for their contributions and informed about the next steps, maintaining transparency and reinforcing the importance of their input to the study's success.

In addition to the one-on-one interviews, the study also employed observations as a method for data collection. Observational methods are crucial for collecting comprehensive and nuanced data in qualitative research (Merriam & Tisdell, 2016; Yin, 2018). These methods involve systematically watching, listening to, and recording behaviors and interactions within their natural settings, providing rich context and deeper understanding of the phenomena being studied.

On the day of each observation, the researcher visited the selected schools where participants were greeted and briefed on the study's details, emphasizing the voluntary nature and confidentiality of their participation. Sessions typically lasted about 45 minutes. During these sessions, the researcher took comprehensive notes, including non-verbal cues such as body language, facial expressions, and gestures, ensuring to capture the depth and nuance of each response (Angrosino, 2007; Spradley, 2016).

Non-verbal cues play a significant role in qualitative observations as they can convey emotions and reactions that participants may not express verbally. These cues can provide additional insights into the participants' true feelings and attitudes, adding a layer of depth to the data collected (Kyprianou et al., (2015; Mulhall, 2016).

Upon conclusion of each session, participants were thanked for their contributions and informed about the next steps. This approach-maintained transparency and reinforced the importance of their input to the study's success. It also helped in building trust and rapport with the participants, which is essential for obtaining authentic and reliable data in qualitative research (Brayda & Boyce, 2014; Creswell & Poth, 2021). The

researcher's presence and interaction with participants were carefully managed to minimize any potential influence on the participants' behavior. This approach ensured that the observations remained as natural and unbiased as possible, enhancing the validity of the findings (Merriam & Tisdell, 2016).

3.11 Data Analysis Procedure

In this study on assessing the instructional practices of science teachers in selected regular, inclusive, and Deaf basic schools in Ghana, thematic analysis was employed to derive a deeper understanding, explanation, or interpretation of participants' experiences related to the research objectives (Braun & Clarke, 2019). Thematic analysis is a methodical approach to identifying and interpreting patterns or themes within qualitative data collected from interviews and observations.

The first step in this process was data collection and preparation. The researcher gathered qualitative data from one-on-one interviews and classroom observations with teachers and interpreters in the selected schools. This data, primarily comprising transcripts of conversations and detailed notes on non-verbal cues and classroom interactions, was carefully prepared for analysis. This involved transcribing audio recordings and organizing all collected data to ensure accuracy and completeness.

Once the data were prepared, the researcher began the process of familiarization. This involved multiple readings of the transcripts and notes, during which preliminary notes were made and initial patterns or themes were identified. This stage was crucial for gaining a comprehensive understanding of the overall content and context of the data, setting the stage for more detailed analysis (Clarke & Braun, 2006).

The next phase involved generating initial codes from the data. The researcher systematically coded the data using NVIVO 12, a software program designed for the analysis of unstructured text data. Codes were created based on significant phrases or segments of text that were relevant to the research questions. NVIVO 12 facilitated the systematic coding of the data, allowing the researcher to tag portions of the text with relevant labels efficiently (Nowell et al., 2017).

Following the coding process, the researcher began identifying themes. Themes are broader patterns of meaning that are derived from the coded data. The researcher collated the codes into potential themes and gathered all data relevant to each theme. This process involved reviewing the themes to ensure they accurately reflected the coded data and the entire data set. NVIVO 12 supported this analytical process by enabling the researcher to query the data, visualize patterns, and generate reports that highlighted key findings (Vaismoradi et al., 2016).

The final stage was defining and naming the themes, followed by interpretation. The researcher refined each theme, ensuring that it captured the essence of the data. Themes were clearly defined and named, facilitating a coherent narrative of the findings. The researcher integrated the analytical results with theoretical frameworks and existing literature to derive meaningful insights. The aim was to understand the presence, meanings, and relationships of identified themes, considering how these findings answered the research questions and what new understandings emerged about the instructional practices of science teaching in these varied educational settings (Guest, MacQueen, & Namey, 2012).

To ensure the reliability and validity of the findings, the researcher conducted a verification process, revisiting the data and analysis to check for consistency and

accuracy in coding and interpretations. The insights and conclusions were then carefully documented and reported, presenting a comprehensive and coherent narrative of the findings (Creswell & Poth, 2018).

3.12 Limitation

The limited scope of this study, which primarily examined the instructional practices of science teachers in selected regular, inclusive, and Deaf basic schools in Ghana, restricts the generalizability of the findings to broader educational contexts within the country. The research was conducted in specific urban areas, which may not fully represent the diverse educational settings across Ghana, particularly those in rural areas. This urban focus resulted in a lack of variety in the sample, as it did not include schools from rural villages where instructional practices might differ significantly.

Moreover, the sensitivity of the topic and the context of the study posed challenges. Participants might have been influenced by social desirability bias, where they provided responses, they believed were expected or acceptable, rather than their true opinions and practices. This potential bias could affect the authenticity and reliability of the data collected, presenting a constraint to the research.

The duration of the investigation was also a limiting factor. The time allocated was insufficient to conduct a thorough and comprehensive analysis of the instructional practices. Additionally, there were challenges in acquiring information due to some respondents' reluctance to share detailed data. Despite these issues, the researcher managed to collect the necessary information to ensure that the study progressed and yielded valuable insights.

Observer biases and communication barrier were some other challenges encountered during data collection. The presence of the researcher during lesson observations may have altered the behavior of both teachers and learners leading to atypical instructional practices being displayed.

In the deaf and inclusive classrooms, misinterpretation by sign language interpretations could hinder the quality of information being gathered. Again, some of the teachers who were observed in deaf classrooms used sign language throughout their lessons, which could have hindered the richness of the information being gathered.

Overall, while the study faced several constraints, the researcher successfully navigated these challenges to gather and analyze data effectively. The limitations acknowledged here highlight areas for future research, such as extending the study to include rural schools and allowing more time for data collection and analysis to enhance the depth and breadth of the findings.

3.13 Ethical Concerns

The researcher obtained an introductory letter from the Department of Science Education at the University of Education, Winneba. Based on this letter, permission was sought from the appropriate authorities. The researcher assured respondents of anonymity and confidentiality before administering the interview questions. To achieve this, it was explained to respondents how their data would be used and they were assured that their names, identities and identifiable details will not be disclosed in reports. Again, instead of actual names, participants were pseudonyms such as PP1, PP2, PP3, etc. The researcher also obtained informed consent from research participants.

Going through the hands-on experience of sharpening my technical skills and ensuring the validity and reliability of the data collected, I was challenged to develop my skills as a researcher but even my basic virtues as an individual.

While the process of coding and culling findings demands tedious work, it would show me the value of being concise and accurate in identifying categories and data, and to be always mindful of detaching my own interpretation at these stages of data processing. It would teach me how to be discriminating in selecting core and fundamental data from those that are non-essential to give due importance to the information provided by the participants.

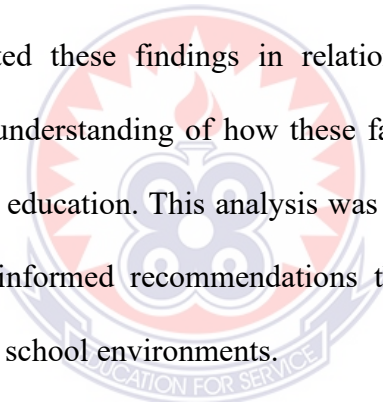


CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

The researcher examined the results and their interpretation of the study aimed at evaluating the qualifications, instructional practices, and professional development of science teachers across regular, inclusive, and deaf schools. This chapter presents a detailed analysis of the qualitative data collected from various educational settings. By examining the academic and professional backgrounds of teachers, their approaches to lesson planning and delivery, the use of assistive technologies, and their participation in in-service education and training (INSET) workshops. The discussion explained and interpreted these findings in relation with the existing literature, providing a contextual understanding of how these factors influence the quality and inclusiveness of science education. This analysis was crucial for identifying effective strategies and making informed recommendations that could enhance educational outcomes across diverse school environments.

The logo of the University of Education, Winneba, is a circular emblem. It features a central design with a sunburst or star-like pattern in the upper half and a stylized figure or symbol in the lower half. The text "UNIVERSITY OF EDUCATION, WINNEBA" is written around the top inner edge of the circle, and "EDUCATION FOR SERVICE" is written around the bottom inner edge.

4.1 Results

4.1.1 Background Information of Respondents

Table 3: Background Information of Respondents

Variable	Category	Frequency	Percentage (%)
Age	20-30	6	20
	31-40	15	50
	41-50	9	30
	Total	30	100
Years of Teaching	0-5	2	6.7
	06-10	10	33.3
	11-15	12	40
	16-20	4	13.3
	21-25	2	6.7
	Total	30	100
School	Regular	16	53.3
	Inclusive	5	16.7
	Deaf	9	30
	Total	30	100

Source: Field data (2023)

Out of the 30 respondents, 25 were males, while 5 were female. This indicates a significant gender imbalance among science teachers in the sampled Regular, Inclusive, and Deaf basic schools in Ghana, potentially reflecting broader societal norms and personal preferences towards science education in the country.

The respondents' ages are categorized into three groups. The majority, 15 out of 30, are between 31 and 40 years old, indicating a group likely established in their careers but still adaptable to new teaching methodologies and technologies. Those aged 20-30 years make up 6 out of 30, suggesting newer professionals who may bring fresh perspectives and recent training experiences. The 41-50-year age group consists of 9 out of 30 respondents, seasoned educators who might hold leadership roles or significantly influence instructional practices due to their experience.

Most respondents had 11-15 years of teaching experience, with 13 out of 30, indicating a solid understanding of the educational landscape and potential efficacy in classroom management and instructional strategies. The 0-5 years and 6-10 years' experience categories each included 5 out of 30 respondents, suggesting a mix of newer and more experienced teachers. Similarly, 4 out of 30 respondents had 16-20 years of experience, and 3 had 21-25 years, representing long-term commitment to teaching and possibly deep insights into changes in educational policies and student behaviors over time.

The respondents teach in various educational settings: 9 out of 30 in Deaf schools, 16 out of 30 in Regular schools, and 5 out of 30 in Inclusive schools. Those teaching in Deaf schools focus on specialized educational practices for hearing-impaired students, employing unique communication techniques and modified curricular approaches. Teachers in Regular schools reflect a conventional teaching environment, while those in Inclusive schools work in settings that integrate students with a wide range of abilities, requiring flexible teaching methods and a broad understanding of educational inclusivity.

These diverse backgrounds and environments of the teachers provide a rich context for analyzing instructional practices in science teaching across different educational settings in Ghana. Each variable—gender, age, years of teaching experience, and type of school—contributes to understanding the dynamics at play in the educational process and outcomes in these schools.

4.1.2 Research Question One: To what extent are the science teachers in the selected schools academically and professionally qualified to facilitate science instructions?

The first research question explored teachers' qualification in teaching science across the three settings of basic school; regular, inclusive and deaf schools. The respondents were of the view that they have the requisite qualifications to teach science. Three themes were generated from the views of the respondents as to their qualifications in teaching science. These are Academic qualification, Professional qualification and Additional qualifications needed.

Table 4: Themes on Teacher Qualification

Themes	Sub-Themes
Academic Qualification	Level of qualification Area of specialization
Professional Qualification	Teacher License status Professional development
Additional Qualifications needed	

Source: Field data (2023)

4.1.2.1 Academic Qualifications and Preparation for Teaching Science

The first theme that was generated on teachers' qualification to teach science at the basic school level was academic qualification. The respondents exhibited varying levels of academic qualifications with subjects of specialization, which significantly influenced their preparation for teaching science. The qualifications ranged from Diplomas to Master's Degrees in Education, with specializations in different areas of science. This diversity in academic background shaped their readiness to tackle the demands of teaching science in their current settings.

Generally, ten (10) out of the thirty (30) respondents (33.3%) expressed that their academic qualifications have adequately prepared them for teaching science.

Respondents expressed their views in many ways and some have been presented.

PP12 for instance said:

“I hold a Bachelor's Degree in Education with a major in Biology. This qualification has provided me with a solid foundation in both educational theories and specific scientific knowledge, enabling me to effectively teach complex biological concepts to my students.” (PP1).

In support of PP12, PP 15 said:

“At the training college I studied Integrated science and completed with a Diploma in Basic education. I did various courses in Biology, Chemistry and Physics. I also read courses in methodology at college. These courses that I did, qualify me to teach science at JHS level. Therefore, I am qualified to teach science”.

Another respondent shared a similar view, emphasizing the advanced preparation provided by his higher education:

After my Diploma in Basic Education at the Training college, I continued to do a Post-Dip. And I have now completed a Master's Degree in Science Education, focusing on Integrated Science. The advanced coursework and research experience have equipped me with in-depth knowledge of various scientific disciplines and contemporary teaching methods, which I apply in my science classes.” (PP16)

However, while recognizing that their academic qualifications were sufficient, some respondents felt the need for additional preparation in specific areas. This was highlighted by a respondent who felt that practical aspects of teaching were not fully covered in their degree program:

“While my college studies have provided me with the necessary content knowledge, I sometimes feel that my preparation in classroom management and differentiated instruction for learners with different needs and interests could be improved.” (PP18)

There were also a few of the respondents who did not have a background in science content, yet they considered themselves as qualified to be involved in science instructions. PP3 who is a sign language interpreter had this to say:

“I have a Diploma in Basic Education, where I specialized in Religious and Moral education. In my university education, I studied Special Education, focusing on sign language interpretation and this is what I do” She added “I do sign language interpretation for all subjects, not only science” (PP3)

Another sign language interpreter in the inclusive school indicated that his major area of study is Social studies but he did his further studies in special education. He noted:

“At the college of education, my major was Social studies so when I completed I was teaching Social Studies before I went for further studies to pursue Special Education and here I am being a sign language interpreter for the school. I interpret lessons for different teachers” (PP28).

4.1.2.2 Professional Development or Training Programmes in Science Education

The second theme derived under research question one was professional development in science and teachers license status as qualification to teach science. The participation in professional development programmes and training related to science education varied among the respondents. These programs played a crucial role in enhancing their teaching skills and keeping them updated with the latest educational practices and technological advancements in science education. However, all respondents indicated that they possessed teachers’ license from the NTC, qualifying them to teach.

Fifteen (15) out of the thirty (30) respondents (50%) mentioned that they had participated in relevant professional development programs. These programmes ranged from workshops on digital tools in science education to training on inquiry-based learning and other innovative teaching methodologies.

“I have participated in several workshops on the use of digital tools in science education. These training sessions have enhanced my ability to integrate technology into my teaching, making science more interactive and engaging for my students, especially, those with deafness.” (PP9)

Another respondent shared a similar experience, highlighting the benefits of professional development in transforming their teaching approach:

“Last year, I attended a professional development programme on inquiry-based science teaching. This training has helped me shift my teaching approach from teacher centered to encourage more student-driven investigations and critical thinking. Apart from that, I am also a licensed teacher” (PP10)

4.1.2.3 Adequacy of Academic and Professional Qualifications

Respondents had mixed responses about the adequacy of their academic and professional qualifications in meeting the demands of teaching science. Some felt well-prepared, while others identified gaps that needed to be addressed through additional training or resources.

Respondents identified areas where additional qualifications or training would be beneficial for enhancing their science teaching skills. These included specialized certifications, advanced training in laboratory techniques, and professional development in inclusive education practices

Eight (8) out of the thirty (30) respondents (26.7%) felt that their qualifications were adequate but recognized the need for continuous improvement to stay current with educational trends and scientific advancements.

Participant 18 highlighted the need for better preparation in specific areas, particularly in handling diverse classroom environments:

“While my college studies have provided me with the necessary content knowledge, I sometimes feel that my preparation in classroom management and differentiated instruction for diverse learners could be improved.” (PP18)

Affirming the views of PP18, PP26 indicated that:

“I think I will need more training to equip me with skills on inclusive practices. Even though I am well equipped with subject matter knowledge in science, I need skills to conduct my lessons efficiently since I have both regular pupils and pupils with deafness in my class. If I can use sign language, there will not be any need for an interpreter because I will do all by myself” (PP 26)

PP30 added this on the need for certification in special education to better support students with special needs:

“I think pursuing a certification in special education would greatly enhance my ability to support students with special needs in my science classes. I believe that if I have a training in sign language, I will not need any interpreter in my lessons” (PP30)

Another respondent emphasized the importance of advanced training in laboratory techniques and safety protocols to conduct more sophisticated experiments:

“Additional training in advanced laboratory techniques and safety protocols would be beneficial. This would allow me to conduct more sophisticated experiments and ensure a safe learning environment.” (PP17)

4.1.3 Research Question Two: What are the current instructional practices of science teachers in terms of planning, delivery, and assessment?

In answering research question two which sought to explore respondents' current instructional practices in science in terms of planning, delivery and assessment, four themes emerged: pedagogical approaches, classroom management and engagement, curriculum adjustment and adaptations and assessment practices.

Table 5: Themes that emerged from Current Instructional Practices

Theme	Description
Pedagogical Approaches	Focus on teaching strategies, including inquiry-based learning, hands-on experiments, and the integration of technology in science instruction
Classroom Management and Engagement	Techniques used to maintain student engagement, manage classroom dynamics, and encourage participation during science lessons and activities
Curriculum Adjustment and Adaptations	How teachers modify and adapt the science curriculum to meet diverse learners' needs, including accommodations for students with disabilities.
Assessment Practices	The use of formative and summative assessments, including alternative assessment methods like science portfolios or project-based evaluations.

Source: Field data (2023)

4.1.3.1 Pedagogical approaches

The first theme generated was the teachers' pedagogical strategies they used in teaching science. They highlighted varied pedagogical strategies they employed in the classroom. The strategies employed includes logical planning, expository teaching strategies, demonstration, inquiry based and problem-solving approach. Respondents indicated their instructional practices begin from the planning stage. Some excerpts from the interviews are as follows:

“When planning my science lessons, I prioritize having a deep understanding of the subject matter. I ensure that I am well-prepared with the content to provide accurate information to my students and to help carry out any practical activities in the lesson.” (PPI, Male)

Another participant indicated that:

“Planning is all about being prepared. I make sure to have all the necessary materials ready and to anticipate any questions or difficulties my students might have. During the lesson, I incorporate textbooks, online materials, and hands-on activities to make the lessons engaging and comprehensive.” (PPI, Male)

Another participant added:

“Planning is all about being prepared. I make sure to have all the necessary materials ready and to anticipate any questions or difficulties my students might have. I Use a variety of resources: I incorporate textbooks, online materials, and hands-on activities to make the lessons engaging and comprehensive” (PP4, Male)

Another respondent had this to say:

“I use a mix of teaching methods, including lectures, discussions, and hands-on experiments and demonstration approach. This variety helps cater to different learning styles and keeps the students engaged.” (PP10, Male)

One respondent also said:

“Examples from everyday life are very effective in explaining scientific concepts. I always try to relate the subject matter to real-life situations to make it more relevant for the students. You know, when you cite examples that students are familiar with, the grasp the content easily” (PP16, Male)

In support of the other respondents, PP18 said:

“Visual aids like diagrams and graphs are essential in my teaching. They help students visualize complex concepts and understand them better. I also use materials that are common in their environment” (PP18, Female)

4.1.3.2 Classroom Management and Engagement

Classroom management and enjoyment was the second theme that emerged as a theme under research question two. The respondents indicated their techniques for classroom management that increased learners’ participation. These techniques include behaviour management such as non-verbal cues, establishing clear rules and expectations, engaging and motivating learners, organizing the learning environment and time management.

One respondent indicated how he engages the pupils, when he said:

“Group work and peer teaching are also important methods I use. They allow students to learn from each other and to develop their understanding through collaboration. I always make sure the lesson does not go beyond the stated period.” (PP11, Female)

Another respondent said:

“I always start by sharing the lesson objectives with my students. This helps them understand what they are expected to learn and keeps them focused throughout the lesson so that they will not misbehave. Then I involve them in setting class rules to encourage ownership of the rules.” (PP2, Female)

Respondent PP18 expressed her view:

“When I am using group and presentations or discussions, I make sure that I give them rules at the beginning of the lesson. This is to promote tolerance and prevent them from making noise. Apart from this I make sure that they are seated in a U-shape to ease movement and to ensure easy access to TLMs and demonstration activities”

4.1.3.3 Curriculum Adjustment and Adaptations

Curriculum adaptation emerged as one of the themes on respondents' current instructional practices. Many of the respondents they made curriculum adjustments to meet the varied needs of their learners. They mentioned such adjustment methods as total communication, peer assisted learning, hands-on inquiry-based learning and Visual emphasis in delivery

Below are excerpts from the responses. One respondent at the school for deaf stated:

“Adjusting how we teach is very crucial. I use verbal language, sign language and lip reading because some of my students use hearing aids and can hear me. I also use a lot of visual aids and illustrations on the marker board. I also move quite slowly when I am teaching” (PP1)

A respondent in a regular school said:

“The language of instruction at JHS is English, but when pupils find it difficult to understand a concept I try to use the local language to

explain for easy understanding. This helps a lot because when I do that they perform well in the exercises”

Another indicated that:

“I find that in our inclusive setting, we have to be very adaptive, using a variety of teaching tools from technology to tactile materials, aiming to meet the broad spectrum of learning needs. Sometimes I used different teaching strategies in the same lesson to meet the different needs of my learners. In most of my lessons, I emphasize on visual delivery by facing students when speaking, using gestures and writing key terms” (PP26 Female).

Another respondent in the inclusive setting explained his adaptation strategies. PP28 said:

“To meet the interest of my students, my lesson moves at a slow pace. This is so because I have to give the interpreter some time to explain in sign language to the learners who cannot hear me. Even when I give exercises, I give more time to the pupils with deafness to complete the exercise. Sometimes I group learners where hearing and DHH collaborate with peers explaining through gestures or simple signs”

4.1.3.4 Assessment Practices

Another theme that emerged under teachers’ current instructional practices is assessment practices. Assessment strategies that emerged from respondents included written test, quizzes, oral questioning alternative assessments and sign language presentations. These assessment strategies were used to evaluate student learning outcomes, though these strategies are mostly ‘pen and paper’ work. Responses from the participants were confirmed during lesson observations. Providing prompt feedback was also emphasized as a key component of their assessment practices. A respondent indicated that:

“I use different assessment strategies, such as quizzes, assignments, and practical tests, to gauge students' understanding. Each method gives me insights into different aspects of their learning. I sometimes allow for sign language presentations as an assessment strategy” (PP9, Female)

Another said:

“I often use formative assessments during the lessons to check for understanding. This allows me to know the weaknesses and difficulties of my students, and I adjust my teaching strategies on the spot if needed.” (PP11, Male)

Another respondent indicated that:

“Peer assessments and self-assessments are also valuable tools. They encourage students to reflect on their own learning and to develop critical thinking skills. Therefore, I sometimes involve peer assessment by learners in my assessment practices” (PP12, Male)

Another teacher gave his view on feedback:

“Providing timely feedback is crucial. It helps students understand their mistakes and learn from them, which is essential for their progress. Even though I teach different class and have many students to assess, I do well to make sure that feedback to my students is quick” (PP14, Male)

4.1.4 Research Question Three: What are the similarities and differences in science teachers’ instructional practices among Regular, Inclusive, and Deaf Basic schools?

4.1.4.1 Comparison of Instructional Practices:

Regular Schools

Teachers in regular school settings reported primarily using lecture-based teaching with some interactive activities. This approach was reflected in their instructional practices.

Four out of the 30 respondents expressed their reliance on lecture-based teaching:

“In our regular school setting, we primarily use lecture-based teaching with some interactive activities. From what I understand, Inclusive and Deaf schools may rely more on group activities and visual aids respectively, which seems to facilitate better engagement for their specific student groups. We might not have as many specialized tools or training to fully engage students with different learning needs.” (PP10)

“We follow a structured curriculum and mostly stick to traditional teaching methods. While this works for many students, I sometimes feel that we could benefit from more innovative approaches to keep all students engaged.” (PP2)

“In regular schools, the focus is often on delivering the curriculum content efficiently. There’s less emphasis on using varied instructional strategies, which can sometimes make it challenging to keep all students engaged.” (PP3)

“We often have to balance covering the curriculum with trying to make lessons engaging. This can be tough without access to the specialized resources available in inclusive or deaf schools.” (PP4)

Inclusive Schools

In inclusive school settings, teachers emphasized the need for adaptive teaching methods to cater to a broad spectrum of learning needs.

Three respondents highlighted their adaptive teaching methods:

“I find that in our inclusive setting, we have to be very adaptive, using a variety of teaching tools from technology to tactile materials, aiming to meet the broad spectrum of learning needs. This seems quite different from what my colleagues in regular schools describe, where the focus might be more on standard curriculum delivery without as much customization.” (PP26)

“Teaching in an inclusive school means constantly adjusting my methods. We use assistive technologies and differentiated instruction to ensure every student can access the material. This requires more preparation but results in a more engaging and supportive learning environment.” (PP28)

“Our approach in inclusive schools is very student-centered. We have to be flexible and responsive to each student’s needs, which means using a wide range of teaching strategies and tools.” He added “Working in an inclusive school means we are always looking for new ways to reach our students. This can be challenging, but it’s also rewarding when we see our students reduce their struggles in the classroom.” (PP29)

Deaf Schools

In deaf school settings, teachers reported using specialized approaches and more resources such as highly visual teaching methods and often employing sign language tailored specifically for their deaf students.

Four respondents shared their specialized methods:

“Our teaching is highly visual and we often use sign language, which is tailored specifically for our deaf students. This is quite specialized compared to regular schools, and even different from inclusive schools, where their focus is on accommodating a variety of disabilities but not as intensely in any one direction as we do with auditory challenges.” (PP1)

To confirm the use of specialized resources and methods, respondent PP6 added:

“We rely heavily on visual aids and technology to support our students' learning. Sign language is integral to our instruction, and we continuously seek out new tools to enhance our teaching.” (PP6)

A respondent touched on the method of communication during science instructions at the deaf school. He noted:

“In deaf schools, the use of sign language and visual aids is essential. We also use a lot of hands-on activities to ensure our students can engage with the material fully. These increase their ability to understand what we teach” (PP8)

Again, another responded said:

“Teaching deaf students requires specialized approaches. We use a variety of visual and tactile methods to ensure that every student can access the material in a way that works for them. Both teachers and students sometimes use assistive devices to help teaching and learning” (PP9)

4.1.4.2 Unique Challenges

Regular Schools

In regular schools, the primary challenge is the lack of specialized tools or training to engage students with diverse learning needs. This was observed in the classroom environment where instructional materials were not always accessible to all students.

Four respondents shared their challenges:

“Our main challenge is engaging all students equally. We lack the specialized training and tools that might be available in inclusive or deaf schools, which sometimes makes it hard to cater to students with specific needs.” (PP1)

“Balancing the needs of a diverse classroom with the demands of the curriculum can be tough. We often don’t have the resources to support students with additional needs as effectively as we would like.” (PP2)

“Without specialized tools, it’s challenging to provide the kind of interactive and engaging lessons that can benefit all students, especially those who need more support.” (PP3)

“We often find ourselves limited by the resources available. This can make it difficult to implement more innovative or inclusive teaching strategies.” (PP4)

Inclusive Schools

Teachers in inclusive schools face the challenge of adapting their methods to meet a wide range of disabilities. Observations confirmed that teachers use multiple instructional methods to cater to different learning styles, but this requires significant customization and flexibility.

Three respondents highlighted their challenges:

“Adapting to each student’s needs is both rewarding and challenging. It demands a lot of time and resources to ensure that every student is supported, but the positive outcomes make it worthwhile.” (PP26)

“Managing such a diverse classroom requires constant adaptation. We have to be prepared to change our approach at any moment to meet the needs of our students.” (PP28)

“Each student has unique needs, which means our teaching methods must be very flexible. This can be challenging but also very rewarding when we see students succeed. So the biggest challenge is ensuring that every student feels included and supported. This requires a lot of creativity and flexibility in our teaching methods and it is time consuming.” (PP30)

Deaf Schools

In deaf schools, the unique challenge was the need for specialized communication methods, such as sign language and visual aids. Teachers must be proficient in these methods to effectively teach their students, which is different from the broader range of disabilities addressed in inclusive schools.

Four respondents shared their challenges:

“Communication is our biggest challenge. Ensuring that all teachers and students are proficient in sign language requires ongoing training and support.” (PP9)

“We need to continually update our skills and resources to keep up with the best practices in teaching deaf students. This can be demanding but is essential for effective teaching.” (PP10)

“Maintaining proficiency in sign language and staying updated with new visual aids and technologies is a continuous process. It’s crucial for effective communication and teaching.” (PP11)

“Ensuring that all students can fully engage with the material requires a lot of specialized training and resources. This is a constant challenge but one we are committed to overcoming.” (PP12)

4.1.4.3 Adapting Teaching Methods

Regular Schools

In regular schools, teachers try to incorporate some interactive activities to complement lecture-based teaching, although they may not have the specialized tools needed for full engagement.

Three respondents highlighted their adaptive methods:

“We do our best to include interactive elements in our lessons, but without specialized tools, it’s challenging to engage every student fully.” (PP1)

“We try to use a variety of teaching methods to keep students engaged, but it’s difficult without the resources available in more specialized settings.” (PP2)

“Finding ways to make lessons interactive is a constant goal, but we’re often limited by the resources we have.” (PP3)

Inclusive Schools

In inclusive schools, teachers are very adaptive, using a variety of teaching tools from technology to tactile materials. This approach aims to meet the broad spectrum of learning needs and involves significant customization of teaching methods.

Four respondents highlighted their adaptive methods:

“We use a range of tools and methods to reach all students, from digital resources to hands-on activities. It’s about finding what works best for each learner.” (PP5)

“Being adaptive and flexible is key. We constantly adjust our teaching methods to meet the diverse needs of our students.” (PP6)

“We integrate a variety of teaching tools to ensure all students can engage with the material, from interactive technology to tactile learning aids.” (PP7)

“Our goal is to create an inclusive environment where every student can thrive. This means using a wide range of teaching methods and tools.” (PP8)

Deaf Schools

In deaf schools, teachers focus on highly visual teaching methods and the use of sign language. These specialized methods are tailored to the auditory challenges faced by their students, which requires a different set of skills and resources compared to regular and inclusive schools.

Four respondents highlighted their adaptive methods:

“Our methods are highly specialized. We rely on visual aids and sign language, which requires continuous learning and adaptation.” (PP9)

“We use a variety of visual and tactile methods to ensure that every student can access the material in a way that works for them.” (PP10)

“Teaching deaf students requires a specialized approach. We use a variety of visual and tactile methods to ensure that every student can engage with the material.” (PP11)

“Our teaching methods are tailored to the needs of our students, using visual aids and sign language to ensure effective learning.”
(PP12)

4.1.4.4 Unique Strategies and Resources

Regular Schools

In regular schools, teachers use a mix of lectures and interactive activities, although they may lack specialized tools.

Four respondents highlighted their strategies and resources:

“Our resources are more traditional, but we try to make lessons interactive with the materials we have.” (PP1)

“We use what we have to create engaging lessons, but there’s always room for more specialized resources.” (PP2)

“We make the most of our available resources, incorporating as much interaction as possible into our lessons.” (PP3)

“Our focus is on using traditional methods effectively, but we’re always looking for ways to make our lessons more engaging.” (PP4)

Inclusive Schools

In inclusive schools, teachers use a wide range of adaptive tools and materials, including technology and tactile resources, to meet diverse learning needs. These methods are essential for addressing the broad spectrum of disabilities present in inclusive classrooms.

Four respondents highlighted their strategies and resources:

“To ensure that we meet the needs of both hearing and deaf and hard-of-hearing students, we leverage various technologies and hands-on materials to engage all students, ensuring that each one can participate fully.” (PP26)

In support of Respondent PP26, respondent PP28 said:

“Our approach is very resource-intensive, using a variety of tools including the use of technology to meet the needs of our diverse students in the class.” (PP6)

To confirm teachers' use of resources including technology, another respondent indicated that:

“Technology plays a big role in our classrooms, helping us create an inclusive environment where all students can succeed. We use a combination of digital resources and tactile materials to ensure every student can engage with the material.” (PP30)

Deaf Schools

In deaf schools, teachers employ highly visual strategies and sign language. These specialized methods are tailored to the needs of deaf students and involve the use of visual aids like concept maps, flow charts, elaborate diagrams and communication techniques that are not as commonly used in regular or inclusive schools.

Four respondents highlighted their strategies and resources:

“Our focus is on visual learning and clear communication through sign language, which requires specific strategies and resources. Using these resources and appropriate strategies help us to engage our learners who need to see and interact with the teaching and learning materials” (PP2)

“Using visual aids and sign language is essential in our classrooms. We continually seek out new tools that are available to us to support our students.” (PP3)

“Visual aids and sign language are integral to our teaching. We're always looking for new resources to enhance our students' learning experiences.” (PP4)

“Our teaching methods are highly specialized, focusing on visual learning and communication to meet the needs of our students. In the deaf classroom, talking is less because we need to let students see materials and through the sign language” (PP9)

4.1.5 Research Question Four: To what extent are the science instructional approaches differentiated for learners in inclusive classrooms?

Research question four sought to explore the extent to which science instructional approaches are differentiated for learners in inclusive classrooms. Interviews with the participants indicated that science instructional approaches are differentiated to a

greater extent for learners in inclusive classrooms. Five major themes emerged from the interviews. These were: Instructional strategies for differentiation, Use of assistive technology, Classroom management and Organisation, Assessment and Feedback, and Challenges in differentiation.

Table 6: Extent to which Science Instructions are differentiated for Learners in Inclusive Classrooms

Theme	Key Insights from Interviews
Instructional Strategies for Differentiation	<ul style="list-style-type: none"> • Content differentiation • Process differentiation • Product differentiation
Use of Assistive Technology	<ul style="list-style-type: none"> • Technology integration • Support for learners with deafness or hard-of-hearing
Classroom Management and Organisation	<ul style="list-style-type: none"> • Flexible grouping • Physical classroom set up
Assessment and Feedback	<ul style="list-style-type: none"> • Formative assessment differentiation • Feedback methods
Challenges in Differentiation	<ul style="list-style-type: none"> • Time management • Resource limitation

Source: Field data (2023)

4.1.5.1 Instructional Strategies for Differentiation

The first theme that came up under the extent to which teachers differentiate their lessons in inclusive classroom is how they differentiate their instructional strategies.

Teachers in inclusive classrooms utilized a variety of strategies to differentiate science instruction for learner with diverse learning needs. These strategies included combining visual, auditory, and tactile methods, adjusting tasks, grouping, and resources to match learners' varied abilities and learning needs. Incorporating videos, visual aids, and interactive apps to support learners with deafness were also mentioned. These strategies were aimed at ensuring all learners can access and engage with the material, regardless of their individual differences. The respondents shared

their views on how the strategies they use to differentiate their instructions. One respondent noted:

"I am aware of the different learning needs of my students in science lessons and I adapt my teaching accordingly. This involves using various instructional methods and materials tailored to each student's needs." (PP26)

Another respondent indicated that:

"My instructions are individualized to ensure that each student understands the concepts being taught. I often use multi-modal teaching approaches to cater to different learning styles. Apart from that, I structure my classroom to support a variety of activities, including group and individual work, to meet the diverse needs of my students " (PP28)

Respondent PP29 added:

"I provide students with the choice in learning activities, allowing them to select the method that works best for them, which helps in accommodating their individual preferences and strengths." (PP29)

Another responded:

"I modify lesson plans to include activities that cater to various learning styles and levels of understanding. This might involve breaking down complex concepts into simpler steps or providing additional resources for students who need more support." (PP30)

4.1.5.2 Use of Assistive Technology

The second theme that emerged was the integration of technology as a means of differentiating instructions for learners in inclusive classrooms. According to the responses, different forms of technology are integrated into their lessons to cater for the needs of learners, especially, those with deafness or hard-of-hearing. Respondent PP6 had this to say:

"I integrate technology into my lessons to support different learning styles and make the content more accessible. I use visual aids and hands-on activities to make the lessons more engaging and accessible for all students." (PP26)

PP26 was supported by PP28. PP28 noted:

“Inclusive teaching requires constant adaptation. I frequently adjust my instructional materials to ensure they are accessible to all students, such as providing visual aids and simplified texts for those who need them” (PP28)

Another participant shared:

“I try to break down concepts which I consider complex. I do this by using videos and simulations with captions. This allows students with deafness and hard-of-hearing to access complex scientific concepts visually.” (PP30)

4.1.5.3 Classroom Management and Organisation

Respondents expressed views that indicated that differentiated instructions could be achieved in terms of a teacher’s classroom management and organization. This could be achieved through physical classroom setup and flexible grouping. Excerpts of teachers views are as follows. One respondent indicated that:

“Whenever, I need to use groups, I usually group students based on the kind of their support needs and I also use mixed ability grouping too” (PP26)

Another PP29 indicated that:

“It is important that the physical classroom arrangement is done to seat the students with deafness and hard-of-hearing so that aside the sign language interpreter, they will be closer to the teacher because some try to read your lips when you are teaching.”

4.15.4 Assessment

Another theme that emerged under differentiation is assessment where respondents’ views indicated that they employ differentiated assessment methods and feedback for their inclusive classrooms. Respondents’ views are presented below:

“I use a variety of assessment tasks to measure student understanding and adjust my teaching methods based on the results. This helps me to identify areas where students might be struggling and provide targeted support.” (PP26)

Respondent PP28 also noted:

"Providing multiple means of expression in the final product allows students to demonstrate their understanding in ways that suit their strengths, whether through written reports, presentations, or creative projects." (PP28)

Another respondent PP29 also noted:

" I often create differentiated worksheets and activities to cater to the different ability levels in my classroom. Another thing is providing timely feedback. This is crucial because it helps students to understand their mistakes and learn from them, which is essential for their progress." (PP29)

4.1.5.5 Challenges in Implementing Differentiated Instruction:

Implementing differentiated instruction in science classrooms comes with its own set of challenges. These challenges emerged as a common issue of concern to teachers.

The excerpts below show teachers views on challenged in differentiating lessons for learners in inclusive classrooms. Respondent PP26 said:

"Differentiating instruction can be very time-consuming. It requires a lot of planning and preparation to ensure that each student's needs are met. Even during the lesson itself, you have to move slowly sometimes and you have to pay attention to individual students too." (PP26).

She added:

"Access to resources is often a challenge. We sometimes lack the materials needed to effectively differentiate instruction, which can limit our ability to fully support all students." (PP26)

Another Respondent noted:

"Managing a classroom with students at varying levels of needs and understanding is challenging. It is important to keep all students engaged while providing additional support to those who need it." (PP28)

For respondent PP29, the major challenge lies in balancing curriculum demands and implementing differentiated instructions. He noted:

"Balancing the curriculum requirements with the need to differentiate instruction is difficult. We need to cover a lot of content while ensuring that all students are keeping up because it is also important to be sensitive to individual needs." (PP29)

One interpreter gave her views on the difficulties she faces. She noted:

"As interpreter, I do sign language interpretation for teachers in different classes and subjects. This makes the work so difficulty, but if each class should have its own sign language interpreter, then the work will be less difficult for us" (PP27)

4.1.6 Research Question 5: Which type of assistive technologies are utilized for science lessons in inclusive and deaf classrooms?

Research question five sought to explore science teachers' use of assistive technologies for science lessons in inclusive and deaf classrooms. Three themes emerged from the interviews: Types of assistive technologies being used, Teacher adaptation and technologies being used, and Challenges with technology use (Table 7).

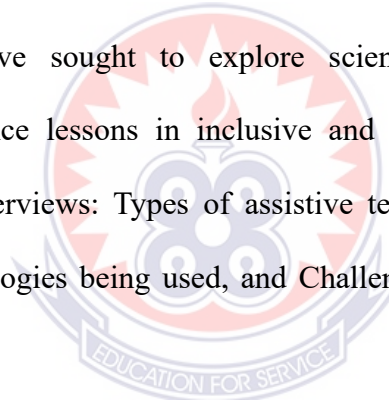


Table 7: Themes on Assistive Technologies utilized in Inclusive and Deaf Science**Classrooms**

Theme	Key insights from interviews
Types of assistive technologies	<ul style="list-style-type: none"> • Use of visual aids such as interactive whiteboards, videos with captions, and visual representations of scientific concepts • Specialized devices like hearing aids, FM systems and cochlear implants for deaf students • Use of tactile or sensory tools for hands-on science learning
Teacher adaptations and integration of technology	<ul style="list-style-type: none"> • How teachers modify or adapt mainstream technology for deaf of HH • Strategies of integrating assistive technologies into regular science lessons
Challenges with technology use	<ul style="list-style-type: none"> • Barriers to accessing or implementing assistive technology • Limitations of current technologies and their impact on student learning outcomes

Source: Field data (2023)

4.1.6.1 Types of Assistive Technologies

The first theme that emerged under research question five was types of assistive technologies being used. The respondents indicated their use of various types of assistive technologies during their science lessons. These technologies are essential in making the content accessible and engaging for all students. Some assistive technologies mentioned by respondents include mobile phones, laptops, projectors, TV with captions and sign language charts and manuals A respondent in the deaf school, PP1 stated:

"We use mobile phones and TV with captions to interact with digital content. Using TV is challenging because you have to move the whole class to the TV room though it makes it easier for them to follow along and engage with the lessons." (PP1)

Another responded indicated:

"The use of pen and paper communication is still very important in the deaf school though laptops and other computers are crucial for our students with deafness. Though these tools make it easier for them to

participate in digital activities, we do not use them very frequently because of the limited number." (PP2)

The views of two respondents from the inclusive school were captured. Respondent PP26 stated:

"We sometimes use a projector to project content with captions for learners but this is really used because you will have to arrange in advance to the projector in order to use. We sometimes use mobile phones too. When we use such devices, learners with deafness engage better with the lessons and participate in discussions." (PP26)

Another respondent added:

"We use sign language cards and manuals and word prediction programmes to facilitate our instructions plus more visual TLMs. These tools make writing assignments more manageable for them." (PP28)

Another respondent spoke on the types of assistive technologies used:

"Sign language charts and captions are used and sometimes SMS messaging through mobile phone. These are used because we have no access to modern technology to deliver our lessons. Because of this, we still rely so much on pen and paper communication. " (PP30)

4.1.6.2 Teacher Adaptations and Integration of Assistive Technologies

The second theme that emerged under use of assistive technology was how teachers adapted and integrated the various types of assistive technology into their lesson plans and instructional delivery in various ways to enhance the learning experience for all students. One respondent indicated that:

"I use interactive whiteboards to display visual content such as diagrams and animations making it easier for learners to follow my lessons. I also use the sign language to support my teaching"

Another teacher indicated that:

"Some of my students use the cochlear implants to aid their hearing ability. Apart from using the sign language during lessons, I also use a lot of illustrations and diagrams. This increases the chances of students understanding" (PP4)

One teacher indicated that he goes the extra mile to integrate online materials to support his teaching. He noted:

“Sometimes I use some virtual labs and simulations to give students a feel of hands-on activities, in this situation auditory instructions are replaced with verbal cues. Sometimes too I use some apps that are specifically design for deaf and hard-of-hearing students, which provide signed translations of activities and games” (PP9)

Another shared his experience to highlight technology adaptation. He indicated:

"I incorporate assistive technologies into my daily lesson plans. For instance, we use light pens during interactive lessons to make the content more engaging and accessible." (PP28)

Another respondent indicated that:

"We use hearing aids and visual aids together to support students with hearing impairments. This combination makes the lessons more accessible for them." (PP10)

"Sticky keys and keyboard alternatives are used to ensure that students with physical disabilities can participate in computer-based activities." (PP30)

4.1.6.3 Challenges with Technology Use

Challenges with technology in during science lessons in inclusive and deaf classrooms is the third theme that emerged from the interview with respondents. Even though the teachers had indicated that they adapted and integrated technology in their lessons, they also admitted having challenges in the use of such technologies. The challenges encompassed Barriers to accessing assistive technology, limitations of current technologies and their impact on student learning outcomes, lack of funding and proficiency on the part of the teachers. Excerpts from the interviews are presented below:

One teacher expresses his views, thus:

"The biggest challenge we face is the cost and maintenance of these technologies. They are expensive and require regular maintenance.

Sometimes, when there is a problem it takes a very long time before it is fixed due to lack of funds" (PP1)

Another respondent, though admitting the integration of technology shares his frustration:

"Occasional technical difficulties can be frustrating, imagine, trying to download content from the internet but you face network challenges, but the benefits of using assistive technologies far outweigh these drawbacks." (PP9)

The responses further indicated that even with the availability of the technology, teachers' ability to use them efficiently could be a challenge. One respondent indicated that:

"Ongoing training for teachers is essential. Though we do not have sophisticated assistive technologies, even having them could still pose a problem because we need to be proficient in using these technologies in order to support our students effectively." (PP29)

4.1.6.4 Evaluating Effectiveness

Teachers evaluate the effectiveness of assistive technologies in enhancing student learning through various methods by monitoring student progress and engagement, feedback and self-assessments.

Respondent PP1 stated:

"I monitor student progress and engagement during lessons to assess the effectiveness of assistive technologies." (PP1)

On his part, Respondent PP9 said:

"Formative assessments help us gather feedback on how well students are using the technologies and whether they are meeting learning objectives." (PP9)

Another respondent in the inclusive school corroborated the earlier views. She noted:

"We use student feedback and self-assessments to evaluate the impact of the technologies on learning. This helps us make necessary adjustments." (PP26)

Another respondent said:

"Improvements in student performance and participation are clear indicators of the effectiveness of assistive technologies." (PP29)

Teachers in inclusive and deaf classrooms reported their use of various assistive technologies to support student learning in science lessons. These technologies are essential in making the content accessible and engaging for all students. However, observations indicated a significant discrepancy between the reported and actual usage of these technologies.

4.1.7 Research Question 6: Which type of differentiated capacity-enhancing activities are organized for science teachers in the selected schools?

Research question six sought to explore the type of differentiated capacity-enhancing activities organized for science teachers in the selected school settings. From the views of the respondents, science teachers in the selected schools have access to various capacity-enhancing activities and professional development programmes aimed at improving their instructional practices. These activities include school-based INSET/ workshops, circuit-based INSET/ workshops, district-based INSET/ workshops, regional-based INSET/workshops, and national INSET/workshops.

Themes that emerged from the responses included Available Capacity-enhancing activities, perceived influence of capacity-enhancing activities on teachers' instructional practice, targeted activities that influence instructional ability, and Gaps in professional development needs.

4.1.7.1 Available Capacity-enhancing activities

Teachers shared their views of available capacity-enhancing activities which were organized as school-based, district-based, regional-based and some at national levels.

Below are views of the some of the respondents. For instance, respondent PP1 remarked:

"We frequently have school-based INSET/workshops, which are great for addressing the specific needs of our school. These workshops allow us to focus on particular challenges we face and develop strategies that are tailored to our context. Some of these workshops are organized by the district on circuit basis and we are able to learn from colleagues in other schools within our circuit, broadening our perspectives. These sessions are invaluable for sharing ideas and gaining insights from other teachers who are dealing with similar issues" (PP1)

Another respondent added:

"District-based workshops which are normally organized by service providers provide a platform for sharing experiences and learning new strategies from other schools in the district. It's a great way to see what's working in different settings and bring those ideas back to our own classrooms. We also take part in regional workshops which expose us to the latest educational trends and innovations, which we can then apply in our classrooms. These sessions often feature expert speakers and provide us with cutting-edge information and techniques" (PP10)

Another noted that they have access to workshops organized at the national level. He said:

"National INSET/workshops offer valuable insights and exposure to best practices on a larger scale. They help us stay aligned with national educational standards and policies, and we get to network with educators from across the country." (PP4)

Respondent PP6 shared his views on attending training sessions at different levels, noting the benefits of these training activities. He noted:

"We have access to various workshops at different levels, which helps in continuous professional development. Each level of workshop offers something unique, from localized problem-solving to broader educational trends. The diversity in training options ensures that we can find the right kind of support for our specific needs and challenges" (PP26)

4.1.7.2 Perceived Influence of Professional Development on Instructional Practices

These capacity-enhancing activities significantly influence the instructional practices of science teachers by providing them with new strategies, techniques, and resources to enhance their teaching. Respondents shared their views on the perceived influence of the available capacity enhancing activities on their instructional practices.

"Participating in these workshops keeps us updated with the latest educational practices and pedagogical strategies. We learn about new approaches and methodologies that we can incorporate into our teaching to make our lessons more effective and engaging." (PP4)

On her part, PP18 noted that:

"The knowledge gained from these sessions allows us to incorporate new teaching methods, like inquiry-based learning and digital tools. These methods have made a big difference in how students engage with the material and understand complex concepts." (PP18)

Another participant said:

"Workshops help us stay current and bring innovative ideas back to our classrooms, improving student engagement. The opportunity to collaborate and discuss what works, and what doesn't, is incredibly valuable. The hands-on nature of these sessions means we can immediately apply what we've learned." (PP20)

Another respondent added:

"Regular participation in professional development activities ensures we are continuously improving our teaching skills. This ongoing development is crucial for maintaining high standards in education and adapting to meet the challenges of dealing of inclusive classroom situations." (PP28)

4.1.7.3 Targeted Activities that Improved Teachers Instructional Ability

Teachers identified technology integration, differentiation classroom management and hands-on practical activities as some specific training and activities that have significantly improved their ability to teach science effectively. Some of the respondents shared their experiences with specific training or activities:

A respondent shared his views:

"Workshops on integrating technology in the classroom have been extremely helpful in making my lessons more interactive. We've learned how to use various digital tools to enhance student learning and engagement." (PP13)

Another indicated that:

"Training on differentiated instruction has enabled me to better address the diverse learning needs of my students. This has been particularly useful in creating inclusive lesson plans that cater to all students." (PP14)

PP14 added that:

"Sessions on classroom management and student engagement strategies too have provided valuable insights. These have helped me maintain a positive learning environment where students feel supported and motivated." (PP14)

Another respondent shared his experiences after attending a workshop on science practical activities. He noted that:

"The focus on practical, hands-on activities during workshops has enhanced my ability to teach complex scientific concepts. By incorporating more experiments and interactive elements, students are more engaged and understand the material better." (PP16)

Another respondent shared his views:

"Workshops on using digital resources have significantly improved my instructional practices. I am more confident in integrating online simulations and interactive modules into my lessons, which have been very effective." (PP29)

4.1.7.4 Gaps in Professional Development Needs

Despite the availability of professional development activities, the respondents admitted that there were gaps that needed to be catered for. The teachers were of the view that these gaps if filled, would further support their professional growth as science teachers.

The respondents shared their views in the following excerpts:

"We need more specialized training in advanced laboratory techniques and safety protocols. This would enable us to conduct more sophisticated experiments and ensure a safe learning environment for our students." (PP19)

Another respondent indicated that:

"Workshops on special education strategies would help us better support students with special needs. Understanding how to adapt our teaching to meet the needs of these students is crucial for their success." (PP26)

Another respondent noted:

"More opportunities for hands-on training and real-world applications in science teaching would be beneficial. This practical experience is invaluable for developing effective teaching methods and engaging students." (PP30)

4.2 Results of Lesson Observation

The Science Teacher Instructional Practices Observation Protocol (STIPOP) is a structured rubric for rating classroom science instruction. It covers domains like lesson planning, classroom culture and student engagement, use of materials and resources, student collaborative work, Inclusion and differentiation and use of assistive technology devices.

Field notes from 30 science lessons (16 from regular, 5 from inclusive, and 9 from Deaf basic schools) were collected using STIPOP. Observations documented teacher actions, student questions, materials used, and any accommodations for diverse learners. Thematic analysis was conducted on these notes, coding for recurring patterns related to pedagogical approach, student engagement, inclusion strategies, and use of assistive/adaptive tools. Common categories (e.g. *teaching style, interaction pattern, adaptive practices, resource use*) were identified inductively.

Qualitative descriptors (“most teachers,” “a few observed,” “frequent”/“rare”) were used below to indicate prevalence of a practice in the sample.

Predominantly Teacher-Centered Instruction

Nearly all lessons were led by the teacher, who provided explanations, wrote on the board, and asked factual questions. In most classrooms observed, teachers occupied the center stage they posed questions expecting learner responses and relied on textbooks or lectures. They mostly wrote notes on the board and paused intermittently to explain the chalkboard/markerboard notes.

Limited Inquiry-Based Learning

Observations revealed that, hands-on or investigative activities were infrequent. Only a few teachers (all in inclusive schools) guided students through simple experiments or hands-on tasks. For instance, Teacher PP27 (Inclusive School) asked, “*if we pour the salt solution onto the filter paper in the funnel, what do you think will happen?*” (field notes). This was unusual: in most lessons, demonstrations or student experiments did not occur. When activities did happen, they were typically teacher-driven (e.g. the teacher demonstrating an activity rather than students doing it).

Hands-on activities were very infrequent, as in most lessons student activities did not occur. When activities happened, they were teacher driven (example, the teacher demonstrating an activity rather than students doing it).

Classroom Interaction and Student Engagement

In all settings, teacher talk dominated the discourse. Students mostly responded to direct prompts or recited known facts. Group discussions were rare except in a few regular classrooms where teachers encouraged small groups to brainstorm new ideas through ‘think-pair-share.’ In most classes across the three settings students typically

sat silently in rows except in in some few cases: for example, Teacher PP4 (Deaf) had his students seated in a semi-circular form. In Deaf schools, interaction took place through sign language; teachers called on students one-by-one to sign answers. A recurring observation in the Deaf school was the teacher's careful monitoring of comprehension. Whole-class student-student dialogues were minimal in all contexts. Questions that went beyond recall were infrequent; only occasionally did a teacher ask students to justify or predict. When such questions occurred, it was mostly in inclusive settings. Frequent student questions or debates were generally absent. This pattern – a largely teacher-led classroom with limited open-ended student participation – fits existing characterizations of Ghanaian science classrooms.

Use of Multilingual and Inclusive Language Strategies

Many teachers used both local language and English language as languages of instruction. In the inclusive and deaf school settings, these languages were used alongside Sign Language either by the teachers themselves or through interpreters. In more than half of the observed lessons in the regular and inclusive classrooms teachers explained key terms in the local language. It was also observed in the Deaf and Inclusive classrooms that most of the teachers highlighted works on the marker board. Such multilingual adaptation was meant to include all learners in the lessons.

Use of Visuals and Hands-on Materials and Other Resources

Quite a number of the teachers incorporated concrete materials into their instructions, though most of them did not allow students to interact with such materials. In most cases, these materials were used for demonstrations, where learners just observed the ongoing activities. For instance, Teacher B2 (Inclusive) used beakers, funnel and filter

paper to demonstrate filtration to students. Teachers in Deaf classrooms also relied heavily on large marker board illustrations and drawings.

4.3 Discussion of Results

The purpose of this study was to examine the instructional practices of science teachers in selected Regular, Inclusive and Deaf basic schools in Ghana. The results reveal categories of teacher qualification, instructional practices, access to professional development activities and technology integration into their instructions.

4.3.1 Academic and Professional Qualifications of Science Teachers Across Regular, Inclusive, and Deaf Schools

The study found that the respondents had varied academic qualifications, from Diplomas to Master's Degrees in Education, influencing their preparation for teaching science. Half of the respondents felt their qualifications provided a solid foundation in educational theories and scientific knowledge, while others needed more practical training in teaching, classroom management, and differentiated instruction. Participation in professional development programs was crucial for enhancing teaching skills and staying updated with educational practices. Most respondents had attended workshops on digital tools, inquiry-based learning, and other innovative methodologies, which they found beneficial for transforming their teaching approaches and integrating technology.

Many acknowledged their qualifications as adequate but stressed the need for continuous improvement to stay current with educational trends and pedagogical strategies, particularly in managing diverse classroom environments.

Koirala et al., (2020) found that teachers with higher qualifications and targeted training were more adept at employing effective teaching methods, materials, and

evaluations, leading to better student engagement and understanding. This supports the current study's finding that respondents with higher qualifications felt better prepared to teach science, emphasizing the importance of academic background in shaping teaching effectiveness. Additionally, the emphasis on the need for practical training in classroom management and differentiated instruction among respondents aligns with the findings of Koirala et al., (2020) that well-trained teachers positively influence student achievement.

Mat Salleh et al., (2020) explored the impact of a STEM Facilitator Training Program on trainee teachers and found significant improvements in their ability to deliver content, manage classrooms, and engage students effectively. This finding resonates with the current study, where respondents highlighted the benefits of participating in professional development programs, particularly in learning new teaching methodologies and integrating technology. Both studies underscore the critical role of ongoing professional development in enhancing teaching skills and confidence.

Pringle et al., (2020) also highlighted the importance of comprehensive professional development programs in improving middle school science teachers' knowledge and instructional practices. The current study's respondents similarly reported that workshops on digital tools and inquiry-based learning were transformative for their teaching approaches. This alignment underscores the importance of structured professional development in keeping teachers updated with the latest educational trends and innovations.

Shana and Abulibdeh (2020) demonstrated that practical work significantly improved student achievement in science. This finding suggests that the respondents' identified need for more practical training in teaching is well-founded. The empirical evidence

indicates that hands-on experiences are crucial for effective science instruction, supporting the current study's call for enhanced practical training for teachers. Fitzgerald et al., (2020) examined the discrepancies between student and teacher perceptions of teaching practices. They found a significant gap between how teachers viewed their performance and how students perceived their classroom experiences. This finding suggests that while some respondents in the current study felt well-prepared, there may be a disconnection between their self-assessment and actual classroom effectiveness. This discrepancy highlights the importance of continuous feedback and professional development to align teacher perceptions with student needs and outcomes. The findings by Hanley et al., (2020) align with the current study's emphasis on the importance of professional development. Hanley et al. (2020) demonstrated that professional development programs significantly improved primary school teachers' ability to deliver science education, which, in turn, enhanced student attainment and attitudes. This supports the current study's finding that professional development is crucial for continuous improvement and effective teaching in science.

The findings of the current study largely align with empirical literature, emphasizing the importance of higher qualifications, continuous professional development, and practical training in enhancing science teaching. However, the gap between reported qualifications and actual classroom effectiveness, as well as the underutilization of assistive technologies, highlight areas needing further improvement. Addressing these gaps through targeted professional development, continuous feedback, and better resource allocation can significantly enhance the quality of science education in inclusive and deaf classrooms.

4.3.2 Current Instructional Practices of Science Teachers in Basic Regular, Inclusive and Deaf Schools

Findings from the study indicate that lesson planning emerged as a clear strength across the observed teachers. The findings indicate that respondents considered several key factors important when planning their science lessons. They had performance indicators that were clearly stated and aligned with the curriculum, and these indicators were communicated to learners at the start of the lesson. This indicates that teachers in all settings took care to define what students should learn and ensured those goals matched the prescribed curriculum. Additionally, activities were logically sequenced and built on students' prior knowledge. Teachers also indicated appropriate teaching and learning materials to be used for delivery. Overall, the strong performance in lesson planning across all three school types means that teachers entered their classes with a solid roadmap for instruction. This aligns with Yacap (2022), who also found that detailed lesson planning was crucial among pre-service teachers, though areas such as affective domain objectives and motivational techniques needed further development. Similarly, Rutt and Mumba (2020) showed that instructional planning skills improved with the integration of language and literacy practices into science instruction, emphasizing the importance of comprehensive and detailed lesson planning.

Respondents highlighted the importance of using diverse teaching methods to make the subject matter comprehensible, including lectures, discussions, hands-on experiments, real-life examples, visual aids, and group work. This finding is consistent with Areepattamannil et al., (2020), who demonstrated that both teacher-directed and inquiry-based instructional approaches positively influence students' enjoyment of science. The variety of methods used to cater to different learning styles

and keep students engaged is also supported by Bumagat et al. (2023), who noted the importance of technology integration and printed modules during online teaching. This notwithstanding, the lesson observations revealed otherwise. Nearly all lessons were led by the teacher, who provided explanations, wrote on the board, and asked factual questions. In most classrooms observed, teachers occupied the center stage they posed questions expecting learner responses and relied on textbooks or lectures. They mostly wrote notes on the board and paused intermittently to explain the chalkboard/markerboard notes. This highlights the need for collaborative professional development to enhance diverse instructional abilities, as noted by Supeno et al. (2022). The findings further show that hands-on activities were very infrequent, as in most lessons observed, student activities did not occur. When activities happened, they were teacher driven (example, the teacher demonstrating an activity rather than students doing it).

Teachers' use of various assessment strategies, such as quizzes, assignments, practical tests, formative assessments, peer assessments, and self-assessments, to evaluate student learning outcomes and provide prompt feedback is supported by Wilsey et al., (2020). They found that frequent assessment informs future instruction, highlighting the evolving nature of assessment practices. The study's findings on the importance of prompt feedback and opportunities for reflection align with Saka and Inaltekin (2023), who emphasized the need for professional development to enhance questioning practices and promote deeper student engagement. Additionally, Bibon (2022) documented the positive correlation between differentiated instructional practices and learners' academic achievement, underlining the importance of tailored instruction. However, observations showed that these assessments were generally pen and paper type, except in the inclusive and deaf schools where teachers employed to a small

extent, some alternative assessment practices. Teachers in some occasions allowed students to sign responses, role play or write responses on the markerboard.

Overall, the findings align well with the empirical literature on instructional practices of science teachers in terms of planning, delivery, and assessment. The importance of detailed lesson planning, diverse teaching methods, and effective assessment strategies is consistently highlighted across various studies, reinforcing the need for continuous professional development and support to enhance instructional practices and improve student outcomes in science education.

4.3.3 Similarities and Differences in Instructional Practices of Science Teachers

The results indicate that across all three school settings, teachers were very apt in their lesson preparations. Again, teachers mostly relied on teacher centered traditional teacher approaches; they mostly wrote notes on the board and paused intermittently to explain the chalkboard/markerboard notes. However, in the inclusive and deaf schools, the involvement of students in the lessons was higher than that observed in the regular school.

One of the key findings of this study was the use of adaptive teaching methods in inclusive schools, which catered to the learning needs of their students. Teachers used such strategies as total communication and visual emphasis as adaptive strategies. Though a lot more strategies could be employed to meet the needs of the inclusive classroom, the results is corroborated by Anyetei et al. (2019), who found that the implementation of inclusive education often requires the integration of multimedia technologies and continuous professional development for teachers. These adaptive strategies are crucial for effectively managing diverse classrooms and ensuring that all students have equitable access to education.

Lindner et al. (2021) also support these findings, noting that differentiation practices are extensively used in special school classes. Their study found that these practices are essential for addressing the diverse needs of students, similar to the adaptive methods observed in inclusive schools in the current study. Both studies highlight the importance of tailored instructional strategies to meet the unique needs of students in inclusive settings.

Though respondents admit the significance of differentiation, stating a lot of strategies, the lesson observations revealed their use to just a small extent. For instance, using a lot of visual aids, using think-pair-share, flexible pacing and alternative assessment were observed. This discrepancy observed aligns with findings by Lindner et al. (2019), who reported a discrepancy between teachers' self-perceptions of their inclusive practices and the students' actual experiences. While teachers believed they were effectively applying inclusive methods, students did not perceive these practices to be as prevalent. This gap suggests a need for ongoing professional development and better alignment between teachers' intentions and students' experiences.

Additionally, Spektor-Levy and Yifrach (2019) pointed out that despite teachers' willingness to adapt their methods for inclusive education, there are significant barriers such as lack of support and resources. These barriers were also evident in the current study, where teachers in inclusive schools faced challenges in adapting methods to meet a wide range of disabilities, requiring constant customization and flexibility.

The current findings on the instructional practices in deaf schools showed a heavy reliance on visual aids and sign language, tailored specifically to the needs of deaf

students. This aligns with the findings of Atika et al. (2023), who highlighted the necessity for targeted training programs and professional development to equip teachers with the skills needed to effectively teach deaf and hard-of-hearing (DHH) students. Both studies underscore the critical role of specialized communication methods and the need for ongoing support and training for teachers in these settings.

Raven and Whitman (2019) also found a broad spectrum of teaching strategies for DHH students, including visual aids and hands-on activities. However, they noted inconsistencies in the application of these strategies across different classrooms, pointing to a systemic issue in educational training. This inconsistency echoes the current study's findings, where despite respondents' indication of the use of assistive technology, observations showed that most of the technology mentioned were not used during lesson implementations.

The current study found that teachers in regular schools primarily rely on lecture-based teaching with some interactive activities. This contrasts with the findings of Kelly et al. (2020), who highlighted significant instructional variance influenced by demographic characteristics and teacher sorting. This suggests that instructional practices in regular schools can vary widely, whereas the current study indicates a more uniform reliance on traditional methods.

The extent of resource utilization also presents a difference. While the current study identified a lack of tools and resources in regular schools as a significant challenge, Raven and Whitman (2019) found that even within specialized settings for DHH students, there is an inconsistency in the use of available teaching strategies. This highlights a broader systemic issue regarding the allocation and effective use of resources across different types of schools.

The alignment of the current study with existing literature underscores the importance of adaptive teaching practices and ongoing professional development. To address the identified challenges, it is essential to enhance teacher training programs and provide continuous professional development focused on inclusive education strategies and specialized teaching methods. Additionally, there should be an emphasis on bridging the gap between teachers' self-perceptions and students' experiences through regular feedback and assessment.

4.3.4 Extent to which Science Instructional Approaches are Differentiated for Learners in Inclusive Classrooms

The study revealed that teachers in inclusive classrooms differentiated their lessons just a small extent. Though respondents admitted the significance of differentiation, stating a lot of strategies for differentiation, the lesson observations revealed their use to just a small extent. For instance, they used a lot of visual aids, appropriate seating, flexible pacing and alternative assessment during instructions. However, the use of individualized instructions, videos, interactive apps and other resources were barely observed. and technology integration. This might be as a result of lack of special competencies on the part of teachers of non- existence of resources, which confirms Anyetei et al., (2019) report of deficiency in teacher expertise in Ghana's inclusive education.

The current findings align with Bacosa and Caballes (2022), who highlight the importance of teacher qualifications in adapting instructional strategies. Teachers' use of diverse strategies and continuous feedback in the study suggests that their educational background and professional development play crucial roles in effectively managing inclusive classrooms. Similarly, Atika et al. (2023) emphasized visual aids

and hands-on activities for DHH students, which align with the current findings where visual aids and technology are used to engage students. Both studies underscore the necessity of tailored strategies to meet specific learning needs and the importance of professional development for teachers.

Adu-Boateng and Goodnough (2021) discussed the tensions in balancing individual needs with classroom order, aligning with the current findings regarding the challenges teachers face. Both studies suggest that frameworks supporting adaptable teaching methods are essential for effective inclusive education. Similarly, Raven and Whitman (2019) noted the variability in instructional strategies for deaf students, reflecting the adaptive approaches noted in the current study. This alignment underscores the necessity for flexible teaching methods to address diverse sensory engagement needs.

Le Hanie et al., (2023) highlighted the need for inclusive digital education strategies, particularly in the context of the COVID-19 pandemic's impact on hearing-impaired students. This aligns with the current findings where technology integration is crucial in inclusive classrooms, emphasizing the importance of robust and adaptable educational practices. Alsalem and Alzahrani (2023) provide a critical analysis of support services and regulations in Saudi Arabia, aligning with the challenges noted in the current study regarding resource limitations. Both studies highlight the need for enhanced support systems and clear policies to facilitate effective inclusive education.

Torigoe (2019) described a co-enrollment project in Japan involving environmental modifications and sign language teaching, aligning with the current findings of using diverse strategies to meet students' needs. Both studies emphasized the benefits of

intentional modifications and inclusive practices in creating equitable learning environments.

Though the empirical literature highlights the effective use of differentiated instructional strategies in inclusive classrooms yields benefits to learners, findings of this study show that the extent to which science teachers in the inclusive school differentiate lessons is low. This underscores the importance of professional development, resource allocation, and adaptable teaching methods in managing diverse learning needs

4.3.5 Types of Assistive Technologies Utilized for Science Lessons

The study identified a variety of assistive technologies used in inclusive and deaf classrooms to support science lessons, such as digital hearing aids, computers, mobile phones, and large board illustrations. However, a significant discrepancy was observed between the reported and actual usage of these technologies, with the sign language charts and manuals being the most common. While teachers integrate these technologies into lesson plans to enhance student engagement and participation, actual usage during lessons was limited. This gap suggests that barriers such as cost, maintenance, and the need for ongoing training hinder effective implementation. Teachers also mentioned methods for evaluating the effectiveness of these technologies, yet observations indicated infrequent evaluations, highlighting the need to address these barriers to fully realize the benefits of assistive technologies. The study further found that pen and paper communication is very predominant in both the inclusive and deaf schools.

The findings align with Taylor, Lohmann, and Kappel (2020), who emphasize the critical need for ongoing teacher education in assistive technology (AT) to enhance

curriculum access for students with disabilities. The discrepancy between reported and actual usage of AT in the current study underscores the necessity for better teacher preparation and ongoing professional development.

Similarly, Sugiman et al. (2022) conducted research on sign language video lectures for deaf students, showing the effectiveness of such technologies in enhancing engagement and comprehension. This aligns with the current study's findings on the potential benefits of assistive technologies like hearing aids, although the actual usage observed was limited. Both studies advocate for broader adoption and better implementation of such technologies to improve accessibility and educational outcomes.

Caldwell (2019) discussed the role of various assistive and instructional technologies in facilitating educational access, aligning with the current findings that highlight the importance of these technologies in inclusive classrooms. However, the observed underutilization in the current study suggests a gap in effective implementation, reflecting Caldwell's emphasis on the need for educators to be well-versed in these technologies.

Zilz and Pang (2019) review the significant gap in teacher preparation for effective technology integration, which aligns with the current study's observation of limited actual usage of assistive technologies despite reported extensive use. Both studies suggest that while assistive technologies are beneficial, better teacher training and preparation are essential for maximizing their impact in inclusive classrooms.

Evmenova (2020) emphasized the need for coordination, collaboration, and situated training for successful AT integration, aligning with the current findings that highlight

challenges such as cost, maintenance, and the need for ongoing training. Both studies stress the importance of overcoming these barriers to ensure equitable learning opportunities and effective use of assistive technologies.

Chambers (2020) explored the dual function of AT in promoting social interaction and curriculum access, supporting the current study's findings on the potential benefits of assistive technologies in engaging and supporting students. The observed underutilization in the current study, however, suggests that these benefits are not fully realized, emphasizing the need for improved implementation strategies and teacher training.

Stinson and Nikolarazi (2020) discuss technologies assisting deaf and hard-of-hearing individuals, highlighting the importance of technologies like captioning and enhanced auditory devices in educational settings. This aligns with the current findings that hearing aids were the primary technology observed in use, indicating the crucial role of such devices in supporting these students, even though other assistive technologies were underutilized.

Park et al., (2021) evaluated the impact of assistive technology training in teacher preparation programs, highlighting the positive impact on teachers' confidence and attitudes towards using AT. This aligns with the current study's emphasis on the need for ongoing training and professional development to enhance the effective use of assistive technologies in classrooms.

Pinheiro et al., (2022) study the challenged of adapting to hybrid teaching modes for deaf students during the COVID-19 pandemic, highlighting gaps in teacher training for remote learning scenarios. This aligns with the current study's findings on the need

for better teacher preparation and ongoing training to effectively use assistive technologies, especially in evolving educational landscapes.

Albalhareth and Saleem (2023) assessed teacher satisfaction with the availability and use of assistive technologies in Saudi Arabia, highlighting the need for improved provision and implementation of AT and teacher training. This aligns with the current findings on the underutilization of assistive technologies and the need to address barriers such as cost, maintenance, and training to fully realize the potential benefits of AT in inclusive classrooms.

4.3.6 Capacity-Enhancing Activities for Science Teachers

The study revealed that science teachers in the selected schools had access to a variety of capacity-enhancing activities and professional development programs. These programs, which range from school-based to national workshops (INSET), are essential for improving instructional practices. The teachers reported that these activities helped in localized problem-solving, idea sharing, and staying updated with educational trends and innovations. The influence of these capacity-enhancing activities is significant, as teachers incorporate new strategies and methodologies such as inquiry-based learning and digital tools, which enhance student engagement and comprehension. Furthermore, these activities foster a supportive community among educators, promoting the exchange of best practices and collaborative problem-solving.

The findings align with Abonyi et al., (2020), who found that support from head teachers and peers, shared norms and values, student interest, and availability of teaching materials significantly contribute to the effectiveness of professional development. The current study's finding that teachers benefit from localized

problem-solving and idea sharing during INSET programs is consistent with Abonyi et al.'s emphasis on supportive factors. However, both studies also identify challenges such as high teacher workloads and resource limitations that hinder successful implementation, highlighting the need for enhanced infrastructures and support.

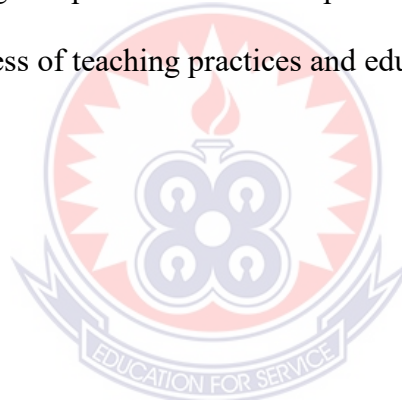
Pasman (2023) conducted research showing that school-based INSET significantly enhances teachers' skills in lesson preparation and planning. This aligns with the current study's findings that localized, hands-on training approaches are effective in improving instructional practices. Both studies emphasize the importance of tailored INSET programs that cater to the specific needs of teachers within their teaching environments, reinforcing the positive impact of such professional development activities.

The study also identified areas where additional capacity-enhancing activities are needed, such as advanced laboratory techniques, safety protocols, and special education strategies. This finding aligns with Azewara et al. (2021), who recommended differentiated INSET approaches at the district level to address disparities in teacher deployment and improve the quality of education in under-resourced rural areas. Both studies highlight the need for targeted professional development to address specific challenges and enhance the overall effectiveness of teaching practices.

Bukari et al. (2023) assessed the effectiveness of Ghana's TVET curriculum and suggested the necessity of regional INSET workshops focused on curriculum development. This aligns with the current study's findings on the need for ongoing, specialized support and regular refresher courses to keep up with advancements in science education. Both studies suggested that continuous professional development

and curriculum reforms are crucial for aligning education with industry needs and enhancing job readiness among students.

The findings on capacity-enhancing activities for science teachers generally align with the empirical literature. Both the current study and the literature emphasize the importance of professional development programs in improving instructional practices, fostering a supportive community among educators, and addressing specific educational challenges. However, the observed need for more specialized training and regular refresher courses indicates that ongoing efforts are necessary to ensure that teachers are fully equipped to meet the diverse needs of their students. Addressing these gaps through targeted professional development and infrastructure support will enhance the effectiveness of teaching practices and educational outcomes.



CHAPTER FIVE

SUMMARY, CONCLUSION, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

5.0 Introduction

In Chapter Five, the researcher presents the summary, conclusions, recommendations, and suggestions for further research derived from our study. This chapter synthesizes the key findings from the research, outlining the significant insights into how these elements collectively influence the efficacy of science education. Conclusions are drawn based on the analyzed data. Recommendations aimed at enhancing teacher effectiveness and student learning outcomes are offered. Additionally, the researcher proposes areas for further research, which are crucial for continuing to improve and adapt science education practices to meet the needs of all students across diverse educational settings. This final chapter aims to provide a comprehensive overview that can guide future policy decisions, educational programmes, and scholarly inquiries in the field of science education.

5.1 Summary

5.1.1 Academic and Professional Qualifications of Science Teachers Across Regular, Inclusive, and Deaf schools

The respondents exhibited varying levels of academic qualifications, significantly influencing their preparation for teaching science. Qualifications ranged from Diplomas to Master's Degrees in Education, with specializations in different areas of science. This diversity in academic background shaped their readiness to tackle the demands of teaching science in their current settings. Generally, half of the respondents felt that their academic qualifications adequately prepared them for

teaching science. They emphasized the solid foundation in educational theories and specific scientific knowledge provided by their degrees. However, some respondents felt the need for additional preparation, particularly in practical aspects of teaching, classroom management, and differentiated instruction.

Participation in professional development programs and training related to science education varied among respondents. These programs played a crucial role in enhancing their teaching skills and keeping them updated with the latest educational practices and technological advancements. The majority of respondents mentioned that they had participated in relevant professional development programs, ranging from workshops on digital tools in science education to training on inquiry-based learning and other innovative teaching methodologies. These programs were highlighted as beneficial in transforming teaching approaches, encouraging more student-driven investigations, and integrating technology into teaching.

Despite these academic and professional qualifications some respondents identified gaps that needed to be addressed through additional training or resources. A significant number of respondents felt that their qualifications were adequate but recognized the need for continuous improvement to stay current with educational trends and scientific advancements. Specific areas needing better preparation included handling diverse classroom environments and staying updated with new pedagogical strategies.

5.1.2 Current Instructional Practices of Science Teachers in Basic Regular, Inclusive and Deaf Schools

Lesson planning emerged as a clear strength across the observed lessons of respondents. They highlighted various factors they consider important when planning their science lessons, including adequate subject matter knowledge, sharing lesson objectives with learners, and using a variety of resources. Ten respondents expressed that their approach to planning science lessons is well-structured and effective. They prioritize deep understanding of the subject matter, ensuring lesson objectives are clear to students, and using a variety of resources such as textbooks, online materials, and hands-on activities. Planning is also about being well-prepared and anticipating potential questions or difficulties students might have. Observations confirmed these practices, showing that teachers communicated lesson objectives at the beginning of lessons and sequenced activities logically, ensuring each activity built on prior knowledge. Inquiry-based activities were included to engage students and provide opportunities to explore scientific concepts.

The good planning practices by teachers, notwithstanding, lesson implementations were mostly teacher centered in all three schools sampled. Nearly all lessons observed, teachers occupied the center stage; they posed questions expecting learner responses and relied on textbooks or lectures. They mostly wrote notes on the board and paused intermittently to explain the chalkboard/markerboard notes.

Teachers used a variety of assessment strategies, though mostly pen and paper type, to evaluate student learning outcomes, with an emphasis on providing prompt feedback. In the inclusive and deaf schools however, teachers adopted alternative assessment strategies such as signing responses, students writing responses on the

chalkboard/markerboard and role play. These methods allow teachers to gauge various aspects of student learning and adjust their teaching accordingly. Providing timely feedback helps students understand their mistakes and learn from them. Observations confirmed that teachers used formative assessments regularly and provided prompt and constructive feedback. Opportunities for reflection were also observed, allowing students to think critically about their learning process.

5.1.3 Similarities and Differences in Instructional Practices of Science Teachers

Teachers in regular schools primarily relied on lecture-based teaching with some interactive activities, following structured curricula with traditional methods. In contrast, inclusive school teachers used adaptive teaching methods to cater to a broad spectrum of learning needs. Teachers used such strategies as total communication where they combined oral language, sign language and lip reading, and visual emphasis as adaptive strategies. Deaf school teachers employed also employed highly visual teaching methods and sign language with some oral language, tailored specifically for their students, relying heavily on visual aids.

Regular schools faced challenges such as the lack of tools and resources or training to engage students in inquiry-based learning. Teachers struggled to balance curriculum demands with innovative approaches. Inclusive schools encountered challenges in adapting methods to meet learning needs, requiring constant customization and flexibility. Deaf schools' unique challenge was in the need for specialized communication technology devices, necessitating ongoing training and support for effective teaching.

5.1.4 Extent to which Science Instructional Approaches are Differentiated for Learners in Inclusive Classrooms

Teachers in inclusive classrooms differentiated their lessons just a small extent. Though respondents admitted the significance of differentiation, stating a lot of strategies for differentiation, the lesson observations revealed their use to just a small extent. For instance, they used a lot of visual aids, appropriate seating, flexible pacing and alternative assessment during instructions. However, the use of individualized instructions, videos, interactive apps and other resources were barely observed. and technology integration

Additionally, lesson plans were frequently modified to include activities that catered to various learning needs and levels of understanding, ensuring that every student had the opportunity to succeed.

Teachers also differentiated their assessments to a certain extent as other modes of representation by students were encouraged. For instance, students were allowed to sign their responses or role-play or write responses on the chalkboard/markerboard. Feedback was mostly prompt and positive.

However, implementing differentiated instruction had challenges, including time constraints, large class sizes, resource limitations, and managing classrooms with varying levels of understanding. Teachers often faced difficulties in providing individualized support and balancing curriculum requirements while ensuring all students keep up.

Overall, the thematic analysis reveals that science instructional approaches in inclusive classrooms were differentiated to a low level, highlighting the importance of

continuous adaptation and professional development to meet the needs of students in inclusive classrooms.

5.1.5 Types of Assistive Technologies Utilized for Science Lessons

Teachers in inclusive and deaf classrooms utilized various assistive technologies to support student learning in science lessons. Technologies such as computers, projectors, TV with captions, hearing aids and word prediction programs, were mentioned as essential tools to make the content accessible and engaging for all students. However, while teachers reported the extensive use of these technologies, observations indicated a significant discrepancy between the reported and actual usage, with hearing aids being the primary technology observed in practice.

Teachers described integrating assistive technologies into their lesson plans and instructional delivery to enhance the learning experience for students. Despite these claims, observations showed that these technologies were rarely used during actual lessons. While sign language charts and manuals were seen, mobile phones were rarely observed, while the other stated devices were never observed, though there were evidences possess TV sets and projectors. It was also evident in the observations that ‘paper and pen’ communication was predominant in both inclusive and deaf schools. This gap suggests that challenges such as cost, maintenance, and the need for ongoing training may hinder the effective implementation of assistive technologies. Teachers highlighted the benefits of these technologies, including increased student engagement and participation, but the underutilization observed suggests that these potential benefits are not fully realized.

5.1.6 Capacity-Enhancing Activities for Science Teachers

Science teachers in the selected schools had access to a range of capacity-enhancing activities and professional development programs aimed at improving their instructional practices. These included school-based, circuit-based, district-based, regional-based, and national INSET/workshops. Teachers highlighted the benefits of these activities, which provide opportunities for localized problem-solving, sharing ideas with colleagues, and staying updated with the latest educational trends and innovations. Such workshops are essential in addressing specific challenges, gaining new insights, and aligning with national educational standards.

The influence of these capacity-enhancing activities on instructional practices is significant. Teachers reported incorporating new strategies and methodologies learned from workshops, such as inquiry-based learning and digital tools, which have enhanced student engagement and comprehension of complex concepts. The professional development activities also foster a supportive community among educators, allowing for the exchange of best practices and collaborative problem-solving. These activities ensure continuous improvement in teaching skills and adaptability to new educational challenges.

However, there were areas where additional capacity-enhancing activities were needed. Observations indicated that teachers would benefit from more specialized training in advanced laboratory techniques, safety protocols, sign language training, adaptive pedagogy, inclusive assessment and assistive technology integration. Regular refresher courses are also essential to keep up with advancements in science education. Despite the benefits of current professional development activities, there is

a need for ongoing, specialized support to address gaps in training and ensure that teachers are fully equipped to meet the diverse needs of their students.

5.2 Conclusion

Science instruction in Ghana often suffers from inadequate teaching resources and rely heavily on teacher-centered instruction. The 2019 standards -based curriculum mandates inclusive and constructivist and inquiry-based teaching practice but its real-world implementation in regular, inclusive and deaf basic schools is unexplored. Therefore, this study was to examine the instructional practices of science teachers in selected Regular, Inclusive and Deaf basic schools in Ghana.

Generally, the study revealed that contextual factors (school type, teacher qualification, available resources) strongly influenced practice. Science teachers in the inclusive and Deaf settings made some efforts (e.g. role-plays, visual aids, sign language) to communicate concepts, echoing strategies documented elsewhere.

The study revealed that science teachers in regular, inclusive, and deaf schools possessed varying levels of academic qualifications, from Diplomas to Master's Degrees in Education with specializations in different science areas. About half of the respondents felt adequately prepared by their academic qualifications, emphasizing their solid foundation in educational theories and scientific knowledge. However, others expressed a need for further preparation, particularly in practical teaching aspects, classroom management, and differentiated instruction. Participation in professional development programs varied among respondents, with many highlighting the benefits of workshops and training sessions in enhancing their teaching skills and staying updated with the latest educational practices and technological advancements. While some teachers felt well-prepared, others identified

gaps that needed addressing through additional training or resources, particularly in handling diverse classroom environments and keeping up with new pedagogical strategies.

Teachers across regular, inclusive, and deaf schools highlighted several key factors in planning their science lessons, including adequate subject matter knowledge, sharing lesson objectives, and using diverse resources. The importance of being well-prepared and anticipating potential student questions or difficulties was also emphasized. Observations confirmed these practices, with teachers communicating lesson objectives at the beginning of lessons, sequencing activities logically, and incorporating inquiry-based activities to engage students. Teachers employed various teaching methods which were mostly teacher-centered to make the subject matter comprehensible to learners. Inquiry-based learning was rarely implemented as hands-on activities were infrequent. A variety of assessment strategies were used to evaluate student learning outcomes, with an emphasis on providing prompt feedback. Observations supported these findings, showing that teachers regularly used formative assessments and provided constructive feedback.

The study found significant differences in the instructional practices of science teachers across regular, inclusive, and deaf schools. Regular schools primarily relied on lecture-based teaching with some interactive activities, following structured curricula with traditional methods. Inclusive schools used some adaptive and differentiated teaching methods, to a small extent, to cater to the learning needs of students in inclusive schools. Deaf schools employed highly visual teaching methods and sign language tailored specifically for their students, relying heavily on visual aids. Challenges varied among the different school settings. Regular schools faced a

lack of tools and resources to engage students with diverse learning needs, while inclusive schools required constant customization and flexibility to adapt methods to meet a wide range of disabilities. Deaf schools faced the unique challenge of needing specialized communication methods and material, such as sign language and visual aids, necessitating ongoing training and support for effective teaching. Observations confirmed these findings, highlighting the commitment of teachers in all settings to adapt their methods and utilize available resources to engage students effectively.

Teachers in inclusive classrooms implemented differentiated instructions to a small extent as they used a lot of visual aids, appropriate seating, flexible pacing and alternative assessment during instructions. However, the use of individualized instructions, collaborative learning, videos, interactive apps and other resources were barely observed. and technology integration. Lesson plans were frequently modified to cater to various learning styles and levels of understanding. In their attempt at implementing differentiated instructions, teachers faced challenges such as time constraints, large class sizes, resource limitations, and managing classrooms with varying levels of understanding. Observations confirmed that teachers utilized some varied instructional methods, adjusted instructions based on student responses. Formative assessment strategies were observed, with teachers providing timely and constructive feedback.

The study revealed that teachers in inclusive and deaf classrooms utilized some assistive technologies to support student learning in science lessons, including mobile phone, sign language charts and manuals, projectors and TV with captions. However, observations indicated a significant discrepancy between the reported and actual usage of these technologies, with sign language charts and manual, and mobile phones

being the primary technology observed in practice. Teachers described integrating assistive technologies into their lesson plans and instructional delivery, but observations showed these technologies were rarely used during actual lessons. Challenges such as cost, maintenance, nonavailability and the need for ongoing training were identified as barriers to the effective implementation of assistive technologies.

Science teachers in the selected schools had access to various capacity-enhancing activities and professional development programs aimed at improving their instructional practices. These included school-based, circuit-based, district-based, regional-based, and national INSET/workshops. Teachers highlighted the benefits of these activities, which provided opportunities for localized problem-solving, sharing ideas with colleagues, and staying updated with the latest educational trends and innovations. The influence of these activities on instructional practices was significant, with teachers incorporating new strategies and methodologies learned from workshops, enhancing student engagement and comprehension of complex concepts. However, additional specialized training in advanced laboratory techniques, safety protocols, sign language training, adaptive pedagogy inclusive assessment and assistive technology use. Regular refresher courses were also essential to keep up with advancements in science education. Despite the benefits of current professional development activities, there was a need for ongoing, specialized support to address gaps in training and ensure that teachers were fully equipped to meet the diverse needs of their students.

This study contributes to and extends existing knowledge in several ways. First, it provides detailed empirical insight into science pedagogy in three contrasting

Ghanaian settings, a scope not found in previous work. Most prior research has focused on policy analysis or isolated case reports (often a single school setting). By comparing a regular, an inclusive, and a deaf school, the present research reveals context-specific pedagogical realities.

For instance, it confirms that mainstream classes tend to remain exclusionary in practice, whereas special and inclusive schools make more deliberate (though inconsistent) accommodations. Second, the findings illuminate new empirical gaps and patterns. The unanimous lack of dual-qualified teachers in inclusive/Deaf settings is a stark addition to Ghana's literature, reinforcing the call for integrated Science–Special Education training. Also, this study shows that teachers do strive to be resourceful (e.g. local language use, UDL principles even under strain, suggesting that models of inclusive pedagogy must account for grassroots innovation in resource-limited contexts.

Inclusive science instruction in Ghana is both a pressing need and a feasible goal, but it hinges on continuous and systemic support. This calls for targeted in-service training in inclusive pedagogy and sign language for scientific content. Classrooms should be equipped with accessible science materials and visual aids to improve inquiry-based science teaching. Low-cost solutions (e.g. locally made models, picture cards) and technology (videos with captions, simulation apps) can help meet the needs of Deaf and other learners. Inclusive implementation requires collaborative structures, deaf schools and regular schools should share expertise, and policy should formalize team-teaching (teachers plus interpreters/resource teachers) as an inclusive science norm.

5.3 Recommendations

Given that this research was a case study of four basic schools, it is important to take cognisance that the conclusion discussed and recommendations that follow may not be generalisable to all basic schools in Ghana. However, both conclusion and recommendations may have implications for science teaching in the sampled schools.

Based on the findings of the study, the following recommendations are made:

- a. Science teachers in St. Joseph Catholic R/C school should be supported with practical training workshops that emphasize inquiry-based and student-centered teaching approaches. The school should also be provided with basic science kits and ICT tools to move beyond lecture methods. Furthermore, targeted workshops on basic inclusive practices will help teachers address occasional learners with mild special needs. The head teacher, through monitoring should ensure that science teachers should implement instructions based on the lesson notes prepared.
- b. Science teachers in the Deaf School and Inclusive School should undergo continuous sign language training, with emphasis on scientific vocabulary development. The schools should establish a repository of signed science materials (videos, visual resources) to enhance teaching. Investment should be made in visual and tactile science equipment (e.g., models, lab kits adapted for learners with deafness) and digital visual resources. Specialized professional development workshops tailored to science teaching in deaf education should be prioritized to improve teacher confidence and instructional effectiveness.
- c. Teachers in the inclusive school should receive sustained professional development in inclusive pedagogy, particularly in differentiated science instruction. The head of the school should collaborate with stakeholders to support

the school with reliable assistive technologies (captioned videos, tactile resources, projectors) and dedicated sign language interpreters for science classes. Additional teaching assistants are needed to relieve the heavy burden on science teachers, and time should be allocated for teachers to prepare adapted lesson materials.

- d. Institutions of higher learning like the University of Education, Winneba and the University of Cape Coast could integrate special education course into their science education programs to train science teachers who could effectively teach science at inclusive and deaf school settings.

5.4 Suggestions for Further Research

- a. To deepen the understanding and effectiveness of science education across diverse educational settings, future research could explore several key areas:
- b. Conduct longitudinal studies to assess the long-term effects of professional development on teacher performance and student outcomes in science education. This research could track changes over time, providing insights into how sustained professional development affects teaching practices, particularly in inclusive and specialized settings such as deaf schools.
- c. Implement comparative studies to evaluate the effectiveness of different instructional methods across regular, inclusive, and deaf school settings. Such studies would provide a clearer understanding of how specific teaching strategies impact student learning and engagement across diverse educational environments, potentially leading to more tailored educational practices. Investigate the effectiveness of various assistive technologies in enhancing educational outcomes for students with specific learning needs, including auditory, visual, and motor challenges. This research could help identify which technologies are most beneficial for different types of learning disabilities and

how they can be integrated more effectively into everyday classroom activities.

- d. Explore the barriers to participation in INSET workshops, particularly at the regional level. This research should examine logistical, financial, and motivational factors that affect teachers' ability to attend and benefit from professional development opportunities. Understanding these barriers can lead to improved strategies for increasing teacher participation and engagement in professional development across various regions.



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APPENDICES

APPENDIX A: INTERVIEW GUIDE

UNIVERSITY OF EDUCATION, WINNEBA

SCHOOL OF GRADUATE STUDIES

FACULTY OF SCIENCE EDUCATION

This instrument seeks information on science teacher instructional practices in regular, inclusive and deaf basic schools. Your candid response is very valuable and will be much appreciated. Your response will be treated as confidential and will help the researcher gather the needed data for the study.

Research Question 1: To what extent are the personnel in the selected schools academically and professionally qualified to facilitate science instructions?

1. What academic qualifications do you possess, and how have they prepared you for teaching science in your current setting?
2. Can you describe any professional development or training programs you have participated in that are related to science education?
3. How do you perceive the adequacy of your academic and professional qualifications in meeting the demands of teaching science in this school?
4. What additional qualifications or training would you consider beneficial for enhancing your science teaching skills?

Research Question 2: What are the current instructional practices of science teachers in terms of planning, delivery, and assessment?

1. Can you describe your approach to planning science lessons? What factors do you consider most important?
2. What teaching methods do you typically use when delivering science lessons, and why do you choose these methods?
3. How do you assess student understanding and progress in your science classes?
4. How do you adapt your instructional practices to cater to the diverse learning needs of your students?

Research Question 3: What are the similarities and differences in science teachers' instructional practices among Regular, Inclusive, and Deaf Basic schools?

1. Can you compare the instructional practices you use in your current setting with those you have observed or used in other school types (Regular, Inclusive, Deaf)?
2. What unique challenges do you face in teaching science in this school compared to other school types?
3. How do you adapt your teaching methods to address the unique needs of students in your school?
4. Can you describe any unique strategies or resources that are particularly effective in teaching science in your school?

Research Question 4: To what extent are the science instructional approaches differentiated for learners in inclusive classrooms?

1. What specific strategies do you use to differentiate science instruction for students with diverse learning needs?
2. Can you provide examples of how you modify lesson plans or instructional materials to accommodate all learners?
3. How do you assess the effectiveness of your differentiated instructional approaches in science?
4. What challenges do you encounter when implementing differentiated instruction in your science classroom, and how do you address them?

Research Question 5: Which type of assistive technologies are utilized for science lessons in inclusive and deaf classrooms?

1. What assistive technologies do you use in your science lessons, and how do they support student learning?
2. Can you describe how you integrate assistive technologies into your lesson plans and instructional delivery?
3. What are the most significant benefits and challenges you have experienced with using assistive technologies in your science classroom?
4. How do you evaluate the effectiveness of assistive technologies in enhancing student learning in science?

Research Question 6: Which type of differentiated capacity-enhancing activities are organized for science teachers in the selected schools?

1. What types of capacity-enhancing activities or professional development programs are available to you as a science teacher in this school?
2. How do these capacity-enhancing activities influence your instructional practices in science?
3. Can you describe any specific training or activities that have significantly improved your ability to teach science?
4. What additional capacity-enhancing activities do you believe would further support your professional growth as a science teacher?



**APPENDIX B: SCIENCE TEACHER INSTRUCTIONAL PRACTICE
OBSERVATION PROTOCOL (STIPOP)**

OBSERVATION PROTOCOL

**SCIENCE TEACHER INSTRUCTIONAL PRACTICES OBSERVATION
PROTOCOL (STIPOP)**

**UNIVERSITY OF EDUCATION, WINNEBA
SCHOOL OF GRADUATE STUDIES
FACULTY OF SCIENCE EDUCATION**

Section A: General Information

Teacher's Name: _____

School: _____ Class: _____

Topic/Sub-strand: _____ Date:

Time: _____

B. Lesson Planning

S/N	Indicator	Yes	No	Comments
1.	Lesson objectives clearly stated and aligned with curriculum			
2.	Objectives communicated to learners at the start of lesson.			
3.	Lesson plan incorporates inquiry and hands-on activities.			
4.	Activities are logically sequenced and clearly build on prior knowledge			
5.	Teacher prepared with appropriate teaching/learning materials.			

C. Classroom Culture & Student Engagement

	Indicator	Strong	Adequate	Weak	
6.	Classroom climate is respectful and inclusive.				
7.	Students are actively engaged in learning tasks.				
8.	Teacher encourages student participation through questioning.				
9.	Smooth transitions between activities.				

D Smooth transitions between activities.					
	Indicator	Excellent	Satisfactory	Needs Improvement	
10.	Use of inquiry-based methods (asking questions, predicting, experimenting).				
11.	Application of real-life/local examples to explain scientific concepts.				
12.	Use of multiple representations (diagrams, charts, models, digital resources).				
13.	Encourages critical thinking and problem-solving.				
E Student Collaborative Work					
	Indicator	Strong	Adequate	Weak	Comment
14.	Students are given opportunities to work collaboratively in groups.				
15.	Group tasks promote shared responsibility and peer learning.				
16.	Collaboration reflects inquiry and problem-solving approaches.				
17.	Teacher facilitates group dynamics and ensures participation from all members.				
F Use of Materials & Resources					
	Indicator	Yes	No	Comment	
18.	Science materials/resources available and accessible.				
19.	Teacher uses materials effectively to support learning.				
20.	Safety procedures followed during experiments				
21.	Use of ICT/digital tools (where available) to enhance science learning.				
G Inclusion & Differentiation					
	Indicator	Yes	No	Comments	
22.	Instruction adapted for students with diverse needs (e.g., learners with deafness, slow learners).				

23.	Participation encouraged for all learners regardless of ability.			
24.	Strategies observed to support students with disabilities.			
25.	Teacher demonstrates gender-sensitive and equitable practices.			
H	Use of Assistive Technology Devices for Deaf Learners			
	Indicator	Yes	No	Comments
26.	Teacher uses assistive technologies (e.g., hearing aids, FM systems, captioning tools)			
27.	Assistive devices are integrated into lesson delivery to enhance participation.			
28.	Students are supported in operating or accessing assistive devices effectively			
29.	Lesson content is adapted for visual representation (e.g., sign language, diagrams).			
I	Assessment for Learning			
	Indicator	Yes	No	Comments
30.	Teacher checks student understanding throughout the lesson.			
31.	Assessment tasks aligned with lesson objectives.			
32.	Feedback provided to students is timely and constructive.			
33.	Students encouraged to self-assess or peer-assess.			
J	Lesson Closure & Reflection			
34.	Indicator	Yes	No	Comments
35.	Lesson objectives reviewed with students.			
36.	Key points summarized and reinforced.			
37.	Homework/extension activity assigned (if appropriate).			
38.	Teacher reflects on lesson (observed in post-conference).			

**APPENDIX C: INTRODUCTORY LETTER FROM THE DEPARTMENT
INTEGRATED SCIENCE EDUCATION, UEW**



Our Ref: *ISED/PG/VOL.1/46*

4th September, 2023

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION:

I write to introduce to you the bearer of this letter Mr James Kwabina Osei with index number 202139591, a student of Science Education in the University of Education, Winneba who is reading a Doctor of Philosophy programme in Science Education.

As part of the requirements of the programme he is undertaking a research topic; **Basic Level Science Teachers' Instructional Practises in Regular, Inclusive and Deaf Schools: An Exploratory Study**. He needs to gather information to analyse the said research topic.

I would be grateful if he would be given the needed assistance to carry out this exercise.

Thank you.

Yours faithfully,

A handwritten signature in black ink, appearing to read "Charles K. Koomson", enclosed in a circular scribble.

DR. CHARLES K. KOOMSON
Ag. Head of Department



**APPENDIX D: INTRODUCTORY LETTER FROM THE MUNICIPAL
DIRECTOR OF EDUCATION EFFUTU**

GHANA EDUCATION SERVICE

*In case of reply, the date, the number
of this letter should be quoted*

Our Ref: GES/TSM/EP/156/V.2/199

Your Ref:



Tano South Municipal Education Office
P. O. Box 48
Bechem – Ahafo

Tel: 024-9446225/020-8902673
email: tanosouthmunicipal@ges.gov.gh

19th September, 2023

REPUBLIC OF GHANA

TO WHOM IT MAY CONCERN

RE: LETTER OF INTRODUCTION

MR. JAMES KWABINA OSEI INDEX NUMBER: 202139591

Mr. James Kwabina Osei is a student of Science Education at the University of Education Winneba, reading a Doctor of Philosophy programme.

The University has instructed him to undertake a research on the topic “Basic Level Science Teachers’ Instructional Practises in Regular, Inclusive and Deaf Schools: An Exploratory Study” as part of the requirements leading to the award of his certificate.

Permission is granted to him to undertake the above stated research and you are kindly requested to accord him the necessary assistance needed.

Thank you.

A handwritten signature in black ink, appearing to read 'Agnes Amhere'.

AGNES AMHERE (MS.)
MUNICIPAL DIRECTOR
TANO SOUTH

Cc:

MR. JAMES KWABINA OSEI
UNIVERSITY OF EDUCATION
WINNEBA

**APPENDIX E: INTRODUCTORY LETTER FROM THE MUNICIPAL
DIRECTOR OF EDUCATION TANO SOUTH**

GHANA EDUCATION SERVICE

In case of reply the number and
Date of this letter should be quoted:



REPUBLIC OF GHANA

MUNICIPAL EDUCATION OFFICE
POST OFFICE BOX 54,
WINNEBA
TEL: 03323 22075
Email: geseffutu@gmail.com

My Ref. NO:GES/CRVE/EDU/W.C.80/VOL.2/19
Your Ref. No:.....

DATE: 11TH OCTOBER, 2023

LETTER OF INTRODUCTION

We acknowledge receipt of your letter dated 4th September, 2023 seeking permission for Mr. James Kwabina Osei a student pursuing a program in Doctor of Philosophy at the University of Education, Winneba, to conduct a research in the Effutu Municipality.

Permission has therefore been granted to Mr. James Kwabina Osei to undertake a research on the topic; *"Basic Level Science Teachers' Instructional Practices in Regular, Inclusive and Deaf Schools: An Exploratory Study"*.

You are to ensure that your research would not disrupt teaching and learning in the schools.

Headteachers of the schools should assist the student to gather relevant data for his work while ensuring that he abides by the ethics of the teaching profession.

DINAH ANDERSON (MS)
MUNICIPAL DIRECTOR OF EDUCATION
EFFUTU-WINNEBA

THE MUNICIPAL DIRECTOR
EFFUTU MUNICIPAL EDUCATION OFFICE
WINNEBA

THE HEAD OF DEPARTMENT
DEPARTMENT OF INTEGRATED SCIENCE EDUCATION
UNIVERSITY OF EDUCATION
WINNEBA

MR. JAMES KWABINA OSEI ✓
DEPARTMENT OF INTEGRATED SCIENCE EDUCATION
UNIVERSITY OF EDUCATION
WINNEBA

HEADTEACHERS
CONCERNED SCHOOLS
WINNEBA

cc: All SISOs, Effutu-Winneba

YIM