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Evaluation of the chemistry curriculum implementation in Senior High Schools in the Eastern Region of Ghana

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EVALUATION OF THE CHEMISTRY CURRICULUM IMPLEMENTATION IN SENIOR HIGH SCHOOLS IN THE EASTERN REGION OF GHANA

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A thesis in the Department of Science Education, Faculty of Science, 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

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DECLARATION

CANDIDATE'S DECLARATION

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

Signature……. **Date**…….

SUPERVISOR'S DECLARATION

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

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Signature …… **Date**……

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DEDICATION

I dedicate the work to my family.

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ABBREVIATIONS AND ACRONYMS

CRDD:	Curriculum Research and Development Division
GES:	Ghana Education Service
SMET:	Science, Mathematics, Engineering, and Technology
IUPAC:	International Union of Pure and Applied Chemistry
WAEC:	West African Examination Council
WASSCE:	West African Senior Secondary Certificate Examination
SHS:	Senior High School
ICT:	Information Communication Technology
GAST:	Ghana Association of Science Teachers
PTA:	Parents Teachers Association
PLCs:	Professional Learning Communities
MOE:	Ministry of Education
HOD:	Head of Department
CIPP:	Context, Input, Process and Product
STEM:	Science, Technology and Mathematics
SBA:	School Based Assessment
CBC:	Competency Based Curriculum
NaCCA:	National Council for Curriculum and Assessment
SMTs:	School Management Teams

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ABSTRACT

This study evaluated the classroom implementation of the Senior High School elective chemistry curriculum in the Eastern Region of Ghana. A cross- sectional descriptive survey design was used for the study. The target population comprised all the public Senior High Schools in the Eastern region of Ghana that offered elective chemistry. The accessible population consisted of seventy-one public Senior High Schools out of which 21 schools were selected making up 30% of the accessible population. The schools were selected through purposive sampling from ten districts and municipalities in the Eastern Region. A random sample of 366 students offering General Science in form three were involved in this study. There were 73 chemistry teachers, 21 HODs science and 21 assistant heads for academics in the selected SHSs who were purposively selected to be part of the research. The chemistry teachers and chemistry students chosen have used the curriculum materials extensively in the teaching and learning process not less than two years. The main instruments used for the research were interview, observation and questionnaire and document analysis. The data from questionnaire was analysed quantitatively using SPSS version 22 and the data from interview guide, observation guide and document analysis were analysed qualitatively. The findings revealed that most teachers who were the chemistry curriculum implementers had the required academic and professional qualifications needed to implement the chemistry curriculum. However, there were a few teachers without the required qualifications. The findings showed that there were dedicated laboratories for chemistry practical. However, there were major challenges associated with the adequacy of facilities and chemicals. The lessons observed were typical teacher-centred. The focus of the lessons were on the transmission of knowledge from the teacher to the students. The study found that the challenges of chemistry curriculum implementation identified by both teachers and students involved in the study were overloaded chemistry content, large class sizes, inadequate chemistry teachers, inadequate instructional resources, and inadequate practical activities. It was recommended that the SHS institutions should allocate dedicated time slots within the school timetable for practical activities. This would help teachers to engage students in practical activities regularly. There is a need for the government and stakeholders to join hands to build well-equipped laboratories with adequate chemicals and necessary facilities such as water, electricity. It is suggested a study should be conducted to assess how teacher training programmes influence the quality of SHS chemistry curriculum implementation. Also, survey should be conducted to explore the relationship between the implementation of the SHS chemistry curriculum and students' academic achievements in chemistry.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter serves as a general introduction to the study. It outlines the background information, articulates the problem under investigation, states the purpose, and specifies the objectives of the research. It also highlights the research questions that direct the inquiry, the study's significance, as well as its identified limitations and delimitations. Furthermore, it provides concise definitions of key terms and explains relevant abbreviations. The chapter ends by presenting the overall structure and organisation of the research work.

1.1 Background to the Study

The delivery of science curricula, with a particular focus on chemistry, plays a vital role in preparing students to thrive in a knowledge-based society. Successfully implementing the chemistry curriculum at the senior high school level is crucial for developing learners' scientific understanding, hands-on competencies, and critical thinking skills, which are important for both their academic achievements and future careers in science-oriented fields. Implementing a curriculum involves multiple interconnected elements, such as the instructional content, pedagogical approaches, availability and utilisation of teaching and learning materials, assessment methods, and the continuous professional development of educators (Fullan, 2007; Olani, 2011; UNESCO, 2015). Gaining insight into how these elements operate in real classroom settings is fundamental to assessing the effectiveness of chemistry education within any educational system.

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The content component forms the core of the chemistry curriculum, outlining the knowledge and skills that learners are expected to acquire. An effective content structure integrates both theoretical principles and hands-on experiences, enabling students to gain a well-rounded grasp of chemistry (Adu-Gyamfi & Agyeman, 2013). Typically, chemistry curricula aim to equip students with scientific theories, laboratory competencies, and the capacity to apply their knowledge to address real-life challenges (Bybee, 2010). Despite these intentions, research indicates that many curricula are burdened with excessive content, making it challenging to adequately cover all topics within the academic year (Zoller, 2011). Similar issues have been documented in several sub-Saharan African countries, including Nigeria and Kenya, where secondary chemistry programmes are often content-heavy, leaving insufficient time for experiments and deeper exploration of concepts (Okebukola, 2012; Msuya et al., 2020).

These challenges significantly constraint students' capacity to engage critically and meaningfully with the subject matter. Within the Ghanaian educational framework, the senior high school chemistry curriculum is strategically designed to prepare learners for tertiary education and various professional fields. However, empirical studies have highlighted that the curriculum is often perceived as excessively broad, resulting in limited depth of instruction and a tendency toward superficial coverage of key concepts (Adu-Gyamfi & Agyeman, 2013). Furthermore, teachers frequently encounter difficulties in completing the syllabus within the prescribed academic timeframe, a challenge that is further intensified when practical laboratory sessions are incorporated into the teaching schedule (Asiedu-Appiah & Asamoah, 2014).

Contemporary science education increasingly prioritises student-centred and inquiry-driven pedagogical approaches that foster active engagement and critical thinking

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among learners (OECD, 2013). Instructional methods are central to enhancing students' learning experiences and promoting meaningful participation in the classroom. A growing body of research supports the adoption of learner-centred strategies that encourage inquiry, collaboration, and critical reflection, particularly within science education contexts (Akpinar, 2013; Nsiah et al., 2018). Globally, educational practices are gradually shifting away from conventional lecture-based instruction toward more interactive techniques such as problem-based learning, collaborative experiments, and the integration of digital simulations (Alfieri et al., 2011). Although lectures remain one of the oldest and most widely used instructional methods in both schools and universities—often valued for their structured delivery of information—they are widely regarded as ineffective in promoting deep engagement with academic content (Laurillard, 2002).

Despite global shifts toward more interactive pedagogies, teacher-centred instructional methods continue to dominate classrooms in many African contexts. Evidence from Tanzania, Ethiopia, and Uganda indicates that science educators frequently rely on traditional chalk-and-talk approaches, largely due to overcrowded classrooms, insufficient teacher training, and limited availability of instructional resources (Onyeka & Olatoye, 2016; Msuya et al., 2020). Studies further reveal that, in large class settings, teachers often resort to teacher-centred strategies because facilitating student-led learning becomes impractical when individual attention to learners is not feasible (Setati, 2011; Yelkpieri et al., 2012; Dhurumraj, 2013). In Ghana, although the National Science Curriculum promotes participatory and interactive pedagogies, research demonstrates that chemistry instruction is still predominantly teacher-directed, with limited opportunities for student engagement (Boateng, 2015). Contributing factors

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include high student-to-teacher ratios, examination-oriented teaching cultures, and inadequate professional development for educators (Nsiah et al., 2018).

Globally, the availability and utilisation of teaching and learning resources—such as textbooks, laboratory equipment, and digital technologies—play a crucial role in determining the quality of science education (UNESCO, 2015). Access to well-structured learning materials and tools significantly enhances curriculum implementation and overall instructional effectiveness (Mensah et al., 2015). In many developed nations, schools benefit from adequately equipped laboratories and rich digital content, which facilitate both practical and virtual science learning experiences (Hofstein & Kind, 2012). Conversely, in many African countries, inadequate educational resources remain a persistent obstacle to effective science teaching and learning. Schools frequently experience shortages of essential laboratory apparatus, science kits, and up-to-date textbooks, restricting opportunities for hands-on experimentation and active student engagement (Akpan, 2010). Empirical studies further indicate that these resource gaps—including inadequate physical infrastructure, insufficient textbooks, and a lack of laboratory equipment—contribute to declining student interest in science subjects and, ultimately, poor academic performance (Amukowa, 2013; Makgato & Mji, 2006; Mwaba, 2011; Mwenda et al., 2013).

In the Ghanaian context, particularly within rural and peri-urban communities, chemistry teachers often operate under severe resource constraints, including limited access to laboratory apparatus, essential chemicals, and even basic instructional materials (Mensah et al., 2015). Such deficiencies significantly impede the development of students' practical competencies and contribute to declining interest in pursuing science-related academic and career pathways (Anamuah-Mensah, 2017).

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Adequate provision of resources is critical for facilitating hands-on activities that strengthen students' scientific process skills and consolidate theoretical understanding (Anamuah-Mensah, 2017). However, many schools in less urbanised areas lack sufficient materials to support practical instruction, thereby undermining the effective teaching and learning of chemistry (Opoku-Asare, 2016).

Assessment serves not only as a mechanism for evaluating student performance but also as a critical tool for shaping instruction and guiding the learning process. In chemistry education, effective assessment practices should integrate both formative and summative methods to evaluate students' knowledge, practical competencies, problem-solving abilities, and scientific reasoning, as well as their attitudes toward learning (Black & Wiliam, 1998; Brookhart, 2013). Increasingly, educational research emphasises the need to align assessment strategies with instructional goals through a balanced combination of formative and summative approaches (Black & Wiliam, 1998). However, in many African educational contexts, assessment in science remains predominantly summative and heavily examination-oriented. In countries such as Kenya and Nigeria, for instance, teachers often focus on "teaching to the test," prioritising exam preparation over the development of deeper conceptual understanding (Okebukola, 2012). A similar trend is observed in Ghana, where the emphasis on high-stakes external assessments, such as WASSCE, often encourages rote learning at the expense of conceptual mastery and practical skill development (Owusu et al., 2019). As a result, learners are seldom evaluated on higher-order thinking and scientific process skills, which are fundamental to meaningful science learning.

Continuous professional development (CPD) is widely acknowledged as a critical element in effective curriculum implementation and the enhancement of instructional

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quality (Darling-Hammond et al., 2017). High-quality CPD is characterised by ongoing, collaborative learning experiences that are closely aligned with teachers' professional needs and classroom contexts (Avalos, 2011). Professional learning equips educators with up-to-date pedagogical knowledge and practical competencies required to deliver the curriculum effectively and respond to diverse learner needs (Darling-Hammond et al., 2017). Opportunities such as peer learning, sustained in-service training, and collaborative professional communities enable teachers to innovate and adapt their instructional practices (Kwakye et al., 2020).

In sub-Saharan Africa, however, access to meaningful professional development for science teachers remains limited, often due to financial constraints, logistical difficulties, and insufficient institutional support (Hardman et al., 2012). Professional training is frequently delivered through one-off workshops rather than continuous, practice-oriented, or classroom-embedded programmes, reducing its long-term impact. In Ghana, although many chemistry teachers express strong interest in professional development, research indicates that such opportunities are often irregular, poorly coordinated, and rarely tailored to the specific demands of the subject (Agyeman & Adu-Gyamfi, 2019). Additional barriers such as lack of sponsorship, time limitations, and inadequate incentives further hinder teachers' participation in out-of-school training programmes (Kwakye et al., 2020).

Many science education initiatives tend to concentrate on curriculum development, often overlooking the practical aspects of curriculum implementation at the school level (Rogan & Grayson, 2003). Implementing science curricula has long posed challenges for both educators and policymakers, primarily due to misalignments among standards, curriculum content, assessment practices, and professional development efforts (Penuel

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et al., 2009). Effective implementation of the chemistry curriculum is essential not only for improving educational outcomes but also for equipping learners with the knowledge and skills necessary to address global challenges. Central to this process is the teacher, who serves as the primary agent of curriculum enactment (Arikpo & Odinko, 2019). Curriculum implementation occurs when educators successfully support learners in realising their potential to address personal, community, and broader societal issues (Ezugo & Ofojebe, 2018).

A well-designed curriculum must be complemented by effective implementation to achieve its intended goals (Achimugu, 2012). According to Okebukola (2004), curriculum implementation involves translating curricular objectives from written plans into actual classroom practices. Similarly, Ivowi (2004) defines it as the conversion of theoretical proposals into practical action, while Igwe (2015) describes it as the process of operationalising curriculum plans in the classroom through the collaborative efforts of teachers, students, school administrators, parents, and the use of available instructional resources within various psychological and social contexts. Igwe (2015) further advocates for innovative implementation strategies, such as encouraging teachers and students to improvise instructional materials and involving teachers in curriculum decision-making and planning, given their central role in the implementation process.

When teachers fail to implement the curriculum effectively and with fidelity, students' academic performance and overall preparedness are negatively affected (Yurdakul, 2015). Cervetti et al. (2015) emphasise the critical relationship between instructional strategies employed by teachers and the quality of student learning outcomes. Their research highlights the importance of equipping educators with appropriate pedagogical

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approaches, targeted training, and sustained professional support to enhance curriculum delivery and, consequently, improve student achievement.

Doyle et al. (2015) argue that recognising and addressing teachers' concerns at the early stages of new curriculum implementation significantly enhances the likelihood of successful and faithful curriculum implementation. Research further underscores the importance of administrative and professional support as key enablers of effective teacher performance and the successful introduction of educational reforms (Bakir et al., 2016; Bautista et al., 2016). Similarly, Van der Heijden et al. (2015) highlight the critical role of creating supportive school environments that empower teachers as active agents in their professional growth. Such contexts foster both individual development and collaborative learning among educators, ultimately contributing to more effective curriculum implementation.

Causarano (2015) notes that teachers often modify curricula with the intention of addressing their students' learning needs, frequently perceiving the need for adjustments to better align with learners' cognitive levels. Teachers' concerns significantly influence curriculum implementation, as these concerns often shape the decisions they make regarding the inclusion or exclusion of specific content or activities (Fullan, 2007). Yeung (2012) views the curriculum as a structured means of achieving desired behavioural outcomes by systematically organising learning experiences to meet educational objectives effectively. Glatthorn et al. (2009) further emphasise the importance of involving teachers in curriculum reform processes, given their central role in translating curricula content and methodologies into classroom practice. However, Elmas et al. (2014) observe that teachers frequently receive inadequate or no

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support during the implementation of educational reforms, which undermines their ability to implement changes successfully.

The study aims to provide stakeholders with insights into both the achievements and the challenges associated with the classroom implementation of the Senior High School (SHS) chemistry curriculum. Notably, the implementation of this curriculum commenced during the 2010/2011 academic year.

1.2 Statement of the Problem

The West African Examinations Council (WAEC) Elective Chemistry Chief Examiner's Reports from 2016 to 2019 have consistently highlighted persistent student weaknesses in both theoretical knowledge and practical competencies. The reports reveal that many students lack a clear understanding of key concepts and are unable to accurately carry out and report on quantitative and qualitative experiments. These deficiencies have contributed to the overall decline in students' performance in elective chemistry over the years. In Ghanaian senior high schools, chemistry is widely perceived by students as a challenging subject, largely because the curriculum contains numerous abstract concepts that are difficult to grasp (Taber, 2002). To cope with the extensive content within the limited academic calendar, teachers often rely on teacher-centred instructional methods (Byusa et al., 2020). Johnson (2011) further identifies several factors that influence students' achievement in chemistry, including the physical conditions of classrooms and laboratories, instructional practices, and the effectiveness of school management.

Ampiah (2004) asserts that "learning by doing" is the most effective approach for developing scientific process skills, as students are able to master these skills when practical activities are integrated with theoretical instruction. A lack of hands-on

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experiences during teaching and learning often contributes to students' poor performance in examinations. Mensah and Somuah (2013) attribute the weak performance of students in science subjects largely to the prevalence of rote learning within schools. Similarly, Adu-Gyamfi (2013) found that students' declining interest in science is linked to the time-intensive and largely theoretical mode of instruction, which tends to rely heavily on teacher explanations and textbook knowledge transfer, with limited opportunities for practical engagement. Chepkorir (2013) further argues that negative student attitudes, lack of interest, and low self-confidence significantly contribute to poor achievement in chemistry. Additional factors, such as extensive syllabus coverage, limited awareness of career prospects in chemistry, inadequate laboratory facilities, and ineffective teaching methods, also play a role in shaping students' negative perceptions of the subject.

Research indicates that students come to the classroom with pre-existing knowledge and beliefs about science. For effective knowledge transfer to occur, it is essential to build connections between these prior conceptions and the new scientific ideas being introduced (Taber, 2001; Barke et al., 2009). However, many learners perceive chemistry concepts as highly complex and often rely on teachers to simplify the content for them, preferring passive reception over active engagement (Mahajan & Singh, 2005). Based on classroom interactions with students during chemistry lessons, it has become evident that many learners face significant conceptual difficulties. A considerable number struggle to understand basic chemistry principles, face challenges linking theoretical knowledge with practical applications, and hold misconceptions that obstruct a deep and accurate grasp of the subject matter.

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Existing literature highlights that the persistent low performance of students in science is a multifaceted issue that demands a comprehensive and well-coordinated response (Anamuah-Mensah et al., 2009; Anamuah-Mensah & Benneh, 2010; Anderman et al., 2012; Adu-Gyamfi, 2013; Ampiah, 2004). According to Anamuah-Mensah et al. (2009), despite several educational reform initiatives at the pre-tertiary level, there has been minimal impact on classroom instructional practices. This shortfall is largely attributed to the limited focus on the actual teaching and learning processes occurring during lessons. Although various studies have explored the implementation of chemistry curricula and programmes in different contexts—for example, Lee (2003) in Hong Kong; Musaiwa (2020) in Malawi; Moses (2014) in Nigeria; and Mokoro (2020) in Tanzania—as well as in Ghana by Kumabia (2014), Amadu et al. (2023), and Amoah (2018), no study has specifically examined the implementation of the Senior High School (SHS) chemistry curriculum within the selected schools in the Eastern Region of Ghana. Consequently, this study was undertaken to evaluate how the SHS chemistry curriculum is being implemented in this context.

1.3 Purpose of the Study

The purpose of this study was to evaluate the classroom implementation of the chemistry curriculum in selected SHSs in the Eastern Region of Ghana.

1.4 Objectives of the Study

The objectives of the study were to:

1. determine the extent to which the chemistry teachers were academically and professionally qualified to teach the subject
2. find out the financial, material and infrastructural resources available for implementing the chemistry curriculum at the classroom level

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3. investigate the instructional activities that were organised by the teachers during chemistry lessons
4. determine the monitoring strategy that have been designed to enhance classroom implementation of the chemistry curriculum
5. find out the personnel capacity-enhancing activities which were organised for the teachers
6. investigate the teachers' and the students' views of the challenges to the effective classroom implementation of the chemistry curriculum.

1.5 Research Questions

The following research questions were addressed in the study:

1. To what extent are the chemistry teachers academically and professionally qualified to teach the subject?
2. What financial, material and infrastructural resources were available for implementing the chemistry curriculum at the classroom level?
3. What instructional activities are organised by the teachers during chemistry lessons?
4. What monitoring strategies were designed to enhance the classroom implementation of the chemistry programme?
5. What personnel capacity-enhancing activities were organised for the teachers?
6. In the views of the teachers and students, what are the challenges to the effective classroom implementation of the chemistry curriculum?

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1.6 Significance of the Study

Firstly, the study is crucial for assessing the quality of chemistry education, identifying strengths and weaknesses, and ensuring alignment with Ghanaian and international standards.

Secondly, the study would provide stakeholders like heads of SHS, Parents-Teachers Association, Ghana Education Service with information which would enable them adopt strategies to improve teaching and learning of chemistry in Ghana.

Also, the study would serves as a valuable source of information for making decisions concerning the allocation of resources. This covers choices related to materials, staffing and funding required to effectively facilitate chemistry curriculum delivery.

Thirdly, assessing curriculum implementation in chemistry yields vital insights for policymakers and administrators for shaping future policy in Ghana regarding the implementation of the chemistry curriculum at SHSs.

Also, curriculum evaluation ensures consistent implementation across classrooms and schools, maintaining high education standards and providing students with equal learning opportunities regardless of their location.

In addition, evaluating curriculum implementation offers valuable feedback to educators, aiding in refining curriculum and teaching methods to better match curriculum goals. Adjustments can be made based on feedback, such as providing extra assistance for challenging concepts, leading to improved student understanding.

Furthermore, evaluating curriculum implementation helps pinpoint curriculum gaps, which might stem from outdated content, misalignment with research or industry

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practices, or inadequate student preparation. Addressing these gaps enhances curriculum quality and relevance for students' future pursuits.

Fourthly, evaluating a chemistry curriculum's implementation ensures it aligns with standards, remains relevant to scientific practices, and equips students with a strong foundation for success in their academic and professional pursuits in chemistry.

Also, regularly evaluating the implementation of a chemistry curriculum can lead to continuous improvement in education, helping educators identify areas for enhancement and make changes that improve student outcomes, resulting in a more effective and relevant chemistry curriculum.

Finally, evaluation of chemistry curriculum implementation helps identify gaps and areas for improvement, allowing educators to make necessary changes to better meet learner needs and improve student performance.

1.7 Delimitations of the Study

The study took place in Ghana's Eastern Region, where seventy-one Senior High Schools run the General Science Programme. The study targeted third-year students offering chemistry as an elective subject. This group was selected because they had engaged with the chemistry curriculum for a minimum of two years, enabling them to share meaningful experiences and perspectives on its implementation. In addition, chemistry teachers from the participating schools were included in the study to provide professional insights into how the curriculum is delivered and its overall effectiveness in the classroom.

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1.8 Limitations of the Study

The study faced a limitation in its data collection due to the decision to focus on only 21 selected SHSs out of a total of 71, attributed to constraints in financial resources and time. Nevertheless, drawing from personal experience as a former chemistry teacher in SHS, the findings offer a meaningful reflection of the broader situation across the region. The study aimed to uncover issues related to the implementation of the chemistry curriculum within the context of the 21 selected schools. Given the similarity of fundamental conditions, the identified key issues holds relevance for all SHSs in Ghana.

1.9 Definitions of Terms

Some terms used in the study have been defined as follows:

Evaluation: It is the process of assessing or appraising the value, quality, or effectiveness of something.

Curriculum: It is a structured plan that outlines what students will learn during an educational program. It encompasses the content, skills, and assessments designed to achieve specific educational goals

Chemistry Teacher: This refers to any person who taught chemistry in the selected SHSs irrespective of their areas of specialisation.

Chemistry Curriculum: This refers to the elective SHS chemistry curriculum designed by the CRDD in 2010.

Professional qualification: It refers to certifications, licenses, or credentials that individuals acquire to demonstrate their expertise, skills, and competence in a specific profession.

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Academic qualification: It is the formal education and degrees an individual has obtained from educational institutions. The qualification serves as a measure of a person's knowledge, skills, and expertise in a particular field.

Resources: In this study the term refers to the material, financial and infrastructural resources in the schools.

Implementation: It refers to the process of putting a plan, system, policy, or idea into effect or practice.

1.10 Organisation of the Study Report

This report is structured into six chapters. Chapter One presents an overview of the study, including the background, problem statement, purpose, objectives, and research questions. It also outlines the significance, limitations, and delimitations of the research, as well as provides definitions of key terms and abbreviations used throughout the work.

Chapter Two presents a comprehensive review of existing literature related to the implementation of the chemistry curriculum. It examines learner-centred educational philosophies, the CIPP evaluation framework, and the structure of the SHS chemistry curriculum. The discussion further explores teachers' content, pedagogical, and technological knowledge as they relate to curriculum delivery, along with various implementation strategies. Additionally, the chapter highlights the significance of teacher qualifications and experience, their roles in curriculum enactment, opportunities for professional growth, availability of essential resources, monitoring mechanisms, instructional approaches, and assessment methods. It also considers the cognitive, psychomotor, and affective domains in chemistry teaching and learning, emphasising student engagement, the value of practical activities, prevailing

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challenges, theoretical foundations, empirical studies, and existing gaps in research on chemistry curriculum implementation.

Chapter Three outlines the research methodology adopted for the study. It details the research design, target population, sampling methods, data collection instruments, procedures for establishing validity and reliability, ethical considerations, as well as the processes used for data collection and analysis. Chapter Four is devoted to the presentation and interpretation of the research findings, while Chapter Five discusses these results in relation to existing literature. Lastly, Chapter Six provides a summary of the study, draws conclusions, offers recommendations, suggests areas for future research, and highlights the study's contributions to the field of science education.

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CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter focuses on reviewing relevant literature that informs and supports the study. It examines key themes such as learner-centred curriculum ideologies, the Context, Input, Process, and Product (CIPP) Evaluation Model, and the structure of the Senior High School (SHS) chemistry curriculum. The discussion explores the importance of content, pedagogical, and technological knowledge in effectively implementing the chemistry curriculum, as well as various curriculum implementation strategies. Additionally, attention is given to the significance of teacher qualifications and experience, the roles teachers play in the implementation process, the impact of continuous professional development, the availability and use of instructional resources, monitoring mechanisms, teaching methods, and assessment practices.

Furthermore, the chapter outlines the cognitive, psychomotor, and affective domains in chemistry learning. It emphasises the role of practical work in enhancing conceptual understanding and identifies the key challenges that hinder effective curriculum implementation. Finally, the chapter presents the theoretical underpinnings, conceptual framework, empirical studies, and identifies gaps in the existing research that this study seeks to address.

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2.1 Learner-Centred Ideology Curriculum

Curriculum refers to the structured plan for a course, outlining how its content is organised and transformed into a detailed framework for teaching and learning to achieve specific educational objectives (Richards, 2013). In a learner-centred chemistry curriculum, the primary focus is on the interests and needs of students. This approach engages learners in interactive and meaningful experiences that foster critical thinking, problem-solving abilities, and independent learning. Its core objective is to make chemistry more engaging and accessible to all students, regardless of their prior knowledge or academic background.

Proponents of child-centred educational philosophies describe learner-centred approaches using terms such as child-centred education, developmentally appropriate practices, constructivism, and progressive education (Schiro, 2013). A central aim of this philosophy is to support the holistic development of learners by nurturing their intellectual, social, emotional, and physical capacities in a balanced manner. Schiro (2013) underscores the importance of integrating hands-on experiments, group discussions, and collaborative projects into the chemistry curriculum to enhance active learning and student engagement. Research has shown that students exposed to learner-centred instructional approaches tend to develop more positive attitudes toward chemistry and demonstrate improved conceptual understanding of the subject matter.

According to Yeung (2012), the central aim of education is to support learners in becoming independent thinkers and self-directed learners who can explore and construct knowledge autonomously. This perspective aligns with the view that certain capabilities are innate or hereditary rather than acquired through experience (The Free

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Dictionary, 2018). For instance, individuals such as painters, poets, and musicians may possess inherent talents, with the foundational skills for their craft present from birth.

Al-Mekhlafi and Nagaratnam (2012) emphasised that a learner-centred approach involves recognising and valuing students' prior knowledge, learning needs, goals, preferences, and perspectives regarding both instruction and classroom activities. In this model, teachers play a supportive role by closely monitoring students, offering targeted assistance, and designing diverse instructional activities that are responsive to learners' developmental levels. Rather than acting solely as transmitters of knowledge, teachers function as facilitators, curriculum designers, and mentors who guide learners to construct their own understanding (Schiro, 2013). Yeung (2012) further argues that educators should create meaningful contexts and learning environments that stimulate students' cognitive growth as they actively build knowledge and meaning for themselves. In a learner-centred classroom, students occupy a central position in the teaching and learning process, actively engaging in classroom activities and decision-making (Fulcher, 2004).

In learner-centred classrooms, students are actively involved in assessment processes through self- and peer-evaluation activities. These practices help learners develop the ability to critically assess their own work and that of their peers, thereby promoting independence and self-regulation. Rather than focusing solely on grading, the primary purpose of assessment in this approach is to enhance learning (Weimer, 2002). According to Weimer, a learner-centred classroom involves transforming five key dimensions of instructional practice: (1) the balance of power between teachers and students, (2) the role and function of content, (3) the teacher's role, (4) accountability for learning, and (5) the purpose and methods of evaluation. The author argues that

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when students are meaningfully engaged and actively connected to the learning process, they are motivated to invest more time and effort, which correlates with improved learning outcomes. Similarly, Tudor (1993) highlights that giving students an active role in shaping classroom content and activities enhances their interest, motivation, and overall learning engagement.

Learner-centred education aims to cultivate students' metacognitive abilities, including critical thinking, creative intelligence, and problem-solving skills, which enable them to monitor, regulate, and apply their cognitive processes effectively (Mtika & Gates, 2010). Rather than focusing solely on memorisation, this approach emphasises discovery-based learning, where greater attention is placed on students' active engagement and learning outcomes (Hardman et al., 2008; O'Sullivan, 2004; UNESCO, 2007). Central to learner-centred teaching is the intentional planning and adaptation of instructional strategies and resources to address learners' diverse needs, interests, developmental stages, and individual learning profiles (Mtika & Gates, 2010).

Jones (2007) clarifies that a student-centred classroom does not imply that learners have complete autonomy over what they study. Instead, it represents an environment where students' collective and individual needs are carefully considered, and where they are encouraged to be active participants in the learning process. By aligning instruction with students' current interests and needs, teaching becomes more relevant and meaningful, thereby increasing the effectiveness of learning. This approach also promotes greater student participation, shifting their role from passive recipients of information to active contributors in the construction of knowledge.

In highly learner-centred classrooms, the teacher's role shifts fundamentally from being the primary source of knowledge to serving as a facilitator who supports and guides

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students' active engagement in the learning process (Shihiba, 2011). Weimer (2002) explains that in such classrooms, instructors act as facilitators and designers of meaningful learning experiences rather than the central figure who dominates instruction. They are no longer the "star" of the classroom, solely responsible for driving all teaching activities.

O'Sullivan (2004) argues that adopting a learner-centred approach is a more effective and transformative way to teach chemistry, as it counters the dominance of traditional teacher-centred, didactic methods. These conventional practices often position teachers as authoritative figures and learners as passive recipients, resulting in rote memorisation and inhibiting students' critical and creative thinking skills. In contrast, a learner-centred chemistry curriculum positions students at the heart of the educational experience, prioritising their active involvement in learning. This approach is grounded in constructivist learning theory, which posits that learners build their own understanding of concepts through interaction with their environment and personal experiences.

2.2 CIPP Evaluation Model

The CIPP model is a theoretically informed framework designed to support systematic curriculum and programme evaluation. Developed by Daniel Stufflebeam in the 1960s, it has become one of the most widely applied models in educational research and programme assessment. The framework evaluates educational programmes through four interconnected dimensions: **Context**, **Input**, **Process**, and **Product**, offering a structured and holistic approach to evaluation (Stufflebeam, 2002). Essentially, the CIPP model serves as a versatile guide for both formative and summative evaluations across projects, individuals, products, organisations, and evaluation systems (Stufflebeam & Shinkfield, 2007). It was selected for this study because of its emphasis

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on comprehensive evaluation within the broader scope of organisational activities, making it particularly suitable for educational settings (Stufflebeam, 2003).

The CIPP Evaluation Model serves as a structured guide for evaluators and stakeholders to ask relevant questions and conduct systematic assessments at different stages of a programme—**before implementation** (context and input evaluation), **during implementation** (input and process evaluation), and **after completion** (product evaluation) (Zhang et al., 2011). Zhang et al. (2011) describe the model as a comprehensive and systematic approach for examining social and educational programmes within real-world, dynamic contexts, a view also supported by Stufflebeam and Shinkfield (2007). A key strength of the CIPP model lies in its holistic examination of a programme through the four interconnected components of **context**, **input**, **process**, and **product**. Grounded in systems theory, the model treats educational programmes as complex and evolving systems influenced by various internal and external factors. Furthermore, it highlights the need to integrate diverse stakeholder perspectives throughout the evaluation, offering a flexible structure that can be adapted to a wide range of educational settings and objectives.

2.2.1 Context evaluation

Context evaluation focuses on identifying and analysing the needs and opportunities that exist within a particular environment or setting (Stufflebeam & Shinkfield, 2007). Its main purpose is to clarify and address the needs of the target population by identifying existing problems and assessing the relevance of the programme's goals in relation to those needs (Khuwaja, 2001). According to Stufflebeam (2003), this stage examines the broader environmental conditions to determine the extent to which the current goals and priorities align with actual needs, as well as whether the proposed

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objectives are appropriately responsive. Context evaluation involves a systematic assessment of the **needs, available resources, and challenges** within a defined setting (Stufflebeam, 2002). It also takes into account various **social, political, economic, and cultural dimensions** that shape the development and implementation of the curriculum.

2.2.2 Input evaluation

Input evaluation aims to generate essential information for assessing the **resources and strategies** required to achieve the programme's objectives (Khuwaja, 2001). These resources encompass **time, human capacity, physical facilities, infrastructure, curriculum materials, and content**, all of which are critical for evaluating the quality of education within a school setting. This stage of the CIPP model helps to determine the most effective plans and procedures for meeting identified needs by asking the key question: *"How should the programme be implemented?"* (Zhang et al., 2011). It involves examining procedural frameworks and instructional strategies that are most likely to yield the intended educational outcomes. Moreover, input evaluation focuses on analysing the system's existing capacities while exploring and critically evaluating alternative approaches that could be relevant to the programme's goals (Zhang et al., 2011). It also involves comparing different strategies, work plans, and budgets, as well as reviewing other programmes that could serve as useful models for the initiative under review (Stufflebeam, 2002).

2.2.3 Process evaluation

Process evaluation examines how a programme is administered and how teaching and learning activities are carried out within the educational setting. At this stage, the focus is on the implementation phase, where inputs are put into action to achieve the intended

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objectives, outcomes, and overall goals of the programme. The evaluator critically analyses operational procedures to understand how the school functions and to identify the specific processes that contribute to enhancing performance and maintaining high educational standards. This stage involves making key implementation decisions that influence programme delivery (Patil & Kalekar, 2014).

In a school context, process evaluation covers a range of activities, including structured instructional methods, classroom teaching and learning interactions, parent–teacher meetings, co-curricular and extracurricular programmes, as well as student assessments through both formative and summative approaches such as board examinations (Print, 1993). Overall, this type of evaluation tracks, records, and assesses the ongoing activities of the programme, providing stakeholders with timely and relevant information about progress made during implementation (Stufflebeam, 2002).

According to Stufflebeam and Shinkfield (2007), process evaluation involves systematically identifying procedural challenges and unforeseen flaws that arise during programme implementation. It focuses on detecting areas that require mid-course adjustments, collecting additional data to support necessary improvements, and keeping detailed records of how the programme is being executed. This often includes ongoing interaction with and observation of project participants to ensure the smooth operation of activities. Zhang et al. (2011) further explain that a key aim of process evaluation is to document implementation practices and provide continuous feedback on two main aspects: first, the degree to which planned activities are being effectively executed; and second, whether modifications or revisions to the initial plan are needed to enhance the programme's success.

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2.2.4 Product evaluation

Product evaluation focuses on assessing the overall outcomes of a programme by analysing their value, effectiveness, and relevance. It aims to determine how well the programme has addressed the needs of its stakeholders and achieved its intended objectives (Zhang et al., 2011). According to Stufflebeam (2002), this stage evaluates the degree to which the initiative has effectively served its target population. In the context of schools, product evaluation goes beyond examining students' academic performance. It places emphasis on the development of essential skills, knowledge, attitudes, and competencies that learners can apply in real-life situations for personal and societal benefit. As Scriven (1994) notes, the ultimate purpose of schooling is to produce individuals who are capable of contributing meaningfully to society and living independently.

The product component of the model does not only assess outcomes at the conclusion of a programme but also examines results at different stages of its planning, implementation, and development. By comparing the outcomes to the original objectives, the model helps to detect shortcomings and plan appropriate modifications to enhance educational quality (Sancar et al., 2013). Often referred to as impact evaluation, this stage focuses on measuring how effectively the programme reaches and serves its intended population (Stufflebeam, 2002).

Despite its strengths, the CIPP model is not without limitations. One major criticism is that it tends to oversimplify the complexities of organisational decision-making, assuming a level of rationality that may not reflect real-world situations. It also tends to overlook the political dynamics that can influence these processes. Additionally, as Guba and Lincoln (1981) observed, the model can be challenging to implement and

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expensive to sustain. Product evaluation ultimately examines the results of the curriculum in terms of student performance, learner satisfaction, and the programme's broader societal impact.

2.3 The SHS Chemistry Curriculum

2.3.1 Rationale for Teaching Chemistry

Chemistry focuses on the study of matter and the transformations it undergoes, making it deeply connected to human life and the environment. It plays a crucial role in sustaining living organisms through the countless chemical processes occurring within their bodies. In everyday life, chemistry is present in essential areas such as food, clothing, medicine, shelter, and transportation, and it even extends to phenomena in outer space. Many common household items—such as soap, plastics, books, radios, televisions, video equipment, and computers—are products of chemical knowledge and innovation. Moreover, chemistry provides the tools to understand, explain, manage, and mitigate various natural and human-induced occurrences, including bushfires, industrial pollution, metal corrosion, and ozone layer depletion. For these reasons, chemistry is a discipline of fundamental significance to human existence and development.

2.3.2 General Aims

This syllabus is intended to:

i. Create awareness of the interrelationship between chemistry and the other disciplines or careers.

ii. Provide knowledge, understanding and appreciation of the scientific methods, their potential and limitations.

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iii. Create awareness that chemical reactions and their applications have significant implications for society and the environment.

iv. Develop the ability to relate chemistry in school to the chemistry in modern and traditional industries or real-world situations.

v. Use facts, patterns, concepts and principles to solve personal, social and environmental problems.

vi. Use appropriate numeric, symbolic, nomenclature and graphic modes of representation and appropriate units of measurement (e.g. SI units).

vii. Produce, analyse, interpret and evaluate qualitative and quantitative data; solve problems involving quantitative data; identify sources of error and suggest improvements to reduce the likelihood of error.

viii. Apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting hazard symbols; by using appropriate techniques for handling, maintaining and storing laboratory materials and by using appropriate personal protection equipment.

ix. Develop the ability to communicate ideas, plans, procedures, results, and conclusions of investigations orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g. data, tables, laboratory reports, presentations, debates, models).

x. Make the subject interesting and motivating through designing hands-on activities for students to enhance their understanding of the subject.

xi. Train students to use their theoretical ideas to design experiments to solve practical chemistry problems.

xii. Encourage investigative approach to the teaching and learning of chemistry and make chemistry lessons, problem solving in nature.

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2.3.3 Scope of Content

The syllabus builds upon the science learnt at the Junior High School level, and is designed to offer at the Senior High School level, the chemistry required to promote an understanding of the chemical processes taking place all around us. The syllabus is also designed to provide enough chemistry to students who:

i. will end their study of chemistry at the SHS level,
ii. require knowledge of chemistry in their vocational studies,
iii. wish to continue their studies at tertiary institutions.

In providing a course based on this syllabus, a wide range of activities including projects have been suggested to bring out the initiative and creativity of both the teacher and the student.

2.3.4 Pre-Requisite Skills

The outline of the course requires proficiency in English language, a high level of achievement in JHS Integrated Science and good Mathematical Knowledge.

2.3.5 Duration of the course: Three (3) years of Senior High School education.

2.3.6 Period allocation per week

In the timetable for Senior High School chemistry instruction, six periods are allocated weekly, with each period lasting forty minutes. Of these, two periods are designated for practical work, while the remaining four periods focus on theoretical instruction. It is expected that teachers adequately prepare learners prior to each practical session to ensure effective participation and learning. Furthermore, practical lessons are to be introduced at the beginning of the second year, running concurrently with theoretical lessons to strengthen students' understanding of core concepts through hands-on experiences.

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2.3.7 Suggestions for Teaching the Syllabus

General Objectives

At the start of each section, the general objectives are clearly outlined, indicating the skills, knowledge, and behaviours learners are expected to develop through the various units within that section. Teachers are encouraged to review these objectives thoroughly before beginning instruction, ensuring that their teaching aligns with the intended learning outcomes. Once all units in a section have been taught, teachers should revisit the general objectives to confirm that they have been sufficiently addressed throughout the instructional process.

Sections and Units

The structure of the syllabus is organised into sections and units. Each academic year's content is broken down into several sections, with each section representing a coherent set of related concepts within the subject area. These sections are further divided into units, which focus on more specific and closely related knowledge and skill sets, allowing for systematic and progressive learning.

Columns

The syllabus is organised into five columns, namely: Units, Specific Objectives, Content, Teaching and Learning Activities, and Evaluation. Each column serves a distinct purpose, described as follows:

Column 1 – Units: This column lists the unit topics within each section. Teachers are generally expected to follow the units in the sequential order presented. However, if it becomes pedagogically advantageous to temporarily move to another unit and return later, such flexibility is permitted to enhance teaching and learning outcomes.

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Column 2 – Specific Objectives: This column presents the specific objectives associated with each unit. Each objective is identified using a Syllabus Reference Number, such as 1.3.5 or 2.2.1. In these numbers, the first digit indicates the section, the second digit represents the unit, and the third digit specifies the order of the objective within that unit. For example, 1.3.5 refers to the fifth specific objective of Unit 3 in Section 1.

The use of syllabus reference numbers facilitates clear communication among teachers and other educational stakeholders and provides a systematic way to select objectives when constructing assessments. For instance, if Unit 2 of Section 2 contains five specific objectives (2.2.1–2.2.5), a teacher might choose to develop test items based on objectives 2.2.3 and 2.2.4 only, rather than including all five. This approach allows teachers to sample objectives strategically, ensuring that assessments accurately reflect the relative importance of the various skills taught in class.

It is important to note that each specific objective is student-focused, indicating what learners are expected to achieve upon completing the instruction for a given unit. Consequently, each objective begins with the phrase, “The student will be able to…”. This emphasizes the need for teachers to address the learning needs of individual students, tailoring instruction wherever possible so that most learners can successfully achieve the objectives outlined for each unit of the syllabus.

Column 3 – Content: The third column outlines the specific content that should be covered when teaching each unit. In certain instances, the content provided is comprehensive, while in other cases, teachers may need to supplement with additional information to enhance understanding. Additionally, there are some units where the

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content section is left intentionally blank, allowing teachers the flexibility to develop and include relevant material according to the learning needs of their students.

Column 4 – Teaching and Learning Activities (T/LA): This column outlines activities designed to maximize student engagement during lessons. Teachers are encouraged to move away from rote memorisation and drill-based methods, instead emphasising participatory and interactive learning approaches. Instruction should address the cognitive, affective, and psychomotor domains wherever appropriate. Educators have the flexibility to reorder or supplement the suggested activities to ensure optimal learning outcomes.

The overarching goal of these activities is to enable students to apply their knowledge to real-life situations, both inside and outside the classroom. One effective strategy to foster analytical thinking and problem-solving skills is to begin each lesson with a practical problem. The chosen problem should allow students to draw on knowledge from previous lessons as well as other relevant information not explicitly taught in class. Teachers should present the problem at the start of the lesson, either verbally or on the board, and encourage students to analyse, propose, justify, and evaluate possible solutions. The primary aim is to develop students' capacity for critical thinking and practical problem-solving.

Column 5 – Evaluation: Evaluation activities can include oral questioning, quizzes, class assignments, essays, structured questions, project work, and other forms of assessment. Teachers should design tasks that encourage students to apply their knowledge to practical problems, develop solutions, and foster positive scientific attitudes as a result of instruction. The evaluation tasks suggested in the syllabus are not exhaustive, and educators are encouraged to create additional innovative

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assessment activities to ensure students have achieved the skills and behaviours outlined in the specific objectives of each unit. For in-class evaluations, teachers should set clear mastery levels for students' responses. For example, if a mastery level of 80% is desired, ensure that each student's answers and performance meet or exceed this benchmark.

2.3.8 Profile Dimensions in the Chemistry Curriculum

The Chemistry syllabus is structured around profile dimensions, which serve as the foundation for teaching, learning, and assessment. These dimensions include Knowledge and Understanding (30%), Application of Knowledge (40%), and Practical and Experimental Skills (30%), with each carrying a specified percentage to indicate its relative importance. The primary aim of the syllabus is not only to enable students to acquire theoretical knowledge but also to develop comprehension and the ability to apply that knowledge in practical contexts. Integrating all three dimensions ensures that chemistry is taught as a dynamic subject, encouraging students to use scientific understanding to address real-world problems. Additionally, the syllabus emphasises the cultivation of practical and experimental skills, which are essential for effective scientific inquiry and problem-solving. The following sections provide a detailed explanation of each dimension, along with the key action verbs associated with them:

2.3.8.1 Knowledge and Understanding (KU)

Knowledge refers to the capacity to remember or recall information that has already been learned and represents the foundational level of learning (Anderson & Krathwohl, 2001). It involves activities such as recognising, listing, naming, matching, describing, identifying, and retrieving information. Practical strategies to support this level include using tools like highlighting, bookmarking, and note-taking. Knowledge also extends

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to digital practices, such as conducting searches via search engines, engaging with social networks, and recalling facts, definitions, and principles (Mayer, 2009).

Understanding, on the other hand, is the ability to comprehend and interpret the meaning of information presented in verbal, visual, or symbolic forms. This cognitive level encompasses skills such as explaining, interpreting, inferring, exemplifying, categorising, summarising, translating, paraphrasing, and predicting outcomes based on observed trends. Digital and social tools can further support understanding through activities like advanced searches, annotating, tagging, subscribing to information feeds, and sharing insights on platforms such as Twitter (Bloom et al., 1956; Anderson & Krathwohl, 2001).

2.3.8.2 Application of Knowledge (AK)

The syllabus highlights the importance of applying knowledge, which involves multiple levels of cognitive and behavioural engagement. These levels include application, analysis, innovation/creativity, and evaluation, and it is essential that instruction addresses each level equitably to ensure comprehensive learning. The "Applying Knowledge" dimension incorporates all four of these levels, providing specific expectations for each.

Application refers to the ability to utilise learned rules, methods, principles, or theories in new and unfamiliar contexts. It also involves actively producing or performing tasks such as solving problems, demonstrating procedures, implementing strategies, operating tools, carrying out experiments, or executing digital activities such as uploading, editing, sharing, running, or interacting with digital content (Anderson & Krathwohl, 2001; Bloom et al., 1956).

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Analysis refers to the cognitive skill of deconstructing information or material into its constituent components to better understand its structure and relationships. This includes abilities such as differentiating, comparing, categorising, outlining, structuring, integrating, linking, and evaluating elements within a concept or text. Analytical thinking also involves identifying key points, detecting implicit assumptions, recognising logical inconsistencies or fallacies, and drawing reasoned inferences from available facts (Anderson & Krathwohl, 2001; Bloom et al., 1956).

Innovation/Creativity is the capacity to synthesise existing components to produce a new, original, and coherent whole, whether in thought, design, or tangible outcomes. This level of learning involves skills such as combining, composing, devising, constructing, planning, producing, inventing, designing, organising, and generating novel ideas or solutions. It also encompasses creative outputs in digital and media contexts, including programming, filmmaking, animation, podcasting, video production, and broadcasting. Innovation represents the highest form of learning, as it enables individuals to transform knowledge into original contributions, designs, or products that enhance the world and address real-world challenges (Anderson & Krathwohl, 2001; Bloom et al., 1956).

Evaluation is the ability to judge the quality, value, or significance of information, ideas, or products based on established criteria or standards. This higher-order cognitive skill is critical for informed decision-making and goes beyond simple recall or comprehension. Evaluation involves activities such as appraising, comparing, critiquing, justifying, hypothesising, testing, monitoring, reviewing, and drawing conclusions. It also encompasses collaborative and digital practices, including discussing, posting, moderating, networking, reframing, supporting, and making well-

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founded recommendations (Anderson & Krathwohl, 2001; Bloom et al., 1956).

2.3.8.3 Practical and Experimental Skills (PES)

Practical skills refer to hands-on competencies demonstrated through the use of tools, machinery, or equipment to address real-world challenges. Effective teaching of these skills involves engaging students in projects, case studies, and fieldwork, allowing them to actively participate in practical tasks and explore solutions to authentic problems (Anderson & Krathwohl, 2001).

Experimental skills involve the systematic application of scientific inquiry processes. These include abilities such as planning experiments, making careful observations, manipulating materials, classifying data, drawing and measuring accurately, interpreting results, recording findings, reporting outcomes, and conducting work safely in laboratory or field settings.

Both practical and experimental skills fall within the psychomotor domain, which focuses on physical and manipulative abilities. A structured approach to teaching these skills requires clear guidance, demonstrations, and opportunities for students to practice and refine their techniques. The following summary outlines key skills and explanations necessary for effective practical and experimental work.

Experimental Skills refer to the deliberate and structured application of scientific inquiry processes. These skills encompass planning and designing experiments, observing phenomena accurately, manipulating materials, classifying and organising data, producing precise drawings, taking measurements, interpreting and analysing results, recording observations systematically, reporting findings clearly, and

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performing all activities safely in laboratory or field contexts (Anderson & Krathwohl, 2001).

Equipment Handling involves the proper and safe operation of tools and instruments during practical and experimental tasks. It is essential for teachers to guide students in developing proficiency and confidence in using scientific equipment, ensuring that experiments are conducted efficiently, accurately, and safely.

Planning and Designing Experiments: Involves formulating hypotheses, designing and organising experimental procedures, persistently carrying out experimental activities, and making necessary adjustments to experiments to achieve valid and reliable conclusions.

Observation: Entails the careful use of the senses to make precise judgments. Students should be able to describe and classify specimens based on characteristics such as colour, shape, texture, and structure.

Manipulation: Refers to the skilful handling of scientific materials, tools, and equipment to perform specific tasks. This includes setting up laboratory apparatus, preparing specimens, and organising materials for observation and experimentation.

Classification: Involves grouping objects or specimens according to shared properties or characteristics to facilitate analysis and understanding.

Drawing: Requires creating accurate and clearly labelled illustrations of specimens or objects to support observation and reporting.

Measuring: Entails the correct use of measuring instruments to obtain precise and reliable readings during experiments.

Interpretation involves assessing the quality, reliability, and significance of collected data. It includes drawing logical inferences and predictions, analysing information

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presented in textual or graphical form, and deriving well-founded conclusions based on the evidence obtained from experiments.

Recording: Involves creating clear and well-labelled graphical or visual representations that accurately reflect the data and are relevant to the investigation being conducted.

Reporting: Students should be able to communicate findings from their projects effectively, whether orally or in writing. Reports must be concise, precise, clear, and accurate, presenting the key outcomes of investigations.

Conduct in Laboratory/Field: Requires strict adherence to safety protocols, showing concern for personal safety and the well-being of others. Students should demonstrate the ability to work independently and collaboratively, maintain a clean and organised workspace, use materials economically, persist in achieving results, and employ creative approaches to problem-solving and resource use.

Attitudes: Success in chemistry, or any scientific endeavour, depends not only on skills and knowledge but also on the cultivation of positive attitudes. Chemistry education should foster the following dispositions:

- **Curiosity:** A natural inclination to seek understanding about how things function across different contexts and phenomena.
- **Perseverance:** The ability to persist with investigations and problem-solving efforts until reliable results are obtained.
- **Flexibility in Ideas:** Openness and willingness to revise opinions or hypotheses when presented with more compelling evidence.
- **Respect for Evidence:** Commitment to collecting, analysing, and using data rigorously, along with acknowledging and respecting the data and conclusions of others.

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Reflection: Refers to the practice of critically evaluating how an investigation was conducted, identifying potential errors, limitations, or weaknesses, and considering alternative approaches or improvements for future investigations.

2.3.8.4 Assessment

When designing assessment procedures for the chemistry curriculum, it is important to select clear and specific objectives that allow for evaluation of a representative subset of the overall syllabus goals. Each individual syllabus objective functions as a benchmark for measuring student performance. Developing a test with items drawn from a carefully chosen sample of these objectives constitutes a criterion-referenced test, which assesses how well students have achieved the intended learning outcomes. In cases where it is not feasible to assess all term- or year-long objectives in a single evaluation, alternative assessment strategies—such as class tests, assignments, and projects—should be designed to cover key objectives over a period of time, ensuring a comprehensive evaluation of student learning.

The example below illustrates an examination structure comprising three papers—Paper 1, Paper 2, Paper 3—along with a School-Based Assessment (SBA). Paper 1 is typically an objective-type test, focusing primarily on assessing students' recall and recognition of knowledge. Paper 2 includes structured or essay-type questions that primarily evaluate the "Applying Knowledge" dimension, while also incorporating items that assess "Knowledge and Understanding." Paper 3 is dedicated to practical assessments, testing students' hands-on and experimental skills. The SBA covers all three profile dimensions—knowledge, application, and practical/experimental skills—as outlined in the syllabus. The allocation of marks across objective questions, essay

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questions, practical tasks, and SBA components should correspond to the relative weightings of the profile dimensions specified in the curriculum.

In the WASSCE examination, Paper 1 typically includes around 60 objective-type questions along with some structured and essay questions, designed to assess both knowledge recall and understanding. Paper 2 may consist of three practical questions and is intended to be more intellectually demanding, focusing on higher-order thinking and the application of knowledge. Paper 3 evaluates practical skills and experimental competence. In this structure, Paper 1 carries 60 marks, Paper 2 90 marks, Paper 3 60 marks, and the School-Based Assessment (SBA) carries 90 marks. The allocation of marks reflects the relative importance and cognitive demand of each component. Since Paper 2 challenges students with more complex problem-solving and application tasks, it is weighted more heavily than Papers 1 and 3. The final row in the mark distribution table illustrates the proportion of total marks assigned to each of the four assessment components.

Guidelines for School Based Assessment

The new SBA system is designed to provide schools with an internal assessment system that will help schools to achieve the following purposes:

- Standardise the practice of internal school-based assessment in all Senior High Schools in the country
- Provide reduced assessment tasks for subjects studied at SHS
- Provide teachers with guidelines for constructing assessment items/questions and other assessment tasks
- Introduce standards of achievement in each subject and in each SHS class

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- Provide guidance in marking and grading of test items/questions and other assessment tasks
- Introduce a system of moderation that will ensure accuracy and reliability of teachers‟ marks
- Provide teachers with advice on how to conduct remedial instruction on difficult areas of the syllabus to improve class performance.

The arrangement for SBA may be grouped in categories as follows. Laboratory work, Projects, Group Work and End of Term Examinations

1. Laboratory Work: Students will be required to keep laboratory notebook. It is of utmost importance that records be neatly and accurately kept by both student and teacher.
2. Projects/Field Work: These are tasks assigned to students to be completed over an extended time. These will involve the following:
    i. Practical work
    ii. Experiment
    iii. Investigative study (including case study)

A report must be written for each project undertaken.

3. Mid-Term Test: The mid-term test following a prescribed format will form part of the SBA
4. Group Exercise: This will consist of written assignments or practical work on a topic(s) considered important or complicated in the term's syllabus
5. End-of-Term Examination: The end-of-term test is a summative assessment system and should consist of the knowledge and skills students have acquired in the term. The end-of-term test for Term 3 for example, should be composed of items/questions based on the specific objectives studied over the three terms,

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using a different weighting system such as to reflect the importance of the work done in each term in appropriate proportions. For example, a teacher may build an End-of-Term 3 test in such a way that it would consist of the 20% of the objectives studied in Term 1, 20% of objectives studied in Term 2 and 60% of the objectives studied in Term 3. The end-of-term 3 test should therefore sample the knowledge and skills acquired over the three school terms in appropriate proportions.

Grading Procedure

To improve assessment and grading and also introduce uniformity in schools, it is recommended that schools adopt the following WASSCE grade structure for assigning grades on students test results.

Grade A1: 80 - 100% - Excellent

Grade B2: 70 - 79% - Very Good

Grade B3: 60 - 69% - Good

Grade C4: 55 - 59% - Credit

Grade C5: 50 - 54% - Credit

Grade C6: 45 - 49% - Credit

Grade D7: 40 - 44% - Pass

Grade D8: 35 - 39% - Pass

In assigning grades to students test results, you are encouraged to apply the above grade boundaries and the descriptors which indicate the meaning of each grade. The grade boundaries i.e., 60-69%, 50-54% etc., are the grade cut-off scores. For instance, the grade cut-off score for B2 is 70-79%. When you adopt a fixed cut-off score grading system as in this example, you are using the criterion-referenced grading system. By

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this system a student must make a specified score to be awarded the requisite grade. This system of grading challenges students to study harder to earn better grades. It is hence a very useful system for grading achievement tests.

It is important to always develop and use a marking scheme when evaluating class examination scripts. A marking scheme outlines the expected key points for the best possible answer to each question, the marks allocated for each point, and the total marks for the question. For example, if a question is worth 20 marks and the ideal answer includes six key points, marks can be distributed among these points—such as 3 marks per point, adjusted according to the quality of the student's response—totalling 18 marks. The remaining 2 marks can be awarded for the overall organisation and presentation of the answer. For objective-type papers, an answer key can be prepared in advance to facilitate faster and more consistent marking.

2.4 Research works on Assessment

Several researchers, including Moses (2012) and Egolum and Igboegwu (2013), have highlighted the significance of regularly evaluating the extent to which the chemistry curriculum is implemented. Assessment refers to the systematic gathering of information about the current state of a programme or system to inform decisions or recommend changes. The emphasis on understanding the present situation underscores the fact that programmes and systems are dynamic and subject to modification, necessitating ongoing assessments and longitudinal comparisons to monitor progress and effectiveness (Mohan, 2010).

The importance of assessment in educational programmes is widely recognised. Assessment facilitates informed judgments about a programme, allowing educators and stakeholders to identify its strengths and weaknesses and determine areas that require

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retention or improvement (Osegbue, 2018). This process provides an opportunity to review and refine components of the educational system to enhance overall efficiency. Consequently, a central aim of evaluation in education is to improve the attainment of educational goals and objectives. As noted by Olurinola et al. (2017), educational evaluation generates information that helps stakeholders make informed decisions that can positively influence teaching, learning, and programme development.

Assessment in education can be broadly categorised into formative and summative types. Summative assessment is aimed at evaluating student learning at the end of a unit, course, or programme. Typical examples include standardised tests, final essays or presentations, project reports, and instructor-designed examinations such as multiple-choice tests (Trumbull & Lash, 2013; Wiles & Bondi, 2014). However, because summative assessments often focus on end-point evaluation, they may not align well with educational objectives that emphasise reflective, collaborative, and ongoing development, particularly when measuring personal and professional growth in response to teachers' needs and concerns (Bautista et al., 2017; Fenton, 2017; Mendoza, 2018).

Formative assessment, according to Trumbull and Lash (2013), is an ongoing process that evaluates skills and knowledge as they are being taught. Various forms of formative assessment—such as group discussions, collaborative projects, portfolios, reflective writing, and practical assignments—allow educators to assess learning from multiple perspectives. These assessments help identify student misunderstandings, gaps in knowledge, and areas that require additional instructional support. Their primary benefit is that they enable teachers to address misconceptions promptly and adjust instruction to meet learners' immediate needs.

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Trumbull and Lash (2013) emphasise that effective formative assessment involves strategies such as self-reflection, providing actionable feedback, fostering open dialogue, using clearly defined criteria, and collecting relevant data to guide instruction. In line with these principles, the proposed training outcomes emphasise active learning, collaborative problem-solving, and self-reflective practices. Examples of specific formative assessments include group-created lesson plans, practice teaching sessions, and individual self-assessments. Considering the goals of the project, formative assessment represents the most suitable evaluative approach to monitor and enhance student learning (Trumbull & Lash, 2013).

2.5 Relevance of Content Knowledge in Chemistry Curriculum Implementation

Fenstermacher and Yezierski (2019) highlighted that a robust understanding of chemistry content is essential for effective teaching. Teachers with strong content knowledge are better able to recognise and correct student misconceptions, facilitate meaningful classroom discussions, and provide constructive feedback. They also stressed the importance of ongoing professional development to help teachers build and sustain their content expertise. Similarly, Kaya and Bayrak (2015) observed that while most teachers possessed a solid grasp of fundamental chemical concepts, their knowledge was less comprehensive in certain areas, including chemical kinetics and thermodynamics.

It has been recommended that teacher preparation programmes and professional development initiatives place greater emphasis on strengthening teachers' content knowledge in areas where gaps exist. According to Liu et al. (2000), effective chemistry instruction requires a thorough understanding of the nature of science and the processes by which scientific knowledge is developed. Teachers should be able to explain the

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limitations and uncertainties inherent in scientific knowledge, as well as the methods by which it is generated through inquiry and experimentation. Therefore, teacher education and professional development should prioritise cultivating a deep understanding of the nature of science.

Furthermore, Meiselman (2018) emphasised that effective chemistry teaching also depends on knowledge of the history of chemistry and recognition of the contributions of diverse individuals in the field. She argued that integrating historical contexts and highlighting the achievements of underrepresented groups can enhance student engagement and foster a more inclusive appreciation of the discipline.

Schwarz and Passmore (2017) highlighted that teachers' content knowledge is essential for helping students understand the relationships among different scientific concepts. They argued that teachers must be able to identify and communicate the fundamental principles and patterns that connect various scientific ideas. Consequently, teacher education programmes and professional development initiatives should prioritise equipping teachers with the skills to integrate and link scientific concepts effectively.

Similarly, Wood and Warfa (2018) examined chemistry teacher educators' perspectives on the knowledge required for teaching chemistry. Their study indicated that effective chemistry instruction relies not only on strong subject-specific knowledge but also on pedagogical skills and laboratory management abilities. They recommended that teacher preparation programmes emphasise the development of these competencies to enhance teachers' effectiveness in the classroom and laboratory.

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2.6 Relevance of Pedagogical Knowledge in Chemistry Curriculum Implementation

Pedagogical Knowledge (PK) refers to an understanding of the methods and strategies of teaching and learning, encompassing the ability to design, implement, and evaluate instruction that effectively meets students' needs (Grossman, 1989, 1991; Shulman, 1987). Morine-Dershimer and Kent (1999) describe pedagogical knowledge as a multifaceted construct that includes classroom management and organisation, instructional models and strategies, and classroom communication and discourse. Darling-Hammond (2006) argued that pedagogical knowledge should form the core of teacher education programmes. She emphasised the importance of developing teachers' instructional skills, assessment competencies, and understanding of student learning processes. Additionally, she highlighted that teacher education programmes should be contextually relevant and provide ongoing professional development opportunities to support continuous growth in pedagogical expertise.

Pedagogical knowledge encompasses the understanding and skills that teachers require to plan, deliver, and evaluate instruction effectively. It involves insights into the learning process, strategies for creating a positive and supportive learning environment, and the ability to assess student learning accurately. Shulman (1986), a prominent scholar in this area, introduced the concept of pedagogical content knowledge (PCK), which refers to the specialised knowledge teachers need to teach specific subject matter effectively. Shulman argued that PCK is distinct from both general pedagogical knowledge and subject matter knowledge, and he emphasised that it is essential for ensuring effective teaching and meaningful student learning.

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Cochran-Smith and Lytle (1999) highlighted the significance of teacher-led research in enhancing pedagogical knowledge. They argued that teachers should actively conduct research within their own classrooms to gain deeper insights into student learning and refine their instructional practices. Such research not only benefits individual teaching but also contributes to the broader educational field by generating new knowledge about effective teaching strategies. Similarly, Ball and Forzani (2009) emphasised that effective teaching requires a comprehensive understanding of subject matter, pedagogy, and the instructional context. They argued that developing a robust knowledge base for teaching involves both theoretical understanding and practical expertise gained through experience. Therefore, teacher education programmes should provide opportunities for educators to build this knowledge base through a combination of formal coursework and hands-on classroom experience.

Grossman et al. (2009) argued that effective teaching depends on a sophisticated combination of knowledge and skills that can only be cultivated through continuous learning and reflective practice. They highlighted the value of providing teachers with opportunities for collaborative learning and reflection to enhance their pedagogical knowledge. Furthermore, they emphasised that teacher education programmes should be practice-oriented, allowing teachers to gain hands-on experience by working alongside experienced educators in authentic classroom settings. Similarly, Zeichner and Conklin (2005) asserted that effective teacher preparation programmes should support the development of a deep understanding of pedagogy, subject matter, and the diverse needs of learners. They also underscored the critical role of reflective practice in enabling teachers to refine their instructional skills and adapt their teaching to meet students' needs.

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Researchers have also emphasised that personal beliefs, practical teaching experience, and reflective practice play significant roles in shaping teachers' pedagogical knowledge. Classroom experience provides opportunities for teachers to critically reflect on their implementation of the curriculum, contributing to the development of PCK (Park & Oliver, 2007). Additionally, studies have highlighted the importance of teachers possessing a strong conceptual understanding of the interactions among technology, pedagogy, and content when designing instruction (Harris & Hofer, 2011; Koehler & Mishra, 2005).

Loughran et al. (2007) noted that PCK is an academic construct grounded in the idea that teaching involves far more than merely delivering subject content to students. Effective learning extends beyond rote memorisation and recall of facts. Accordingly, content knowledge remains essential for meaningful classroom interactions (Ball & Bass, 2000). PCK is conceptualised as a transformation of at least two fundamental knowledge domains: general pedagogical knowledge and content knowledge (Ball & Bass, 2000). It differs from these domains in that content knowledge represents the understanding held by any subject matter expert, while general pedagogical knowledge refers to the expertise of experienced teachers, such as organising a classroom and managing student learning (Gess-Newsome, 1999).

The literature indicates a need for further research to clearly define the desired PCK for specific topics and to investigate its impact on teachers' instructional practices (Kinach, 2002; Park & Oliver, 2007; Segall, 2004). PCK directly shapes classroom instruction, and as teachers enhance their PCK, they are better equipped to apply their skills across diverse teaching contexts (Schneider & Plasman, 2011). Given the strong link between

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teacher quality and student achievement, and the ongoing demand for highly effective teachers, educators are encouraged to actively develop their PCK (Park et al., 2011).

There is broad consensus that PCK serves as a valuable framework for examining teacher practice and professional growth (Kind, 2016). It has become widely accepted as a key construct for studying science teacher learning (Park et al., 2011; Sickel & Friedrichsen, 2017). While numerous models identify the components of PCK, some fail to clearly explain how these components interact and influence one another (Friedrichsen et al., 2011).

2.7 Relevance of Technological knowledge in Chemistry Curriculum Implementation

Technological knowledge has become a critical element of effective teaching (Koehler & Mishra, 2009). Many teacher education programmes include a standalone course on instructional technology as part of their core curriculum (Buss et al., 2015). However, pre-service teachers often graduate without the necessary skills to integrate technology meaningfully into their teaching (Brown & Warschauer, 2006; Wachira & Keengwe, 2011). The actual implementation of technology in instruction is influenced by teachers' perceptions of its usefulness for enhancing both content delivery and pedagogical strategies (Hughes, 2005).

In a study examining chemistry teachers' use of digital simulations, Sheikhi and Ramezani (2018) found that those who participated in professional development training demonstrated higher levels of technological knowledge and greater confidence in applying digital simulations in their teaching practices.

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Previous research has shown a strong relationship between teachers' technological knowledge and their mastery of content and pedagogical knowledge. For example, Chai et al. (2013) and Sen (2022) reported that teachers with higher levels of technological knowledge tend to possess greater content and pedagogical expertise. Similarly, Celik et al. (2014) found that teachers expressed the highest confidence in their technological knowledge.

Chai et al. (2010) demonstrated that technological, pedagogical, and content knowledge significantly predict prospective teachers' Technological Pedagogical Content Knowledge (TPACK), with pedagogical knowledge exerting the greatest influence on TPACK (Akturk & Ozturk, 2019; Eren et al., 2014; Celik, 2020). In the same vein, Bahriah and Yunita (2019) emphasised that the integration of content, pedagogy, and technology enhances the competencies of pre-service teachers. Joo et al. (2018) also indicated that chemistry teachers' technological, pedagogical, and content knowledge, alongside their self-efficacy, aligns closely with the professional competencies expected of chemistry educators.

In an era of rapidly evolving knowledge, the integration of technology by teachers has become increasingly important for effective teaching and learning (Bahriah & Yunita, 2019; Senol & Temel, 2016). Incorporating courses on technology use within teacher preparation programmes enables future educators to implement technology-based instructional strategies in their classrooms. This is because pre-service teachers' use of information and communication technologies (ICT) is significantly shaped by the training and education they receive (Senol & Temel, 2016; Tanak, 2020). By developing adequate levels of technological, pedagogical, and content knowledge,

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teachers are better positioned to successfully integrate technology into their instructional practices (Adebusuyi et al., 2020; Tanak, 2020).

Saleh and Al-Haqbani (2019) reported that although many chemistry teachers incorporate technology into their instruction, they often lack the necessary technological knowledge to integrate it effectively. Similarly, Ibáñez-Martín et al. (2015) investigated the use of augmented reality in chemistry education and found that teachers trained in augmented reality tools were able to significantly enhance student engagement and motivation. In another study, Mishra and Dutta (2017) examined the integration of mobile learning technologies in chemistry classrooms and concluded that teachers who received training in mobile learning were better able to improve student learning outcomes and foster greater student participation.

Park and Kim (2018) investigated the use of virtual reality in chemistry education and found that teachers who incorporated this technology were able to improve students' understanding and visualisation of chemical structures and concepts. While several scholars have developed related curricula, textbooks, professional development modules, and other resources to support technology integration (Archambault, 2016), there remains limited data on teachers' actual use of these tools in the classroom. Kastberg and Leatham (2005) noted that without sufficient knowledge of relevant curriculum materials, teachers at any stage of preparation may feel discouraged from effectively integrating technology into their instruction.

2.8 Curriculum Implementation Approaches

Curriculum approaches play a key role in shaping how the official curriculum is translated into classroom practice (Doyle, 1992; Randolph et al., 2007). Each approach offers distinct roles and opportunities, leading to varied effects on teachers'

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professional development (Eisner, 2002; Craig, 2006). In practice, teachers implement curriculum using different strategies such as fidelity, mutual adaptation, or enactment. Teachers who follow the **fidelity approach** act as curriculum transmitters, delivering curriculum content directly to students as designed. Those employing the **adaptation approach** serve as curriculum developers, making modifications to the curriculum. Teachers who use the **enactment approach** function as curriculum makers, making substantial and innovative changes to the curriculum to suit their classroom context (Snyder et al., 1992).

2.8.1 The Fidelity Approach

The **fidelity perspective** focuses on evaluating how closely an instructional programme is implemented according to its original design (Fullan, 1991; Snyder et al., 1992). This approach also examines the factors that facilitate or impede the implementation process. Shawer (2003) observed that teachers following the fidelity approach typically deliver textbook content in a sequential manner—unit by unit, lesson by lesson, and page by page—without adapting the curriculum to their specific classroom context or omitting learning units that may be deemed less relevant.

The fidelity approach to curriculum implementation is applied when teachers are expected to follow the curriculum precisely as designed. This approach emphasises fidelity of implementation, which refers to delivering instruction in the way it was intended (Gresham, 1989). Vaughn et al. (2000) explained that fidelity occurs when teachers present both the curriculum content and the prescribed instructional strategies exactly as outlined by the designers. While many teachers acknowledge that multiple approaches can be used to teach students, research has not always provided clear guidance necessitating changes in instructional practices. Therefore, the fidelity

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approach involves assessing the extent to which a programme is implemented as intended and identifying factors that support faithful implementation (Snyder et al., 1992; Vaughn et al., 2000).

Proponents of the fidelity approach argue that curriculum experts primarily develop curriculum knowledge outside the classroom, which teachers are then expected to implement exactly as designed (Snyder et al., 1992). In such a system, the curriculum is centrally developed and distributed to schools for standardised implementation—a model particularly applicable to centralised education systems, such as that in Ghana. A second key assumption is that curriculum change is a logical, systematic, and linear process. According to Fullan (1991), the effectiveness of this process improves when curriculum developers and implementers identify and address factors that either facilitate or hinder smooth implementation. The third assumption concerns the role of the teacher, who is viewed as a consumer responsible for faithfully executing the curriculum as intended. Consequently, the success of curriculum implementation is closely linked to the teacher's adherence to the prescribed instructional design (Snyder et al., 1992).

The literature indicates that faithful implementation of a well-aligned curriculum enhances students' academic readiness. Ahmed Hersi et al. (2016) and Causarano (2015) highlighted the benefits of supporting teachers through curriculum and instructional reforms to improve fidelity in implementation. Ensuring teacher support and maintaining alignment across grade levels can help stabilise student performance (Ahmed Hersi et al., 2016). Similarly, Yurdakul (2015) emphasised that how teachers interpret and apply the curriculum with fidelity significantly affects outcomes. When

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teachers fail to implement the curriculum as intended, both student performance and preparedness are negatively impacted (Yurdakul, 2015).

Yurdakul (2015) noted that teachers maintain fidelity to the curriculum by adapting instructional practices to fit the specific needs of their classroom context. Administrators and parents generally expect teachers to demonstrate a strong understanding of the curriculum and its connection to student learning outcomes. Aligning curriculum with instructional practices promotes coherence; however, this alignment requires adequate teacher training to ensure educators feel confident in implementing the curriculum faithfully. According to Yurdakul (2015), a lack of fidelity makes it difficult to determine whether observed student outcomes result from the curriculum itself or from teacher adaptations. This underscores the importance of understanding the factors that lead teachers to deviate from the prescribed curriculum and providing support that addresses their concerns (Castro et al., 2015).

2.8.2 The Mutual Adaptation Approach

Curriculum adaptation refers to the process through which curriculum developers and teachers modify a curriculum to better suit the needs of their school or classroom (Snyder et al., 1992). Barnes (2005) observed that while teachers formally acknowledge programmes, policies, directives, and school regulations, in practice they often adjust implementation to meet contextual realities. This approach involves both developers and implementers making changes to the curriculum. Proponents of the reinvention perspective support modifying programmes to address local needs (Berman & McLaughlin, 1978). Adaptations may include additions, enhancements, or deletions to the original curriculum. By adjusting traditional curricula to local conditions, teachers can maximise its effectiveness. Furthermore, teachers' beliefs, the practices of their

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colleagues, and other cultural factors significantly influence the curriculum that students ultimately experience (Barnes, 2005).

Proponents of the **curriculum adaptations approach** argue that curriculum knowledge is shared between developers and the teachers who implement it in the classroom (Fullan, 1991; Snyder et al., 1992). Teachers are considered knowledgeable about the curriculum because they actively apply it in practice. Consequently, for a curriculum to be effective, educators are expected to modify it as necessary during implementation to suit their classroom context. Unlike linear models, this approach views curriculum change as a dynamic and non-linear process, where active teacher participation makes outcomes less predictable (Snyder et al., 1992). Teachers enhance the effectiveness of the curriculum by adapting traditional content to meet local needs, and factors such as teachers' beliefs, peer practices, and cultural contexts significantly influence the curriculum students ultimately receive (Barnes, 2005).

2.8.3 The Enactment Approach

According to Snyder et al. (1992), **curriculum enactment** represents the educational experiences collaboratively shaped by both teachers and students. This approach examines how a curriculum evolves through the ongoing interactions and ideas of classroom participants. Externally developed curriculum materials and instructional strategies are treated as tools that teachers and students can use to construct their own learning experiences. In this sense, teachers and students act as co-creators of the curriculum rather than merely recipients of predefined knowledge (Fullan & Pomfret, 1977). Teachers contribute in various ways, including developing new syllabuses and curriculum guides, serving as syllabus writers or advisory committee members, and participating in school-based trials of curriculum materials (David & Macdonald,

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2001). Their involvement not only influences the curriculum's content but also allows them to incorporate their own perspectives and interests, thereby shaping the nature of the educational experience.

Proponents of the curriculum enactment approach view knowledge as dynamic, continuous, and evolving rather than static or fixed (Jackson, 1992). Through ongoing interactions with students, teachers develop a curriculum that is tailored to the specific context of their classroom. This curriculum is not static; it adapts and changes based on the interactions between teachers and students. Teachers are expected to continually enhance their ability to create meaningful and effective educational experiences over time (Jackson, 1992).

Consequently, the teacher plays a central role in both the development and implementation of the curriculum. Classroom curriculum emerges through the collaborative interaction of teachers and students; without this interaction, a meaningful curriculum does not exist (Snyder et al., 1992). Although all three approaches to curriculum implementation—fidelity, adaptation, and enactment—are recognised in the literature, this study specifically emphasises the fidelity approach. In most discussions, the term curriculum implementation is commonly associated with fidelity orientation rather than with mutual adaptation or curriculum enactment.

2.9 Relevance of Teacher Qualification and Teaching Experience

In many countries, teacher qualifications linked to student learning outcomes have become key targets for teacher education reform. Such reforms often aim to professionalise teacher education by extending its duration, upgrading programmes to the graduate level, and regulating them through licensure, certification, and promotion systems aligned with established standards (Darling-Hammond et al., 2001; Darling-

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Hammond et al., 2002). Research consistently demonstrates a positive correlation between teachers' preparation in their subject area and subsequent student achievement (Darling-Hammond, 2000; Goldhaber & Brewer, 2000). Wang and Cheng (2005) emphasised that, among the factors influencing curriculum implementation, a teacher's qualifications and experience—which reflect their training and skills—are arguably the most critical. Historically, teachers were not always aware when their instructional practices deviated from the intentions of curriculum developers (Reinmann-Rothmeier & Mandl, 1999).

A study by Penuel et al. (2007) found that teachers' educational attainment significantly influences their classroom performance. In particular, a teacher's professional and academic qualifications impact their competence in implementing the curriculum. The research revealed that teachers with professional qualifications were more likely to engage with and adhere to curriculum implementation requirements. Penuel et al. (2007) also highlighted that issues of professionalism are closely tied to teacher qualifications, and that professional and non-professional teachers respond differently to curriculum implementation. Specifically, teachers may choose to ignore, resist, adopt, or adapt the official curriculum, indicating that teacher qualifications play a crucial role in shaping how curricula are implemented.

Research on the impact of advanced degrees on teaching effectiveness has produced mixed results. Some studies report positive effects of higher qualifications (Betts et al., 2003; Wayne & Youngs, 2003), while others indicate negative or negligible effects (Ehrenberg & Brewer, 1994; Kiesling, 1984). Critics have argued that requiring a second degree increases the cost and duration of teacher education, potentially discouraging high-quality candidates from entering the profession (Murnane, 1996).

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Previous studies also suggest that teaching experience is positively associated with instructional quality and curriculum implementation, although the overall evidence is not particularly strong (Hanushek, 2003). While most studies indicate a positive relationship, only a small proportion of these findings are statistically significant. Hanushek further conducted a nonparametric analysis, revealing that the benefits of teaching experience are largely concentrated in the initial years of a teacher's career.

Research examining the impact of teacher experience on student learning has generally found a positive association between teacher effectiveness and years of experience, though this relationship is not always statistically significant or strictly linear (Murnane & Phillips, 1981). Available evidence suggests that inexperienced teachers tend to be less effective than their more experienced counterparts, but the advantages of experience often plateau after several years (Rivkin et al., 2000). Interpreting the link between teacher experience and student achievement is challenging because it is influenced by contextual factors and teachers' motivation to work. Harris and Sass (2007) highlighted the potential for selection bias, noting that if less effective teachers are more likely to leave the profession, it could create the false impression that experience consistently improves effectiveness. Conversely, selection bias might operate in the opposite direction, as highly skilled teachers with better career opportunities may also be more likely to leave the profession.

The issue of professionalism in teaching has been a subject of scholarly attention for several decades. Researchers have emphasised the importance of skilled teachers for achieving effective learning outcomes. Ngada (2008) argued that the success or failure of any educational programme largely depends on the availability of qualified, competent, and dedicated teachers. Similarly, Seweje and Jegede (2005) highlighted

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that a teacher's effectiveness is not solely determined by academic background but also by the pedagogical skills they have developed. Nkwodimah (2003) noted that the quality of teachers inevitably influences the kind of citizens a society produces in the future. In a study by Ngada (2008), over 80% of respondents reported that teachers often exhibit weaknesses, including insufficient exposure to practical teaching, poor classroom management, limited subject-matter knowledge, and a lack of professionalism.

2.10 The Role of Teachers in Chemistry Curriculum Implementation

Teachers are widely recognised as essential actors in the implementation of educational reforms (Glatthorn et al., 2009; Kopweh, 2014). Research highlights that teachers function as key participants and agents of change (Van Heijden et al., 2015) and have been described as "instruments of change" (Karavas-Doukas, 1995). Their centrality is evident because they are directly responsible for enacting educational transformations. Consequently, neglecting the pivotal role of teachers in the reform process can adversely affect the success of curriculum implementation (Fullan, 2007). Glatthorn et al. (2009) further emphasised that teachers should actively participate in reform initiatives, as they are the individuals who translate policy, information, and procedures into effective classroom action.

This suggests that the success of curriculum reforms largely depends on active teacher involvement in the development and implementation process. Kopweh (2014) further argues that such improvements should also engage the surrounding community, particularly families, who often hold high expectations for their children's educational outcomes at the end of primary or secondary schooling. Despite the critical responsibilities assigned to teachers in curriculum reform and implementation,

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educators in many contexts receive limited or no support to effectively carry out these reforms (Gray, 1999; Elmas et al., 2014).

Similarly, Van der Heijden et al. (2015) emphasised the importance of establishing supportive school environments that enable teachers to act as agents of change, positively influence educational practices, and pursue both individual and collaborative professional development. Consequently, those leading curriculum reforms must provide teachers with the necessary support and resources to effectively engage in the reform process and accomplish its intended objectives, including successful curriculum implementation (Engeström, 2001).

2.11 Professional Development in Chemistry Curriculum Implementation

Professional development (PD) is widely recognised as a critical strategy for enabling teachers to implement curriculum reforms successfully. PD is considered essential for enhancing teachers' willingness and preparedness to embrace and enact educational changes (Kennedy, 2005; Anderson, 2010; Wilson, 2013; Guskey, 2002). Without sufficient support through structured PD programmes, teachers may encounter significant challenges in executing reforms effectively. Anderson (2010) notes that, in the absence of adequate tools and guidance, teachers may face unresolved personal or instructional management issues, potentially leading to frustration, resistance, or even abandonment of the intended reforms.

Similarly, Kennedy (1996) highlighted the essential role of professional development in supporting teachers to adopt and implement curriculum changes effectively. He argued that when teachers are provided with appropriate resources and guidance, they are more likely to carry out reforms successfully. Numerous educational reforms worldwide have demonstrated positive outcomes. For instance, Yin (2013) reported that

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the availability of professional development programmes was a key factor enabling teachers to adopt and implement reforms effectively. Likewise, Pegg (2013) observed that the successful implementation of curriculum reforms at universities in the UK was facilitated by a combination of supportive factors, including targeted professional development.

Despite widespread acknowledgment of the vital role professional development plays in supporting teachers to implement curriculum reforms, and the existence of PD programmes in various contexts, many reform initiatives have not succeeded. A key factor contributing to these failures is the insufficiency or inadequacy of PD support, as highlighted by several studies (Borko, 2004; Cook, 2010). For example, Cook (2010) examined factors influencing Japanese English teachers' use of communicative language teaching and found that support programmes for teachers were limited and largely ineffective. To enhance the impact of professional development, educators and PD providers must carefully assess the elements that contribute to effective and meaningful PD programmes.

The literature emphasises the importance of collaboration in professional development, lesson planning, and self-assessment as essential components for teachers' professional growth (Davis et al., 2017; Hurney et al., 2016; Longhurst et al., 2016; Mendoza, 2022). Research suggests that teacher effectiveness is closely linked to the quality of in-service or professional development programmes they receive (Bayar, 2014; Whitworth & Chiu, 2015; Borg, 2015; Darling-Hammond, 2017). Boakye and Ampiah (2017) identified challenges faced by newly qualified teachers, including lesson planning, assessment, time management, and navigating school culture during the transition from training to professional practice. To address these challenges, several studies propose

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key components for effective professional development programmes, including: 1) school-based implementation; 2) consideration of participant needs; 3) alignment with school needs; 4) teacher involvement in PD planning; 5) provision of practical teaching experiences; and 6) sustained engagement over time (Bayar, 2014; Nishimura, 2014; Cordingley et al., 2015).

School-based professional development is considered essential for enhancing teachers' instructional practices. When implemented within the classroom context, such programmes allow teachers to identify relevant resources and strategies that effectively address their students' needs, often through problem-solving activities focused on the teachers' own challenges (Nishimura, 2014). Another critical aspect of effective PD is addressing the specific needs of participants. Research suggests that PD activities tailored to teachers' real-life situations are more impactful (Harris et al., 2006; Bayar, 2014). While individual teachers have unique requirements, these are often shaped by the demands of their professional environments (Cordingley et al., 2015). Additionally, PD programmes should consider the distinct needs of schools, recognising that classroom and school contexts can vary widely (Bayar, 2014). Linking professional development to the realities of each school allows participants to see the practical connection between PD activities and their own classroom situations, thereby increasing relevance and effectiveness (Sandholtz & Scribner, 2006; Starkey et al., 2009).

Another key element of effective professional development is addressing the needs of participants. Studies indicate that PD activities designed around teachers' actual classroom experiences tend to be more effective (Harris et al., 2006; Bayar, 2014). Although individual teachers have specific requirements, these are largely shaped by

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the demands and conditions present in their professional environments (Cordingley et al., 2015).

Teacher involvement in the planning of professional development programmes is another essential component. Research suggests that when teachers are excluded from the planning process, they may feel disengaged and perceive the content as irrelevant to their needs (Bayar, 2014). Therefore, including teachers in PD planning is considered crucial, as it fosters a sense of ownership and commitment to the programme (Starkey et al., 2009; Whitworth & Chiu, 2015).

Active teacher engagement is considered crucial for strengthening the impact of professional development programmes. Teachers tend to learn more effectively through hands-on participation rather than passive listening, highlighting the importance of practical involvement during PD activities (Starkey et al., 2009). Another essential component is sustained, long-term participation in PD programmes. Research indicates that extended engagement enhances the effectiveness of professional development by keeping teachers continuously informed about evolving teaching practices (Cordingley et al., 2015; Bayar, 2014). Conversely, short-term PD programmes are often less effective in maintaining teachers' up-to-date knowledge and skills (Torff & Sessions, 2008; Lauer et al., 2014; Yan & He, 2015).

The literature consistently emphasises the importance of equipping teachers with appropriate "tools" (Engeström, 2001), such as comprehensive and effective professional development (PD), to ensure successful changes in teaching practices and the implementation of new educational policies. Effective PD programmes should provide ongoing support while being responsive to teachers' specific needs. The structure of the educational system—centralised or decentralised—also plays a role in

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shaping how PD is delivered (Harris, 2011; Fullan, 2007). For instance, in decentralised systems like Denmark, schools are responsible for organising PD programmes, whereas in centralised systems such as Libya, Turkey, and Saudi Arabia, these programmes are organised by educational authorities (Darling-Hammond, 2017).

Nonetheless, the effectiveness of PD programs is ultimately determined by the expertise and approach of those delivering the training, rather than the system itself. Cordingley et al. (2015) highlighted this in their review of successful PD initiatives in English teaching schools, noting that trainer expertise significantly influenced programme outcomes. Effective trainers possessed deep knowledge of professional development processes, evaluation methods, and monitoring strategies. Furthermore, they fostered participants' sense of ownership by involving them in leadership roles within the PD activities and treating them as co-learners. This collaborative approach enables participants to share, challenge, and refine their values, understandings, goals, and beliefs about teaching and learning, thereby enhancing the impact of the PD programme.

Curricula are often subject to reform, making it essential for those responsible for implementation—particularly teachers—to understand the objectives, approaches, and methods underpinning these changes, as well as how to apply them effectively. As reforms continue, implementers require sustained support to carry out the revised curriculum as intended. This makes the discussion of professional development (PD) highly relevant to this research. Examining PD provides insight into how chemistry teachers are supported in implementing the curriculum, and it highlights strategies for enhancing the effectiveness of such programmes when gaps are identified. If this project is implemented, it will provide teachers with targeted training to improve

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curriculum fidelity, while also addressing their individual concerns and professional growth through self-assessment. Ultimately, the project aims to enhance students' learning experiences by strengthening teachers' professional development (Kirby & Hennessy, 2014; Okpe & Onjewu, 2017).

Evaluation plays a key role in determining the impact of professional development (PD) on teachers' classroom practices. Collaborative activities and peer-designed lessons enable teachers to make informed decisions about modifying their instructional and assessment strategies. Ongoing monitoring of these practices supports teachers' growth through reflection and peer guidance (Courtade et al., 2017; Pleec et al., 2016; Tollefson-Hall, 2015). Participants will also complete surveys assessing the relevance and effectiveness of the training. Feedback from these surveys will allow instructors to engage in self-reflection and improve their practice, ultimately enhancing the quality of PD for future participants (Gee & Whaley, 2016).

The evaluation of collaborative group model lessons and self-assessments will provide insights into teachers' professional growth (Gonczi et al., 2016; Pleec et al., 2016). Peers will offer constructive feedback on each other's lesson plans, allowing participants to raise questions and address concerns. Each group will receive a copy of the feedback notes to support self-evaluation and identify areas for improvement. This process aims to foster teacher learning and professional development through peer collaboration and reflective practices, ultimately enhancing student learning outcomes (Courtade et al., 2017; Pleec et al., 2016; Tollefson-Hall, 2015).

Administrators have multiple roles in supporting professional development. They are responsible for approving logistical aspects such as time, location, and budget, ensuring that sessions fit within the existing in-service schedule. Additionally, administrators are

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encouraged to attend sessions to observe teacher participation and growth, demonstrating the importance of professional development through active involvement. Finally, administrators contribute to a positive school climate by fostering collaboration and providing ongoing opportunities for teacher development (Turner et al., 2018; Willis & Templeton, 2017).

Concepts related to self-evaluation and reflection should be introduced on the final day of training, as reflection allows teachers to engage in critical self-analysis and benefit from evaluating their own practices (Carbone et al., 2017; Okpe & Onjewu, 2017). During this session, groups would discuss the lesson-planning process, formats to be used, and model lessons. Each participant would maintain a reflective journal to document their training experience. Research indicates that content-specific professional development, tailored to teachers' needs and those of their students, is most effective. Literature further emphasises that collaboration and peer interaction are essential for supporting professional growth, fostering positive team dynamics, and providing opportunities for problem-solving and developing improvement strategies (Carson & Dawson, 2016; Gutierez & Kim, 2017). Prior studies have also shown that professional development that encourages peer-group interaction and self-reflective practices enhances teacher learning, which aligns with the goals of the proposed project (El-Bilawi & Nasser, 2017; Shagrir, 2017). Finally, existing literature provides guidance for producing meaningful deliverables such as lesson plans and reflective journals.

The training format begins by identifying teachers' concerns, followed by collaborative efforts to address these issues. Next, the training provides an in-depth review of available resources and a model lesson. Teachers then work with their colleagues to

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develop a lesson plan that integrates these materials and resources. Finally, participants present and teach their lesson plans to their peers, sharing best practices and strategies to deepen their familiarity with the curriculum (Chandran et al., 2017; Teng, 2016).

The final factor in the training model includes self-assessment and self-reflection, which foster critical thinking about lesson planning and the selection of instructional practices (Carbone et al., 2017; Okpe & Onjewu, 2017). The training begins with identifying teacher concerns, as understanding participants' needs is essential for selecting an effective format (George et al., 2013; Hall & Hord, 2015). Collaborative professional development provides a forum for problem-solving, open discussion of concerns, strengths, and weaknesses, and the sharing of best practices (Gutierez & Kim, 2017). In contrast, general lectures, large workshops, and conferences often minimise teacher experiences and needs, reducing relevance to practice (Bautista et al., 2017).

Content-specific professional development delivered in smaller, more intimate sessions enables teachers to learn from one another in a safe environment. The training format aligns with the Professional Learning Community (PLC) model, in which teachers collaborate to solve problems, develop lesson plans, reflect on instructional and assessment strategies, and discuss student progress. PLCs offer opportunities for collaboration, peer feedback, and self-reflective practices, ultimately enhancing both teacher professional growth and student learning experiences (Vanblaere & Devos, 2018; Jones & Thessin, 2017; Willis & Templeton, 2017). Turner et al. (2018) also observed that collaboration within PLCs strengthens team relationships and communication among peers. Based on these findings, the proposed project structures and implements professional development using PLCs as a guiding framework.

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Vanblaere and Devos (2018) examined the role of department heads in PLCs and highlighted the importance of strong leadership and administrative involvement in ensuring PLC success. In the proposed project, administrators are included because their participation adds value to professional development initiatives. Willis and Templeton (2017) also acknowledged the benefits of PLCs but emphasised that teacher buy-in is essential for their effectiveness. Collaboration during PLC sessions offers multiple advantages, including enhanced communication among team members and team leaders (Turner et al., 2018). Open communication fosters effective collaboration, enabling teams to address challenges more efficiently. Overall, PLCs consistently support teachers' professional growth while enhancing students' curriculum-related experiences, with collaboration and peer support being among the most significant benefits.

2.12 Resources for Chemistry Curriculum Implementation

Effiong and Igiri (2015) described instructional resources as print and non-print items used to convey information to students during the educational process. These resources—including textbooks, newspapers, photographs, and videos—play a critical role in enhancing the learning experience. While oral instruction can be effective, it is sometimes insufficient on its own. Teachers must therefore utilise appropriate instructional materials to improve the quality and effectiveness of their teaching rather than relying solely on verbal methods. Moreover, the provision of diverse classroom equipment alongside sufficient training materials is necessary to support teachers in implementing the intended instructional changes (UNESCO, 2014). However, merely using instructional resources does not guarantee effective teaching or the achievement of desired learning outcomes. To maximise instructional effectiveness, materials must be carefully selected and appropriately applied in the teaching process (Wambui, 2013).

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Instructional materials play a crucial role in enhancing students' memory and understanding of content (Wambui, 2013). The absence of adequate resources and equipment can hinder the effective implementation of educational reforms. For instance, Carless (1997) observed that insufficient resources were a key factor limiting the success of curriculum reform in Hong Kong. Similarly, Karim (2004) reported that teachers in Bangladesh faced significant challenges in implementing English curriculum changes, largely due to a shortage of teaching and learning materials. In Tanzania, Makunja (2016) noted that the lack of necessary resources prevented teachers in Morogoro Municipality from effectively applying curriculum reforms. Even when resources are available, they may be perceived as irrelevant if they do not align with the reform's principles. Therefore, it is essential to carefully plan and provide teaching and learning resources that adequately support student learning (Golding, 2023).

The availability, adequacy, and quality of curriculum resources can significantly affect the success or practicality of implementing curriculum changes. Textbooks often serve as the main reference for teachers when introducing new curricula innovations. Yidana and Aboagye (2018) emphasise that existing resources should be sufficient to support innovation, and that appropriate facilities, equipment, and materials must be provided to facilitate effective curriculum implementation. Carless (1997) observed that the initial rollout of the Target-Oriented Curriculum in Hong Kong struggled due to a lack of teaching resources. Teachers had insufficient instructional materials and limited non-contact time to rehearse lessons, which led many to refrain from applying the new curriculum. Furthermore, even when materials are provided, their effectiveness may be limited if they are of poor quality or fail to accurately reflect the principles of the innovation.

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Research indicates that curriculum materials play a key role in supporting teachers during curriculum implementation (Ball & Cohen, 1996; van den Akker, 1988). They achieve this by offering theoretical explanations of the intended changes, illustrating how these changes can be applied in practice, and giving teachers the chance to try out model activities. To fulfil these purposes effectively, the materials need to provide detailed, clear, and practical guidance for teachers on planning, organising, and delivering lessons.

Research in Southern Africa has also explored the impact of curriculum materials designed with these principles. In Namibia, Ottevanger (2001) found that high-quality curriculum materials can serve as valuable support for teachers during the early stages of implementation, helping them plan and deliver lessons that focus on learner-centred approaches. Similarly, a study in Botswana by Thijs (1999) revealed that effective curriculum resources can help teachers overcome initial apprehensions and motivate them to experiment with learner-centred teaching strategies. The use of such materials provided teachers with new ideas for engaging students more actively in the learning process.

Chen and Wei (2015) investigated the factors that shaped how teachers in China adapted curriculum materials for the new senior secondary chemistry curriculum, a standards-based science programme. The study was grounded in the idea that classroom outcomes are influenced by the way teachers interact with curriculum materials within their social context. The analysis identified seven factors that affected teachers' adaptations: pedagogical content knowledge (PCK), external examinations, time constraints, availability of teaching resources, class size, beliefs about science, and peer

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coaching. Of these, PCK, external examinations, and time limitations were found to be the most influential in determining how teachers modified the curriculum materials.

Ezeliora (2001) described a science laboratory as a workspace where scientific activities are conducted in a suitable environment, and where equipment, materials, and instruments are stored safely. Similarly, Omiko (2007) defined a laboratory as a dedicated room, building, or scheduled period designed for practical or experimental studies, emphasising that it serves as the core of a strong science programme by providing students with experiences aligned with scientific literacy objectives. This underscores the idea that effective science teaching and learning in secondary schools is not feasible without a properly equipped laboratory. Supporting this view, Ufondu (2009) noted that a laboratory is an essential component of a school for achieving successful teaching and learning in science subjects.

The Oxford Advanced Learners Dictionary (2018) defines a laboratory as a space—either a room or a building designated for scientific research, experimentation, demonstrations, testing, and data analysis. The primary purpose of activities conducted in a science laboratory is to develop practical skills that contribute to the advancement of scientific knowledge and, ultimately, the progress of society. According to Dienye and Gbamanja (1990), the laboratory teaching method is an interactive approach involving one or more participants, using exercises and experimental techniques that are essential in science education. The experimental method allows students to actively explore information through hands-on procedures that require careful observation and data interpretation, fostering inquiry, investigation, and engagement with the unknown. Furthermore, Ufondu (2009) and Omiko (2015) note that incorporating laboratory work in science teaching offers numerous educational benefits.

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1. Laboratory-based teaching enables students to understand the nature of science and technology, thereby enhancing their intellectual and aesthetic comprehension while fostering knowledge of human scientific endeavours. Dienye and Gbamanja (1990) emphasised that science involves observing natural phenomena, quantifying these observations, integrating the data, and interpreting the results to derive meaningful conclusions. Through this process, students learn to identify cause-and-effect relationships and develop essential analytical skills.
2. Laboratories help students acquire scientific inquiry skills that are transferable to other areas of problem-solving. A fundamental aim of science education is to equip students with skills that can be applied in various real-life situations. For effective transfer, the learning experiences should share relevant similarities with the situations where these skills will later be used.
3. Laboratory activities also allow students to appreciate and emulate the work of scientists while developing manipulative skills. This can be achieved in several ways: (a) indirect observation of materials and objects, which promotes both mental and practical skills—such as measuring substances or using balances and graduated cylinders; (b) repeated experimentation, where students manipulate materials and activities without predetermined theories to reach meaningful conclusions; and (c) guided observation based on established theories, enabling students to make predictions about selected phenomena.
4. Laboratory experiences foster students' interest, attitudes, and values in science. Personal interaction with real materials and phenomena is particularly effective in stimulating a lifelong curiosity for scientific exploration. Omiko (2007) identifies eight key aspects of scientific attitudes that can be nurtured in the

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laboratory: curiosity, open-mindedness, objectivity, intellectual honesty, rationality, willingness to suspend judgment, humility, and reverence for life.

According to Bretz (2019), science educators consider the laboratory an essential component of science teaching. Laboratory instruction is particularly important because it improves students' observational abilities, provides in-depth information, and fosters interest in scientific investigation. Bretz further noted that creating and conducting an effective laboratory session requires the same level of skill, creativity, and effort as executing a high-quality research project. A well-designed laboratory programme can achieve multiple educational goals, including: (i) enhancing intuition and deepening understanding of scientific concepts, (ii) applying learned concepts to new situations, (iii) directly experiencing fundamental scientific phenomena, (iv) developing experimental and data analysis skills, (v) mastering the use of scientific instruments, (vi) estimating statistical errors and identifying systematic inaccuracies, and (vii) improving both written and oral reporting abilities.

Science laboratory materials refer to the resources that teachers use to facilitate teaching and learning in the science classroom. These include textbooks, computers, thermometers, fire extinguishers, first aid kits, ovens, incubators, chalkboards, models or mock-ups, as well as electronic devices such as televisions and radios (Kankam, 2013). The effective use of these resources enhances learning outcomes, as they not only engage students but also serve as motivational tools that encourage active participation (Asare, 2010).

Studies by Omiko (2015) and Ufondu (2009) indicate that laboratory instruction is often integrated with large lecture courses to allow students to acquire practical skills and

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apply the theories and concepts discussed during lectures. Omiko (2015) further emphasised that hands-on laboratory experience fosters a spirit of inquiry and helps students develop both scientific skills and the proper attitudes needed to handle scientific equipment and materials. The laboratory offers students rich experiential learning that they can transfer to society and future workplaces, providing opportunities to actively engage in scientific practice. For laboratory teaching to be effective, students must understand not only how to conduct experiments but also the purpose behind them and how they contribute to a deeper understanding of scientific concepts, relationships, or processes. It is therefore recommended that chemistry instruction be conducted in well-equipped laboratories, that governments invest in constructing and furnishing science laboratories, and that more qualified chemistry teachers be employed in the secondary education system. Many science teachers recognise laboratory activities as essential because they stimulate students' interest and enhance their scientific skills (Dillon, 2008). As science is fundamentally experimental, laboratory work plays a critical role in developing students' scientific competencies (Oscarsson et al., 2009; Suleiman, 2013).

2.13 Monitoring Strategies in Chemistry Curriculum Implementation

Cheruiyot et al. (2020) highlighted that Heads of Departments (HODs) should provide instructional leadership through consistent monitoring and evaluation of science teaching in secondary schools. Their study found that science HODs collaborated with teachers to plan assessment and evaluation activities, concluding that there was a significant positive relationship ($p < 0.05$) between the HODs' monitoring and control skills and students' academic performance in science subjects in selected public schools.

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Malinga (2016) noted that HODs of natural sciences often face the challenge of balancing administrative responsibilities with classroom teaching. Many science HODs lack sufficient instructional experience across all the sub-disciplines they oversee, and some do not possess the necessary qualifications, subject matter expertise, pedagogical content knowledge (PCK), or professional credibility to lead science instruction effectively. Consequently, they frequently rely on desk-based reviews of teachers' and students' work rather than conducting meaningful classroom observations or engaging in curriculum discussions with teachers.

Niyivuga et al. (2019) investigated the link between monitoring and evaluation practices and academic staff motivation in Rwandan higher education, employing a mixed-methods approach with 105 faculty participants. The study revealed that monitoring and evaluation—including self-evaluation, student feedback, peer review, and supervisor assessment—were applied to varying degrees. Gramme and Naidoo (2011) emphasised that in a global knowledge-based economy, monitoring and evaluation of student achievement must go beyond basic understanding to encourage critical thinking, analysis, and informed decision-making. Effective monitoring and control is an ongoing management process that strengthens the use of factual information for decision-making, helps address weaknesses, leverages opportunities, mitigates threats, and improves overall performance by comparing internal practices with external standards to achieve desired outcomes.

According to researchers such as Sima (2006), Bibik (2017), and Grischenko (2016), sufficient, comprehensive, and ongoing monitoring is a critical component of the successful implementation of any educational programme. Monitoring is based on and influences the implementation of educational policy, objectives, and educational plans;

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it determines the timeliness of decision-making, it provides accountability, and it serves as a foundation for evaluation, because effective monitoring of the educational process integrates information at all levels and provides management, and ultimately the governing body, with insight into the outcomes of educational activity at a specific educational institution (Marriott & Goyder, 2009).

Effective monitoring is a critical element of learning activities and contributes to the long-term success of educational initiatives (Marriott & Goyder, 2009). It has been described in various ways: as a continuous, intermediate, and summative evaluation system (Mertens, 2009); as a process of data collection (Mishra, 2005); and as a form of assessment aimed at obtaining specific information (Noh, 2006). Fegan and Field (2009) further note that monitoring within education is implemented to assess the effectiveness of educational programmes and to provide stakeholders with relevant information regarding the quality and outcomes of these programmes.

The relevance of training and its outcomes can create opportunities for professional development and increased familiarity with the curriculum (Jordan, 2016). In some schools, however, actions taken under the guise of monitoring teaching and learning are inconsistent or contradictory. This aligns with observations by Bush and Glover (2012) and Hoadly et al. (2009), who note that monitoring instructional activities is not always prioritised by school principals. Hoadly et al. (2009) further pointed out that much research focuses on prescriptive theories of what school managers should do rather than on their actual practices. Nevertheless, Bush and Middlewood (2013) assert that the closer school leaders are involved in teaching and learning, the greater the likelihood of student success—a view supported by scholars both in South Africa and internationally (Robinson, 2007; Bush, 2013). The key issue, however, lies in

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determining the specific actions school leaders can take to achieve desired learning outcomes and how they can effectively engage in curriculum implementation monitoring.

The underlying premise is that quality education contributes to achieving broader societal goals, including poverty reduction. Education is delivered through teaching, learning, and assessment (Gamlem & Smith, 2013), and these processes are most effective when supported by continuous monitoring. Monitoring instructional activities is considered a crucial leadership function, as it helps identify weaknesses in the teaching and learning process and supports improvements in both instruction and student performance (Bush, 2011; Du Plessis, 2013).

Both international and local perspectives share the view that monitoring is a method for determining whether expected standards in teaching and learning are being met. Bush and Glover (2012) describe monitoring as a continuous process aimed at assessing whether instruction is occurring as intended. In the United Kingdom, for example, Southworth (2004) noted that monitoring involves classroom visits, observing teachers in action, and providing feedback. Southworth further emphasised that this responsibility is distributed across HODs, deputy principals, and principals, indicating that monitoring is not limited to subject specialists alone. Similarly, Bush et al. (2010) found that HODs often review teachers' portfolios and students' work to verify instructional claims, while principals additionally examine both the HODs' oversight and the learners' books directly. Overall, there is increasing evidence supporting the active involvement of school management teams in classroom activities through ongoing monitoring.

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Olayiwola (2012) emphasised that the shared responsibility of SMTs is to act as instructional leaders, meaning that teachers, regardless of their hierarchical position, should focus primarily on enhancing student learning. It is widely suggested that instructional leaders are best positioned to influence classroom practices (Harris & Frost, 2010). Henard and Roseveare (2012) identified three levels that SMT members and other educational practitioners must recognise to effectively carry out management duties, including monitoring: the school level, programme level, and individual level. At the school level, leadership is supported by well-defined policies that guide internal quality assurance systems. Policies serve as frameworks for managers to carry out planned activities, including, but not limited to, learner admission, attendance, homework, staff duty allocation, and assessment (Du Plessis, 2013). School leaders are also expected to develop a vision for the school and clearly communicate expectations for both teachers and students (Bush et al., 2010). This assumes that school managers allocate time for planning, budgeting, assigning responsibilities, setting expectations, and organising sequences of events to ensure smooth school operations.

At the programme level, monitoring focuses on the content and delivery of classroom programmes. When properly implemented, these measures provide clear areas where monitoring can be most effective, with school principals and HODs actively participating in overseeing instruction. At the individual level, school leaders support teachers' initiatives aimed at enhancing student learning, which reinforces a learner-centred approach. Encouraging high-quality instruction contributes to improved learning outcomes (Henard & Roseveare, 2012). Similar to quality products in the corporate sector, effective management requires close oversight of teachers' work and other classroom activities to ensure instructional excellence (Owen, 2001).

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Leaders can accomplish this by clearly outlining the key stages and critical aspects of the implementation strategy and communicating them to followers in straightforward terms. Effective leadership involves translating strategic plans into actionable steps while simultaneously monitoring the processes involved (Owen, 2001; Davis & Davis, 2012). According to Davis and Davis (2012), successful leaders aim for their followers to understand and internalise the important stages of the tasks they are expected to carry out.

Malinga (2016) noted that Heads of Departments (HODs) for Natural Sciences often face the challenge of balancing administrative responsibilities with their duties as classroom teachers. Gramme and Naidoo (2011) further highlighted that in today's dynamic, knowledge-based global environment, monitoring and evaluating student achievement has evolved. Students are not only expected to acquire basic knowledge but also to develop critical thinking skills, analyse information, and draw inferences to support informed decision-making.

Evaluation and review are also conducted to maintain or strengthen relationships with stakeholders in schools. In Kenya, schools perceived to have low teaching commitment and poor student performance were reported to be at greater risk of declining enrolment (Olayiwola, 2012). Schools that face resource shortages due to inadequate funding may also experience reductions in other areas, including student enrolment (Mthiyane & Bhengu, 2012). Excessive teacher workloads, often resulting from staffing norms that assign fewer teachers to schools with low enrolment, can further hinder student performance. There is increasing evidence highlighting the critical role of monitoring in education (Bush et al., 2010; Archer & Brown, 2013; Gamlem & Smith, 2013).

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Specifically, school principals are responsible for supervising staff performance and providing the necessary structures to enhance teaching and learning. Heads of Departments (HODs) support principals by overseeing teachers' and learners' activities within their departments. Collectively, principals, deputies, and HODs are central to instructional processes, with active involvement in curriculum monitoring being a key aspect of their roles (Hardie, 1998).

2.14 Teaching methods in Chemistry Curriculum Implementation

Teachers often tend to rely on passive teaching methods, such as the traditional "chalk and talk," believing it helps them cover the required chemistry content within the school calendar; however, research shows that this assumption is not always accurate (Byusa et al., 2020). Moreover, studies indicate that teacher-centred methods have several limitations in effectively teaching chemistry (Tenaw, 2015). As a result, there has been a global shift toward learner-centred approaches, which place students at the heart of the learning process, actively engaging them throughout instruction. This method has been shown to improve student performance in measurable ways (Michael, 2006). Successful implementation of learner-centred teaching also requires strong support from head teachers, who oversee the daily management of all school activities and play a crucial role in driving significant educational changes (Naz & Tatlah, 2011).

Teaching methods are the primary techniques that educators use to achieve the objectives of a lesson (Borich, 2007). Lerman (2014) highlighted that innovative teaching strategies have been developed across all levels and curriculum settings in chemistry to make the subject more engaging for students. Muhammad (2013) and Dori et al. (2013) found that shifting from traditional lecture methods to innovative, hands-on approaches, including the creation of practical equipment from locally available

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materials, significantly improves chemistry teaching and learning. Supporting the effectiveness of alternative approaches, a study by Abdi (2014) involving 40 grade 5 students from two purposively selected classes over eight weeks demonstrated that students taught through inquiry-based learning outperformed those taught using traditional methods.

One effective way to actively involve students in learning is through problem-based learning (PBL), which presents learners with real-world problems and guides them in developing solutions. Research indicates that PBL enhances student engagement, critical thinking, and problem-solving skills in chemistry (Clement et al., 2020; Lee & Yoo, 2021). Another strategy is inquiry-based learning (IBL), where students are encouraged to explore open-ended questions and conduct investigations independently. This approach fosters scientific reasoning, inquiry skills, and curiosity about the subject (Bergman & Klussmann, 2020; Rodenbusch et al., 2021). Collaborative learning is also effective in promoting active participation, as students work together to solve problems, discuss ideas, and share knowledge. Studies have shown that this method improves understanding of chemistry concepts while developing communication and teamwork skills (Cavanaugh & Kim, 2020; Mason & Singh, 2021).

Research indicates that active learning strategies enhance student engagement, knowledge retention, and academic performance in chemistry (Kirschner & van Merriënboer, 2020; Loper & Cavanagh, 2020; O'Flaherty & Phillips, 2021). For instance, students participating in flipped classroom models demonstrated notable improvements in conceptual understanding and problem-solving abilities (Wang et al., 2020). Similarly, using problem-based learning in organic chemistry courses increased

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student engagement and fostered higher-order critical thinking skills (Roberts & Chang, 2021).

Active learning also supports the development of essential skills such as teamwork, communication, and problem-solving, which are highly valued in the workforce and critical for success across multiple disciplines (Cavanagh, 2020; Feinberg et al., 2021). Additionally, it promotes equity and inclusivity by allowing students from diverse backgrounds to actively participate in the learning process and take responsibility for their own learning (Leung et al., 2020). Effective implementation of active learning strategies in chemistry classrooms requires careful planning and support from educators. Teachers must adopt a facilitative role, be open to experimenting with new instructional methods, and invest in the necessary resources and professional development to successfully integrate these approaches (Loper & Cavanagh, 2020).

Empirical evidence strongly supports the effectiveness of learner-centred instructional methods in enhancing students' performance in chemistry. Adesoji et al. (2021) found that students exposed to learner-centred teaching strategies demonstrated significantly better academic outcomes in chemistry compared to their counterparts who experienced traditional, teacher-dominated instruction. Similarly, a study conducted in South Korea by Kim et al. (2021) revealed that learner-centred approaches substantially enhanced students' scientific literacy and critical thinking skills. Learners involved in these instructional methods exhibited greater competence in analysing scientific data and making evidence-based decisions.

In the Ghanaian context, Asante and Frimpong (2020) examined how learner-centred pedagogies were implemented in senior high school chemistry classrooms. Their findings indicated that this approach led to increased student engagement and improved

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academic achievement relative to conventional teacher-led methods. Likewise, research in Cameroon by Ndombo and Njouonkou (2020) highlighted that adopting a learner-centred chemistry curriculum not only motivated students but also strengthened their ability to relate abstract chemistry concepts to real-life situations. Beyond enhancing engagement and academic achievement, learner-centred chemistry instruction plays a crucial role in fostering students' critical thinking and problem-solving abilities. Thakur and Singh (2021) investigated the effects of implementing a learner-centred chemistry curriculum on the development of critical thinking among Indian secondary school students. Their findings revealed that students taught through learner-centred methods exhibited significantly greater improvement in critical thinking skills compared to those taught using conventional teacher-led approaches.

Therefore, the active involvement of students in chemistry instruction is vital for enhancing their comprehension and ensuring a more engaging and impactful learning experience.

2.15 Cognitive Domain in Teaching and Learning of Chemistry

Learning not only shapes an individual's attitudes but also promotes the development of new skills. The cognitive domain focuses on cultivating mental abilities and acquiring knowledge. According to Anderson and Krathwohl (2001), it consists of six categories: knowledge, comprehension, application, analysis, synthesis, and evaluation. Porter (2005) defines the cognitive domain as the set of mental processes involved in acquiring and applying knowledge, including perception, attention, memory, and reasoning. Understanding these cognitive processes is particularly important in chemistry education, as it allows teachers to design instructional strategies that enhance learning efficiency. Porter (2005) emphasises that visual perception is a critical

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cognitive process in chemistry, as chemical structures and equations are often represented through diagrams and symbols that require spatial reasoning and pattern recognition. Research indicates that students with stronger spatial reasoning skills tend to achieve higher performance in chemistry. Therefore, it is important for educators to provide visual representations of chemical concepts and to encourage students to develop their spatial reasoning abilities.

Jang et al. (2020) noted that attention, as a cognitive process, involves the ability to concentrate on relevant information while filtering out distractions. In chemistry education, students frequently need to memorise substantial amounts of information, such as the periodic table and chemical reactions. Consequently, teachers should deliver instruction in a structured and organised manner, breaking complex concepts into smaller, manageable segments to facilitate understanding.

Memory is another essential cognitive process in chemistry learning, as students need to recall key facts and concepts to apply them in new contexts. One effective approach to enhancing memory is spaced repetition, which involves reviewing information at gradually increasing intervals (McDermott et al., 2014). Teachers can also support memory development by helping students organise information into meaningful units and by using mnemonic techniques to facilitate recall. Additionally, reasoning is a vital cognitive skill in chemistry, requiring students to apply their knowledge to solve problems and make predictions. Developing reasoning skills can be achieved by providing students with opportunities to engage in problem-solving and critical thinking activities, such as laboratory experiments and case study analyses (Köse & Bektas, 2020).

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Widhiyanti (2017) investigated the perspectives of chemistry teacher educators regarding the knowledge required for effective chemistry teaching. The study concluded that chemistry teachers need a strong grasp of core chemistry concepts, the capability to design and execute effective lesson plans, and proficiency in managing laboratory activities.

Moreover, the cognitive domain plays a crucial role in chemistry instruction by guiding the use of active learning strategies that promote higher-order thinking skills, such as analysis, synthesis, and evaluation. Research has demonstrated that approaches like problem-based learning, inquiry-based learning, and collaborative learning can enhance student performance and foster a deeper understanding of chemistry concepts (Liu et al., 2021; Akbari et al., 2020).

The cognitive domain is also important in chemistry education through the use of technology-enhanced learning environments. Tools such as simulations, virtual laboratories, and other interactive resources allow students to engage in authentic scientific practices while developing their cognitive skills within the context of chemistry (Fazio et al., 2020; Khan et al., 2021).

The cognitive domain is also essential for assessing student learning in chemistry. Evaluations that target cognitive skills, such as the ability to analyse and solve complex problems, provide valuable insights into students' comprehension of chemistry concepts and enable instructors to adapt their teaching strategies to better address student needs (Lee & Yeo, 2020). The cognitive domain guides the development of thinking skills aligned with the instructional goals set by teachers. It outlines the stages of thought that students must master to translate theoretical knowledge into practical understanding and daily application. The domain encompasses various types of

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knowledge, including factual, conceptual, procedural, and metacognitive knowledge (Liu et al., 2021). These stages of thinking are organised into levels based on Bloom's taxonomy, revised by Anderson, which include six levels: remembering, understanding, applying, analysing, evaluating, and creating. Students' attainment of these competencies can be assessed through their performance in learning activities.

Ndun (2016) described learning as an intentional process conducted by educators to bring about changes in behaviour, shaped through individuals' interactions with their environment. The cognitive domain focuses on the acquisition of specific knowledge and skills, emphasising mental (thinking) processes. According to Hoque (2016), learning within this domain involves a hierarchical progression of skills, including processing information, constructing understanding, applying knowledge, solving problems, and conducting research.

In summary, the cognitive domain is fundamental to chemistry education, as it enables students to engage in higher-order thinking and achieve a profound understanding of the subject. Strategies such as active learning, technology-enhanced instructional tools, and assessments targeting cognitive skills are effective in fostering students' cognitive growth in chemistry.

2.16 Psychomotor Domain in Teaching and Learning of Chemistry

The psychomotor domain involves the development and coordination of motor skills. Its subdomains include perception, set, guided response, mechanism, complex overt response, adaptation, and origination (Sousa, 2016). Perception refers to the ability to use sensory information to guide motor activity; for example, a student may practice exercises from a textbook to improve exam performance. The "set" subdomain relates to the readiness to respond to challenges effectively. Guided response involves

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imitating demonstrated behaviours or employing trial-and-error methods to solve problems (Sousa, 2016). The mechanism stage reflects the ability to perform learned tasks habitually and with confidence, such as solving exam questions accurately after repeated practice. Complex overt responses refer to the skilful execution of intricate action sequences, such as a student improving typing speed through practice.

Adaptation is a key aspect of the psychomotor domain, reflecting the ability to modify acquired skills to suit specific situations. For example, a student who has learned various underlying theories may apply that knowledge to construct a functional model using everyday materials. Origination involves generating entirely new movement patterns tailored to particular tasks (Sincero, 2011). The psychomotor domain, one of the three learning domains, focuses on the development of physical skills and abilities necessary to perform subject-specific tasks. In chemistry education, this domain is particularly important as it enables students to acquire laboratory skills and conduct experiments, which are critical for success in the discipline.

The psychomotor domain is particularly significant in chemistry education through hands-on laboratory experiences. Engaging in laboratory experiments allows students to develop essential psychomotor skills, including measuring, weighing, mixing, and manipulating chemicals, while applying their theoretical knowledge in practical contexts (Elsayed et al., 2020; Fadzliana & Kurniawati, 2024). Research indicates that such laboratory experiences enhance students' comprehension of chemistry concepts and improve their ability to apply these concepts to real-world situations (Cavanagh et al., 2021; Wang & Ren, 2020). Additionally, the psychomotor domain is critical for assessing student learning in chemistry. Performance-based evaluations, such as laboratory reports and practical demonstrations, offer valuable insights into students'

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psychomotor abilities and their capacity to translate theoretical knowledge into practical applications (Lok & Yau, 2020; Nanda & Kurniawati, 2024).

Moreover, research has indicated that participation in laboratory activities can enhance students' comprehension of chemistry concepts while fostering essential psychomotor skills, including measuring and mixing chemicals, using laboratory equipment, and analysing experimental data (Ling et al., 2021; Tarhini et al., 2021).

Research has shown that the psychomotor domain is effectively supported through the use of simulations and virtual laboratories, which give students opportunities to develop and refine their psychomotor skills in a safe and controlled environment. These digital tools enable students to experiment with chemical reactions, handle laboratory equipment and materials, and analyse data without the risks associated with traditional lab settings (Fazio et al., 2020; Khan et al., 2021; Ahmadi et al., 2021). Furthermore, the psychomotor domain is crucial for assessing student learning in chemistry. Evaluations that target psychomotor skills, such as laboratory reports and performance-based assessments, provide important insights into students' ability to apply their knowledge and skills in practical contexts (Sharma et al., 2020).

The psychomotor domain, often referred to as the skill domain, relates to the development of abilities that enable a person to act effectively following a learning experience. It reflects learning outcomes achieved through the application of skills that are grounded in cognitive competence, indicating a student's level of expertise in performing specific tasks (Simpson, 1972). Simpson identified several levels within the psychomotor domain, including imitation, manipulation, perception, articulation, and naturalisation. Examples of psychomotor domain applications in education include scientific experiments, individual or group presentations, performances, and role-

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playing activities. Similarly, Sonmez (2017) categorises the psychomotor domain into levels such as excitement, manual control, skill, situational adaptation, creation, and evaluation. This domain involves the coordination of physical movements and motor skills, which require practice and are assessed in terms of speed, accuracy, range, procedures, and technique (Hoque, 2016). In the context of chemistry education, the psychomotor domain is crucial, as it enables students to develop essential laboratory skills and conduct experiments, which are fundamental to success in the subject.

2.17 Affective Domain in Teaching and Learning of Chemistry

The affective domain encompasses an individual's feelings, emotions, and attitudes. Its categories include receiving phenomena, responding to phenomena, valuing, organisation, and characterisation (Anderson & Krathwohl, 2001). The receiving phenomena category involves developing awareness of emotions and the ability to focus attention, such as listening attentively during lessons. Responding to phenomena refers to learners' active engagement in class activities or group discussions (Cannon & Feinstein, 2005). In chemistry education, the affective domain is significant as it addresses the cultivation of attitudes, values, and emotions. Affective skills in chemistry include appreciating the subject's relevance to everyday life, fostering interest in chemistry as a discipline, and developing a positive disposition toward learning the subject.

Research has demonstrated that the affective domain plays a significant role in chemistry education through the use of real-world examples and practical applications of chemistry concepts. Providing students with examples that illustrate the relevance of chemistry in daily life has been shown to enhance their interest in the subject, foster

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positive attitudes toward learning, and increase their motivation to engage with chemistry (Wei et al., 2020; Ağaoğlu & Yalçın, 2020; Mahajan, 2021).

Implementing student-centred instructional approaches supports the development of the affective domain by allowing learners to take responsibility for their own learning and fostering curiosity and interest in chemistry concepts (Lee et al., 2021; Wu et al., 2020). Furthermore, the affective domain is essential for assessing student learning in chemistry. Evaluations that focus on learners' attitudes, values, and emotions can offer valuable insights into their engagement, motivation, and overall disposition toward the subject (Wei et al., 2020).

Additionally, engaging students in problem-solving activities can enhance their confidence, self-efficacy, and ability to transfer knowledge to novel situations (D'Souza & Pereira, 2021). Research has also shown that collaborative learning strategies, including group projects and class discussions, can positively influence students' attitudes toward chemistry and boost their motivation to learn (Barron, 2020; Teixeira-Dias et al., 2021).

Moreover, the affective domain plays a vital role in assessing student learning in chemistry. Evaluations that target affective skills—such as attitude questionnaires and self-assessment tools—can provide important insights into students' beliefs, values, engagement, and motivation toward the subject (Goh & Chia, 2020; Saftari & Fajriah, 2019). Overall, the affective domain is essential in chemistry education, as it fosters the development of positive attitudes, values, motivation, and self-efficacy required for academic success. Strategies such as real-world applications, problem-solving exercises, collaborative learning activities, and assessments focusing on affective skills are all effective in promoting growth within this domain.

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Teachers play a key role in fostering the affective aspects of learning. Affective learning involves integrating students' attitudes, beliefs, and behaviours into the educational process (Olatunji, 2014). These attitudes can be shaped, nurtured, and developed to align with desired behaviours. Specifically, the learning process should aim to cultivate positive attitudes toward the subject matter, toward the teacher, and toward the overall learning experience (Wu et al., 2020).

Olatunji (2014) identified five hierarchical levels within the affective domain: (1) **Acceptance**, where students become aware of a topic, event, or issue and are willing to engage with it; (2) **Responding**, which ranges from complying with required tasks to deriving satisfaction from completing them; (3) **Valuing**, in which students consistently demonstrate behaviours aligned with internalised values; (4) **Organisation**, where students integrate individual values into a coherent value system; and (5) **Characterisation by value**, in which students' adopted values guide their behaviour in everyday life. The affective domain broadly encompasses feelings, emotions, and attitudes, reflecting how individuals emotionally engage with learning experiences, including values, appreciation, motivation, enthusiasm, and attitudes (Hoque, 2016). In conclusion, students who develop positive attitudes toward learning are more motivated and better able to understand and appreciate the concepts being taught.

2.18 Relevance of Practical Work in Chemistry Curriculum Implementation

Practical work is defined as teacher-led demonstrations or student-conducted experiments and observational exercises designed to connect theoretical knowledge with hands-on activities in the laboratory, classroom, field, or other settings (Tytler, 2007; UNESCO, 2001). Research indicates that practical activities are crucial at all levels of science education and are particularly important in secondary schools, where

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they help students internalise and understand theoretical concepts in subjects such as chemistry, biology, and physics. For practical activities to be effective, equipment and experiments must be carefully chosen to provide meaningful and relevant experiences. Students' understanding is further enhanced when these activities are connected to real-life contexts. While providing appropriate equipment and reagents is necessary, it alone is not sufficient to ensure successful science instruction.

Several factors, including the lack of trained laboratory technicians, the appropriateness of available equipment, teachers' commitment, and the distribution of resources by educational authorities, can affect the quality of practical activities. Research has consistently shown that practical work offers numerous benefits, such as enhancing laboratory skills, scientific knowledge, and the understanding of scientific concepts and theories (Fadzil & Saat, 2013; Schwichow et al., 2016). Supporting the importance of practical work in science education, Roberts (2008) developed a guide on high-quality practical activities, emphasising that students attain deeper comprehension when they investigate independently and experiment with methods and techniques that have led to discoveries about the human body, the environment, and the universe.

Practical work has been found to foster positive student attitudes and enhance motivation for effective science learning (Okam & Zakari, 2017). A favourable attitude toward practical activities has been shown to positively influence students' academic achievement in science (Hinneh, 2017). Additionally, practical work can help improve students' communication skills, enabling them to collaborate in problem-solving and become more motivated in scientific subjects (Woolnough, 1985). Engaging in hands-on experiments also stimulates students' interest in science, demonstrating that it is an applied discipline rather than purely theoretical. Laboratory activities are especially

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significant in science education (Hofstein & Mamlok-Naaman, 2007), as they provide opportunities to develop scientific notation, construct models, and test hypotheses. Laboratory experiences further help students distinguish between observation and data presentation (Lawson, 1995). Supporting this, Tobin (1990) noted that laboratory activities allow students to learn with understanding while actively participating in the construction of scientific knowledge through hands-on experiences.

Some scholars have presented a critical perspective on laboratory-based teaching. Abrahams and Millar (2008) argue that laboratory instruction can be inefficient and may not accurately reflect the nature of scientific inquiry, which they suggest is better taught through direct instruction. Similarly, Hodson (1990) contended that practical work is sometimes conducted in a manner where students merely follow teacher instructions, limiting opportunities for creativity and higher-order cognitive processing. In such cases, practical activities can be perceived as confusing, unproductive, and a poor use of instructional time.

Several studies investigating the impact of practical work on student achievement have explored various factors influencing its effectiveness, including how tasks are designed to connect theoretical knowledge with hands-on activities. In research examining 25 science lessons involving practical work in English secondary schools, Abrahams and Millar (2008) found that practical tasks helped maintain students' focus and engagement in hands-on activities. However, the study highlighted a lack of clear evidence that task designers consistently ensured that conceptual understanding was explicitly linked to observable phenomena. Millar (2004) recommended that students should first be provided with background information before engaging in practical

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work, and that task design should actively guide learners to make meaningful connections between theoretical concepts and their practical applications.

As a result, science teachers need ongoing professional development grounded in current research to enhance their instructional practices, dedicating time and effort to help students make meaningful connections between scientific concepts and real-world phenomena (Jokiranta, 2014). Conversely, Sotiriou et al. (2017) argued that traditional laboratory activities often emphasise technical terminology and focus merely on observing experiments. In such settings, students may follow step-by-step instructions from lab manuals, which limits opportunities for creativity and does little to foster cognitive skill development. Without linking experimental procedures to real-life contexts, the value of these activities for deep learning is significantly diminished.

Madhuri et al. (2012) highlighted that a key limitation of the traditional "cookbook" style of laboratory work is that it fails to help students translate experimental outcomes into meaningful learning. In a study conducted in the Eastern Region of Ghana, Ofori-Appiah et al. (2020) assessed biology teachers' competencies in organising practical lessons and their impact on student engagement. The findings revealed that although teachers provided clear explanations and conducted practical activities, students rarely worked collaboratively and had insufficient time to complete tasks. Additionally, teachers often did not mark student work promptly or provide immediate feedback. Despite these challenges, researchers have argued that practical work has the potential to motivate learners and deepen their understanding of scientific concepts (Abrahams & Reiss, 2012). Practical activities enable students to engage in diverse learning behaviours, allowing them to master scientific subjects and develop higher-order thinking skills through hands-on experiences (Motlhabane, 2013).

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Teaching science purely through theoretical approaches is considered ineffective in contemporary education, as it fails to promote creativity, innovation, and the integration of technological tools such as ICT to enhance learning and development (Serdyukov, 2017). Both students' and teachers' attitudes toward science are strongly influenced by the teaching methods employed. Well-designed and effectively implemented "minds-on" and "hands-on" practical activities in science education can cultivate critical thinkers who are not only competent in the labour market but also capable of addressing societal challenges (Lunetta et al., 2007; Oludipe et al., 2020).

Consequently, practical work should extend beyond the confines of the classroom or laboratory to provide students with diverse learning experiences. Engaging in practical activities enables learners to become active participants in the instructional process (Babalola, 2017). Through hands-on involvement, students can independently observe phenomena, pose questions, and interpret responses, thereby enhancing their understanding. In science education, practical or experiential learning aims to develop learners' abilities to hear, manipulate, and observe expected outcomes effectively (Kibirige & Maponya, 2021).

The success of practical work also depends on the presence of qualified and committed teachers, as well as laboratory assistants, to guide students effectively (Anza et al., 2016). Additionally, the use of science kits allows educators to demonstrate experiments, strengthen their own scientific knowledge, and create opportunities for students to conduct experiments independently, fostering deeper engagement and skill development (Jones et al., 2011).

According to Apeadido (2023), engaging in practical work enhances learners' acquisition of knowledge, promotes the development of skills and competencies

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necessary to address the scientific and technological needs of the nation, and makes scientific phenomena more tangible. Additionally, practical activities foster social interaction among students. Furthermore, when teachers focus on the quality rather than the quantity of content, learners are better able to develop a deeper understanding and cultivate skills for lifelong learning (Knut Neumann, 2019).

2.19 Challenges Associated with Chemistry Curriculum Implementation

The literature indicates that the low level of chemistry curriculum implementation is associated with several factors, including poorly prepared science textbooks, insufficient laboratory equipment and materials, inadequately trained or unqualified chemistry teachers, limited subject-matter knowledge among teachers, lack of laboratory facilities, large class sizes, an overly extensive curriculum, low teacher motivation, reliance on inappropriate teaching methods, limited in-service training, and insufficient practical activities (Uzoechi, 2006; Ugwu, 2008; Ayodele, 2009; Ejidike & Oyelana, 2015).

Achimugu (2016) found that factors such as insufficient funding, low teacher motivation, limited instructional time, inadequate laboratory facilities, and an overly extensive curriculum negatively impacted the effective implementation of the chemistry curriculum. However, the location of schools did not significantly affect teachers' responses. Similarly, Nsanzimana et al. (2021) reported that the abstract nature of some chemistry concepts, the shortage of laboratory apparatus and chemicals, and the absence of laboratory technicians were major obstacles to effective teaching and learning of chemistry.

Omoniyi and Akinsete (2022) observed that teachers often failed to cover all themes in the chemistry curriculum, frequently skipping challenging concepts. They identified

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inadequate resources and insufficient subject-matter expertise as major contributors to ineffective curriculum implementation. To address these challenges, they recommended targeted capacity-building and retraining programmes for chemistry teachers. Umerez and Mossio (2013) defined a constraint as any factor that imposes a limitation, restriction, or prevents planned activities from being effectively carried out. Pia (2015) categorised constraints in teaching and learning into three types: systemic, pedagogical, and social. Systemic constraints are those arising from the structure of the education system itself, including overcrowded classrooms, inappropriate language of instruction, insufficient teacher training to handle classroom diversity, and the lack of teaching assistants. Pedagogical constraints relate to teachers' instructional skills, teaching methods, and use of teaching aids (Lupton & Hempel-Jorgensen, 2012). Social constraints, on the other hand, are influenced by learners' social environment, family background, and the level of parental involvement in education (Baran, 2019).

According to Ibe and Nwosu (2016), the teaching and learning of science subjects continue to be affected by gender-related biases. This suggests that social discrimination between males and females may influence how chemistry teachers implement the curriculum. Similarly, Igboanugo (2018) highlighted that the geographical location of a school can affect teaching and learning outcomes in chemistry. In this context, school location—whether urban or rural—may also impact teachers' ability to effectively deliver the chemistry curriculum. Supporting this, Adesoji and Fisuyi (2001) found that students from rural areas exhibited higher levels of anxiety toward learning chemistry compared to their urban counterparts. Their study revealed that, among sixteen identified sources of anxiety, rural students reported significant concern in eleven areas, whereas urban students reported heightened anxiety in only five. Rural students were particularly worried about limited job opportunities,

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the extensive syllabus, lack of exposure, teachers' competence, instructional methods, and the prevalence of academic failure. Urban students, on the other hand, were mainly anxious about extensive calculations, frequent failures, and the breadth of the syllabus.

Research indicates that students' understanding of chemical concepts often differs from the explanations presented by their instructors (Treagust, 1999). When students are asked to articulate their own interpretations of established chemistry concepts, various misconceptions frequently emerge. Once these misconceptions become integrated into a student's cognitive framework, they can hinder the learning of subsequent concepts (Lochner et al., 2015; McShane & Eden, 2015).

Similarly, Wambua and Waweru (2019) conducted a study to examine the challenges associated with implementing the Competency-Based Curriculum (CBC) in public primary schools in Machakos County. The study found that teachers were inadequately prepared for the rollout of CBC, and that schools faced shortages of staff, insufficient infrastructure, and limited teaching and learning resources.

Hipolite (2019) investigated the challenges associated with implementing the Competency-Based Curriculum (CBC) in public secondary schools in Morogoro Municipality, Tanzania. The study revealed that several factors hindered effective curriculum implementation, including overcrowded classrooms, insufficient teaching and learning materials, and teachers' limited understanding of the CBC framework. Similarly, Sifuna and Obonyo (2019) examined obstacles to CBC implementation in Kenya and found that the curriculum was neither systematically planned nor effectively executed. The study also reported that teacher training on curriculum content and instructional methods was minimal, instructional materials were inadequate, and there was limited involvement of parents and other key stakeholders in the curriculum reform

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process. Moreover, Ndayambaje (2018) noted that, despite training provided to all primary school teachers on CBC implementation, some educators resisted the change and continued to rely on traditional teaching methods and materials.

Ndayambaje (2018) further highlighted that the insufficient availability of teaching and learning resources posed a significant challenge to the effective implementation of the Competency-Based Curriculum (CBC) in Rwanda. Similarly, Mugabo et al. (2021) conducted a case study examining the relationship between school characteristics and the capacity to implement CBC. The study found that disparities in CBC implementation among teachers were influenced by differences in professional development, inadequate CBC training, limited teaching and learning resources, and insufficient school infrastructure. Likewise, Isaboke et al. (2021) investigated the challenges experienced by teachers in public pre-primary schools in Nairobi City County, Kenya, and identified several obstacles, including a lack of adequate learning facilities, limited teacher training, overcrowded classrooms, insufficient teaching staff and instructional materials, and minimal parental involvement.

Kurz et al. (2010) described curriculum as being conceptualised in three interconnected forms as it is translated into classroom practice. The intended curriculum represents the official system-wide standards and objectives established at the policy level. The enacted curriculum reflects how teachers deliver and interpret this content during instruction. Finally, the attained curriculum denotes the knowledge and understanding that students actually acquire through the learning process. In a study conducted by Ogunode and Jegede (2019) on the implementation of science programmes in secondary schools in Abuja, Nigeria, the findings indicated that most respondents identified several challenges affecting effective implementation. These included

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shortages of qualified science teachers, insufficient funding, inadequate infrastructure, lack of instructional materials, poor planning, and weak supervisory practices.

2.19.1 Inadequate Practical in Chemistry Curriculum Implementation

Nwachukwu and Okoroafor (2014) indicated that insufficient practical work in science education, particularly in chemistry, has been a longstanding challenge negatively affecting the quality of instruction. They emphasised that practical activities are a vital aspect of science education, as they enable students to develop hands-on skills, deepen conceptual understanding, and stimulate interest in the subject. A lack of practical work, therefore, may result in reduced student engagement and poor academic performance. Similarly, Abrahams and Reiss (2012) highlighted the significance of practical work in fostering essential skills such as problem-solving, data analysis, and critical thinking. They further noted that inadequate practical activities limit students' opportunities for experiential learning, hinder active engagement with scientific concepts, and reduce preparedness for advanced studies in chemistry. The scarcity of practical work is often linked to challenges such as insufficient resources, inadequate teacher training, and limited instructional time.

In their studies on chemistry education in Nigeria, both Nwosu et al. (2021) and Akinbobola and Adeyemi (2020) identified inadequate practical work as a major challenge in secondary schools. They reported that students often have limited access to laboratory facilities and equipment, while teachers frequently lack the skills required to conduct practical experiments effectively. These limitations were found to contribute to poor student performance in chemistry examinations.

Adelabu (2020) examined the state of science practical work in Nigerian schools and identified inadequate practical activities as a key challenge. The study found that

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teachers often lacked the necessary skills and experience to conduct experiments effectively, and laboratory facilities were insufficient. The author emphasised the need for policy interventions to address these issues and enhance the quality of science education. Similarly, Ndihokubwayo (2017) reported that teachers face ongoing challenges in science teaching, including limited time, scarcity of materials, and insufficient improvisation skills.

Niyitanga et al. (2021) found that the implementation of practical work was hindered by insufficient teacher training, lack of regulatory policies, and inadequate resources and facilities. To address these challenges, the study recommended prioritising in-service professional development for teachers, integrating practical skill assessments, allocating government funding for laboratory infrastructure, including practical physics in the school timetable, and ensuring consistent classroom supervision. They emphasised that practical work actively involves learners, helping them understand scientific concepts and relate them to real-world phenomena.

Okorie and Ugwuanyi (2020) investigated the implementation of practical activities in teaching chemistry in senior secondary schools in Nsukka Local Government Area, Nigeria. Their study revealed that students' performance in WAEC chemistry examinations was generally poor, partly due to insufficient engagement with practical activities. The findings indicated that practical activities were underutilised in classroom instruction, student participation was limited, the chemistry curriculum was inadequately covered, and practical exercises were often conducted only in the final year, reducing their effectiveness.

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2.19.2 Overcrowded Chemistry Curriculum

Famurewa and Babalola (2020) examined the challenges associated with teaching and learning chemistry in Nigerian secondary schools, identifying an overcrowded chemistry curriculum as a major obstacle. They observed that the extensive curriculum made it difficult for teachers to cover all topics within the available time, resulting in superficial understanding. Similarly, Williams and Saleh (2020) investigated the effects of content overload on students' learning in the chemistry curriculum in Saudi Arabia and found that the excessive curriculum content limited opportunities for practical work and the development of critical thinking skills. The authors suggested that streamlining the curriculum could enhance students' comprehension and engagement with the subject.

Onasanya and Idowu (2021) investigated teachers' perceptions of the challenges in teaching chemistry in senior secondary schools in Lagos State, Nigeria, and reported that curriculum overcrowding posed a major challenge. Teachers found it difficult to cover all the required topics within the designated time, which resulted in superficial understanding of the content. Similarly, Adesoji and Ezeudu (2020) examined chemistry education in Nigerian secondary schools and observed that the extensive curriculum hindered teachers from addressing all topics thoroughly, contributing to poor student performance in examinations. A comparable situation was reported by Dalia and Al-Khasawneh (2021) in Jordanian secondary schools, where curriculum overload restricted teachers' ability to cover the content comprehensively, negatively affecting students' understanding and academic outcomes.

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2.19.3 Inadequate instructional materials

Opata and Nweke (2020) examined the availability and use of instructional materials for teaching basic science and technology in primary schools in Anambra State, Nigeria, and identified a shortage of instructional resources as a major challenge. The study highlighted that teachers had limited access to essential materials such as textbooks, charts, and diagrams, which negatively affected students' learning outcomes. Similarly, Ajayi and Fakokunde (2020) investigated science teachers' perceptions of using instructional materials in secondary schools in Nigeria and reported that insufficient access to teaching aids, including models, specimens, and audio-visual resources, led to decreased student interest and motivation in science subjects.

Adu-Gyamfi and Asamoah (2020) examined the availability and use of instructional materials for teaching science in selected basic schools in Ghana and found that insufficient resources posed a major challenge. The study revealed that teachers had limited access to textbooks, charts, and laboratory equipment, which negatively affected students' interest and motivation. Similarly, Tetteh and Ahiakpa (2020) investigated the use of instructional materials for teaching chemistry in selected senior high schools in Ghana and reported that inadequate access to laboratory equipment, chemicals, and textbooks contributed to poor student performance. Additionally, studies on agricultural science instruction in Nigerian secondary schools also identified a lack of instructional materials as a significant barrier to effective teaching and learning.

Adigun and Adeniyi (2021) reported that teachers had limited access to instructional resources, including field trips, farm equipment, and textbooks, which negatively

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impacted students' academic performance. Similarly, Oladipo and Olaleye (2020) assessed the availability of laboratory instructional materials for teaching chemistry in secondary schools within the Ibadan metropolis, Nigeria, and found that insufficient access to chemicals, laboratory apparatus, and textbooks posed a significant challenge. In agreement, Nwosu (2020) evaluated laboratory facilities and instructional resources in Nigerian senior secondary schools and concluded that the lack of essential materials, such as laboratory equipment, chemicals, and textbooks, hindered effective teaching and contributed to poor student outcomes.

Adeoye and Adu (2021) examined the availability and influence of laboratory equipment and chemicals on students' performance in science subjects, including chemistry, in secondary schools in Ibadan, Nigeria. Their findings revealed that insufficient access to essential instructional materials, such as chemicals and laboratory apparatus, posed a major obstacle to effective teaching and learning.

Jimoh and Omoyele (2021) examined the availability and use of instructional materials in the teaching of senior secondary school chemistry in Oyo State, Nigeria. Their study revealed that a lack of essential resources, including laboratory equipment, chemicals, and textbooks, significantly hindered students' academic performance. Similarly, Adebayo and Gbenu (2021) reported that insufficient access to these critical instructional materials in Lagos State negatively affected teaching effectiveness and students' achievement in chemistry.

2.19.4 Ineffective methods of teaching and learning

Adeyemi and Yusuf (2020) assessed the impact of ineffective teaching methods on students' academic performance in chemistry in selected senior secondary schools in Oyo State, Nigeria. They found that ineffective methods such as lecture-based teaching,

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rote memorisation, and lack of practical activities negatively impacted students' performance.

Akinbobola and Fadare (2020) examined the impact of problem-based learning on senior secondary school students' performance in chemistry in Ondo State, Nigeria. Their findings indicated that conventional teaching approaches, such as lecture-based instruction, were largely ineffective, whereas implementing problem-based learning significantly enhanced students' academic achievement in the subject.

Arslan and Cakmakci (2020) investigated how different teaching approaches influenced students' conceptual understanding and attitudes in chemistry. Their study revealed that inquiry-based teaching was more effective than traditional lecture-based instruction in enhancing students' grasp of concepts and fostering positive attitudes toward the subject.

Eşme and Şenocak (2021) examined the impact of multimedia-assisted instruction compared with traditional teaching methods on students' achievement and retention in chemistry. Their findings indicated that multimedia-supported teaching significantly enhanced both academic performance and retention relative to conventional methods. Similarly, Tumilaar et al. (2021) investigated the use of flipped classroom strategies in an Indonesian chemistry course and found that this approach was more effective than traditional teaching in fostering active learning and improving students' academic outcomes.

2.19.5 Textual materials in Chemistry Curriculum Implementation

Several studies indicate that textbooks function as a primary instructional resource for teachers across different school subjects (Mullis et al., 2012). They serve as the main

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source of lesson content (Chou, 2020; Johansson, 2006) and provide supporting visual aids and graphics (Shehab & BouJaoude, 2017). The extent to which teachers rely on textbooks is influenced by their teaching experience (Horsley, 2009; Loewenberg-Ball & Cohen, 1996). Research also suggests that textbooks strongly shape teachers' choices regarding subject matter and instructional methods (Lepik et al., 2015). Consequently, textbooks can act as intermediaries between state curricula and classroom instruction, and in some cases, teachers may even prioritise textbooks over the official curriculum if discrepancies exist.

According to Sikorová (2010), some teachers follow textbooks strictly when planning their lessons, while the majority modify the content according to their preferences, and a small number consult multiple sources of information. Textbooks can also serve as a supplementary resource for teachers, providing more detailed explanations of the course, additional pedagogical suggestions, and theoretical background knowledge (Steenbrugge et al., 2013). Conversely, textbooks that offer limited support for teachers and cover multiple topics within a single unit are generally considered less effective (Steenbrugge et al., 2013). This highlights the crucial role textbooks play in how teachers interpret and implement the curriculum. For effective classroom practice, state curricula must be clearly communicated and discussed with teachers, as simply revising the curriculum at the policy level will have little impact unless textbooks are updated accordingly.

2.19.6 Inadequate Provision of Classrooms and Laboratory Facilities

Facilities refer to the equipment, buildings, and furniture—such as tables, chairs, lockers, and benches—that enable chemistry teachers and students to perform tasks efficiently, particularly in laboratory settings. Ehiametalor (2001) indicated that

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adequate facilities are essential for workers to achieve organisational goals. Similarly, Garba (2004) emphasised that the use of instructional facilities enhances the learning experience and promotes interaction within the educational environment, thereby improving student outcomes. In the context of implementing the chemistry curriculum, necessary facilities include laboratories, workshops, lockers, gas cylinders, water tanks, and preparatory rooms.

Nwachukwu (2005) observed that public secondary schools have experienced significant deterioration in terms of facilities. According to him, many schools no longer reflect the standards expected in a modern educational system, exhibiting issues such as collapsing buildings, leaking roofs, poorly maintained surroundings, lack of public toilets, and neglect of aesthetics. Such conditions suggest that these schools are functioning in a way that provides substandard services to the majority of students. The shortage and decay of facilities have a direct negative impact on the implementation of the chemistry curriculum and must be addressed, as school facilities serve as essential operational inputs for instructional programmes. Schools can be likened to manufacturing organisations, where equipment and infrastructure must be fully functional to achieve desired outcomes. Supporting this perspective, Atiya (2022) emphasised that the effective implementation of a curriculum depends on the availability of adequate infrastructures and facilities.

2.19.7 Inadequacy of Qualified Chemistry Teachers

Lassa (2007) emphasised that teachers play a central role in the proper development of students, highlighting the need for a sufficient number of qualified teachers in all secondary schools. However, the general public's limited interest in pursuing teacher education exacerbates the shortage of teachers at this level. Asiyai (2005) noted that the

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low enrolment of students in university programmes for pure sciences—such as biology, chemistry, and physics education—poses a significant concern. This trend is particularly troubling because teacher education programmes are responsible for preparing future educators, including chemistry teachers, to effectively implement the secondary school curriculum.

2.19.8 Lack of Motivation Among Chemistry Teachers

Ofoegbu (2001) argued that motivation functions as a driving force that can alleviate tension, stress, and frustration arising from challenging situations. In the workplace, lack of motivation often manifests as negative organisational motivation, which can lead to stress and decreased performance. For teachers, motivation encompasses factors within the school system that, if absent, can result in reduced effectiveness, dissatisfaction, and frustration, ultimately lowering both teacher and student outcomes. Supporting this view, Nwani (2011) emphasised that for teachers to perform effectively in curriculum implementation, they must be adequately motivated. Beyond receiving salaries and other entitlements, teachers should also be provided with incentives and necessary resources that facilitate their work and enhance efficiency.

2.19.9 Inadequate Provision of Instructional Materials

Dike (1987) described instructional materials as alternative means of communication that teachers can use to present information more clearly and vividly to learners. This suggests that the use of instructional materials is essential for the effective implementation of the secondary school chemistry curriculum. According to Nwani (2011), students at all levels of the national education system should be provided with appropriate learning experiences through the availability of sufficient instructional resources. When a variety of resources are systematically integrated into the teaching-

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learning process, they create meaningful learning experiences and enhance the effectiveness of instruction. For learning to be truly impactful, students must engage multiple senses—they should see, hear, touch, taste, create, manipulate, and actively participate in learning activities. Ughamadu (1992) further emphasised that curriculum materials are indispensable in the teaching and learning process, as they are specifically designed to facilitate and enrich effective educational experiences.

2.19.10 Funding

Nwachukwu (2005) observed that the current level of underfunding in the public secondary education sector has led to stagnation and deterioration of educational programmes and infrastructure. Similarly, Ofoha (2011) identified inadequate financial support as a major obstacle to effective curriculum implementation in Nigeria, noting that limited funding results in poor infrastructure, scarcity of instructional materials, and restricted opportunities for teacher training, all of which negatively affect curriculum delivery. In addition, Okoroma (2006) emphasised that insufficient funding is a critical factor undermining the implementation of educational policies and curricula, linking financial shortfalls to inadequate resources, ineffective teacher professional development, and a lack of proper monitoring, which together contribute to suboptimal educational outcomes.

2.20 Research Gap

A knowledge gap refers to an area of research where information is either insufficient or entirely lacking, making it difficult for researchers to draw reliable conclusions on specific questions (Weller, 2018). Typical components used to define a knowledge gap include populations, interventions, comparisons, outcomes, and settings (PICOS). Research also suggests that the successful implementation of curriculum changes

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depends largely on how faithfully they are carried out (Bruhn et al., 2015; Keller-Margulis, 2012). When innovations are not implemented as intended, their potential to achieve desired outcomes is significantly diminished (Gage et al., 2020). This perspective aligns with Biggs' (2003) notion of constructive alignment, which emphasises designing learning activities that are closely aligned with curriculum objectives to help students construct knowledge effectively.

In Ghana, research on the science curriculum has addressed various aspects of chemistry education. For instance, Anamuah-Mensah (1995) and Ampiah (2001) examined students' perceptions of difficulties in the senior secondary school chemistry curriculum. Hanson et al. (2011) investigated senior high school students' understanding of introductory chemistry concepts, while Eminah (1993) evaluated the Junior Secondary School science curriculum. Kumabia (2014) studied the implementation of the elective chemistry programme in selected Colleges of Education in the Volta Region, highlighting a discrepancy between teaching practices and the curriculum's intended methods. Similarly, Yekple et al. (2022) reported that although tutors in Colleges of Education preferred learner-centred approaches, their classroom practices did not fully align with the curriculum designers' expectations. In addition, Anderson (2020) identified challenges associated with adopting the New National Teachers' Standard Curriculum at the University of Education, Winneba.

Despite the existing body of literature, no studies were identified that specifically evaluate the implementation of the chemistry curriculum in Ghana. To address this gap, the current study focuses on assessing how the chemistry curriculum is implemented in senior high schools in the Eastern Region of Ghana. This research seeks to fill the existing void in the evaluation of chemistry curriculum practices.

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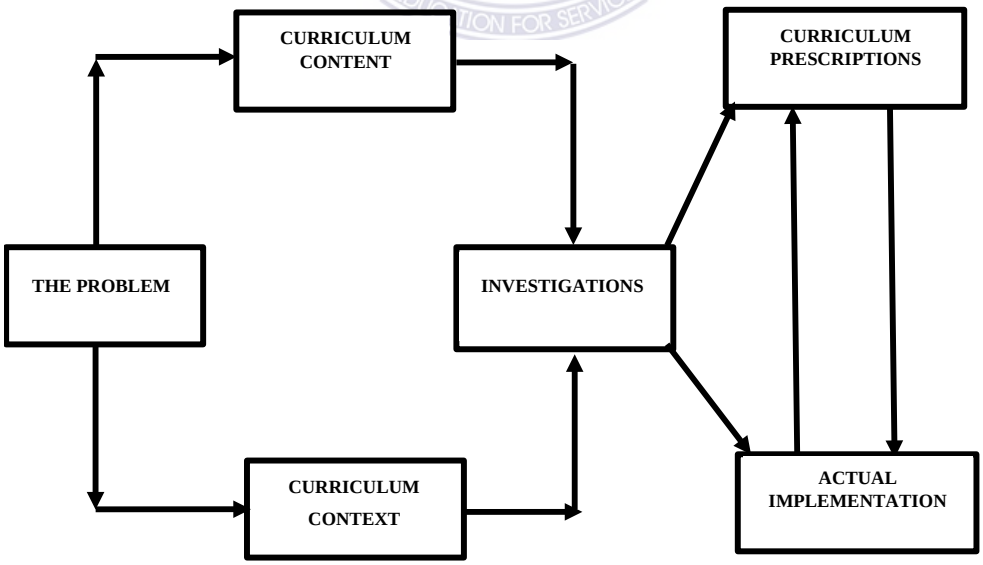
2.21 Theoretical Basis

Borich (1977) proposed that effective teaching requires three categories of competencies.

i. Knowledge competencies, which encompass a teacher's understanding of the subject matter.
ii. Performance competencies, which relate to the teacher's ability to effectively execute instructional tasks.
iii. Consequence competencies, which refer to observable measures of student learning that reflect the knowledge, skills, and abilities gained as a result of the teacher's instruction. In the present study, teacher competencies were assessed using various instruments, and the results were compared against the requirements outlined in the chemistry curriculum.

2.22 Conceptual Framework of the Study



Researcher's Construct

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Curriculum context refers to the conditions and environment in which a curriculum is delivered, encompassing cultural, social, economic, political, and institutional factors that influence education. Acting as a moderating factor, the curriculum context shapes how the curriculum is interpreted, adapted, and applied across different settings. It impacts teacher readiness, availability of instructional resources, and the level of student engagement. For example, even a well-designed curriculum may not succeed if local schools lack adequately trained teachers or essential teaching materials. Similarly, community beliefs and values can either facilitate or hinder the acceptance of certain curriculum content, while policy support and school leadership play critical roles in ensuring smooth implementation. Therefore, the curriculum context significantly determines the effectiveness and adaptability of curriculum implementation initiatives.

Curriculum content functions as a moderating factor that significantly influences the effectiveness of curriculum implementation. Its relevance, clarity, and alignment with students' needs determine the ease with which it can be taught and comprehended. Well-organised content facilitates effective teaching methods and promotes active student engagement, while poorly structured or culturally irrelevant content can impede learning and classroom instruction. The depth and breadth of content also influence lesson pacing and teacher workload, as educators may face challenges when content lacks adequate resources or clearly defined objectives. Furthermore, content that relates to learners' real-life experiences enhances motivation, understanding, and knowledge retention. Consequently, curriculum content plays a crucial role in shaping the overall success of implementation efforts.

Curriculum prescriptions refer to official guidelines that outline what content should be taught, the methods of instruction, and the timing of lessons. They provide structure

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and uniformity across schools, assisting teachers in planning and delivering instruction effectively. Clear and well-articulated prescriptions help educators understand learning objectives and assessment expectations. However, overly rigid prescriptions can restrict teacher creativity and limit adaptability to students' diverse needs. Prescriptions that fail to consider the local context may reduce student engagement or lead to misunderstandings. In such cases, teachers might prioritise content coverage over fostering deep comprehension. Conversely, flexible and thoughtfully designed prescriptions enhance context-sensitive implementation and promote meaningful learning. Therefore, curriculum prescriptions play a critical role in determining the quality and practicality of curriculum execution.

Actual classroom instruction represents the practical enactment of the curriculum, showing how planned content is delivered and experienced by students. It determines the extent to which learning objectives are effectively communicated and achieved. The teacher's instructional strategies, interaction styles, and use of available resources directly impact student understanding, engagement, and participation. High-quality instruction enhances knowledge retention and supports the attainment of curriculum goals. Conversely, ineffective instruction can distort or limit the intended outcomes of the curriculum. Instruction that is adaptable and responsive to diverse learner needs and classroom contexts further strengthens curriculum implementation. Thus, classroom instruction is a pivotal factor in determining the overall success of curriculum execution.

2.23 Empirical Review

Several studies have explored similar topics to the present research. For instance, Egolum and Ukamaka (2023) examined how effectively chemistry teachers in

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secondary schools implement the chemistry curriculum, the challenges they face, and strategies for improving implementation. Their findings indicated that certain aspects of the chemistry curriculum were inadequately implemented, especially by teachers without formal chemistry degrees. Key challenges included a shortage of experienced and qualified teachers, an overloaded curriculum, and poorly equipped laboratories. The study highlighted that improving curriculum implementation requires ensuring sufficient numbers of qualified teachers, increasing funding for laboratory facilities, and adopting innovative teaching approaches in chemistry. Such measures were found to enhance students' skills, knowledge, and overall quality of chemistry education.

Musaiwa (2020) investigated the challenges associated with implementing the new senior secondary school chemistry curriculum in Mulanje District, Malawi. The study found that most schools were inadequately equipped with essential teaching and learning resources, including chemistry textbooks and mobile laboratory equipment, while only a few schools had sufficient materials. Additionally, the research revealed a shortage of qualified chemistry teachers in most schools, though some schools had adequate staffing. These findings suggest that the Malawian government, in collaboration with the Ministry of Education, Science and Technology, needs to prioritise the training and recruitment of chemistry teachers. The study concluded that both the scarcity of teachers and the lack of instructional materials significantly hinder the effective implementation of the senior secondary school chemistry curriculum. To address these issues, the study recommended increasing teacher training and recruitment and ensuring the provision of adequate teaching and learning resources to support successful curriculum implementation in public secondary schools.

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Amadu et al. (2023) examined the implementation of the newly introduced four-year Bachelor of Education (B.Ed.) Chemistry curriculum in Ghanaian Colleges of Education. The study aimed to determine whether the instructional strategies used by tutors adhered to the curriculum guidelines. Guided by Rogan and Grayson's (2003) curriculum implementation framework, the findings revealed a misalignment between the classroom strategies and assessment methods employed by tutors and the recommendations outlined in the curriculum document. Consequently, the study recommended strengthening continuous professional development programmes for tutors and incorporate learner-centred approaches, in line with the curriculum's prescriptions.

Lee (2003) conducted a critical evaluation of the junior secondary science curriculum reform in Hong Kong, examining the curriculum's context, distinctive features, teacher implementation practices, and the resulting impact on students' learning outcomes compared to the previous curriculum. The evaluation considered three levels: the intended, implemented, and achieved curriculum. Findings indicated that the reform was motivated by the need to address personal, social, and educational demands of contemporary society. Key changes in the new curriculum included an emphasis on investigation as a unifying theme reflecting the nature of science, and the integration of science with real-life contexts. The curriculum planners aimed to use investigative activities to enhance students' conceptual understanding, skill development, and ability to tackle open-ended problems. However, the adoption of the investigative approach varied significantly across teachers. Student outcomes showed limited improvement, primarily in simpler process skills, while attitudes toward science and the curriculum deteriorated. These results were linked to discrepancies between the planners' intentions, curriculum design, and classroom practices. The study recommended that

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curriculum improvements should prioritise open-ended investigations and adopt a realistic approach to teacher training, emphasising the transition of teachers from knowledge transmitters to facilitators who guide students in inquiry and achieving curriculum objectives.

Moses (2014) conducted an evaluation of the Senior Secondary School (SSS) chemistry curriculum in Bayelsa State, Nigeria, focusing on the curriculum's objectives, content adequacy, and implementation process. The study adopted an ex-post facto descriptive research design and applied Stufflebeam's Context, Input, Process, and Product (CIPP) evaluation model. Findings indicated that teachers generally viewed the curriculum objectives as relevant. However, they identified several issues with the content, including its overload, complexity, and theoretical nature, which made it difficult to complete within the allocated time. The study also highlighted challenges affecting effective curriculum implementation. Specifically, thirty-three percent of the chemistry teachers were not professionally qualified, and forty percent of the schools had only a single chemistry teacher. In addition, all chemistry laboratory assistants lacked prior experience and had not received any in-service training, further constraining the practical implementation of the curriculum.

The study found that teachers predominantly relied on traditional teaching methods rather than the prescribed guided discovery approach. Additionally, schools were inadequately equipped with the necessary facilities and resources, which contributed to low student achievement in chemistry. The results also indicated no significant differences in chemistry performance between male and female students or between the 2009 and 2010 student cohorts. Consequently, the study recommended that the government recruit more qualified chemistry teachers and laboratory technologists. It

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further suggested that current teachers and laboratory assistants undergo regular training and professional development, hat schools be provided with sufficient facilities and resources, and that teachers adopt the recommended teaching methodologies in the instruction of chemistry.

Mokoro (2020) conducted a study to assess the adequacy of laboratory facilities in supporting the implementation of the competence-based curriculum (CBC) in public secondary schools in Arumeru District, Tanzania. The study revealed that the schools lacked sufficient laboratory facilities, which hindered the effective execution of the CBC. Based on these findings, the study recommended that the government, together with relevant educational stakeholders, provide the necessary laboratory infrastructure to facilitate proper implementation of the competence-based curriculum in these schools.

Igwe (2015) investigated the challenges associated with implementing the secondary school chemistry curriculum in Nigeria and explored potential innovative strategies for improvement. The study defined the curriculum as a structured set of activities within and outside the school, guided by the institution itself, and emphasised the overarching goals and specific objectives of secondary education, particularly in chemistry. The research highlighted the key issues affecting the effective implementation of the chemistry curriculum and suggested strategies to enhance its execution. These included encouraging teachers and students to develop their own instructional materials through improvisation, actively involving teachers in curriculum planning and decision-making, and ensuring that the government recruits an adequate number of qualified chemistry teachers to strengthen curriculum delivery.

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Additionally, the study recommended greater collaboration among key stakeholders in secondary education—such as the government, chemistry teachers, and Parent-Teacher Associations—to ensure the effective attainment of both the general and specific objectives of the secondary school chemistry programme.

Amoah (2018) examined the classroom implementation of the Senior High School elective biology curriculum in Ghana's Central Region, employing a cross-sectional descriptive survey design. The study targeted all public Senior High Schools in the region offering elective biology, with Form Two biology teachers and students selected as respondents. Findings indicated that all teachers in grade A schools were academically and professionally qualified to teach biology. However, 22.65% of teachers in grade B schools and 9.43% in grade C schools lacked professional qualification for teaching biology at the Senior High School level. Across all school categories, teaching and learning resources were insufficient. Consequently, 77.36% of teacher respondents reported challenges in fulfilling their teaching responsibilities, which hindered the development of cognitive and process skills in their instructional activities. Additionally, over 90% of teachers did not conduct practical activities regularly, negatively affecting the attainment of the syllabus's profile dimensions.

Eminah (1993) investigated the implementation of the Junior Secondary School (JSS) Science curriculum in Ghana's Western Region, focusing on how selected teachers' classroom practices aligned with the approaches recommended in the JSS science syllabus and teachers' handbook. The study revealed that teachers predominantly asked lower-order cognitive questions and did not regularly organise practical activities as required by the syllabus. Additionally, many learners struggled with reading and writing in English. The study concluded that the intended instructional changes had not

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materialised, as the curriculum was not being implemented in classrooms according to the developers' guidelines. Overall, the teaching and learning strategies employed deviated from the principles prescribed in the syllabus. Notably, no research has yet examined the implementation of the Senior High School (SHS) chemistry curriculum in the present study area.

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CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter outlines the methodology adopted for the study. It details the selected research design, the target population, and the sampling techniques used to select participants. The chapter also describes the instruments employed for data collection, along with procedures for ensuring their validity and reliability. Furthermore, ethical considerations are discussed, and the methods for data collection and analysis are explained.

3.1 Research Design

The choice of an appropriate research method largely depends on the nature of the research problem or the specific issue under investigation (Creswell, 2009). Selecting a method that can effectively address the research questions is therefore essential. For this study, a cross-sectional descriptive survey design was adopted, integrating both quantitative and qualitative data collection and data analysis techniques. Creswell (2003) explains that a mixed-methods approach is grounded in pragmatism and involves gathering both numerical and textual data to create a comprehensive dataset suitable for integrated analysis. By combining qualitative and quantitative methods, mixed-methods research allows for richer and more detailed insights, as information from one source can complement, elaborate, or enhance data from another (Creswell, 2005). This approach provides a holistic understanding of the research problem by leveraging the strengths of both data types.

This methodological approach enables researchers to capitalise on the advantages of both qualitative and quantitative paradigms, making it possible to address complex

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research questions that might be inadequately explored using a single method (Creswell & Plano Clark, 2018). It also strengthens the credibility of the findings through triangulation and facilitates a more thorough interpretation by combining statistical patterns with rich contextual information (Tashakkori & Teddlie, 2010).

For this study, an explanatory sequential method, a specific type of mixed-methods approach, was employed. In this method, quantitative data are collected and analysed first, followed by qualitative data, which serve to clarify, expand, or explain the quantitative results. This approach is particularly valuable when statistical findings require deeper understanding through participants' perspectives or contextual explanations (Creswell & Plano Clark, 2018). The qualitative phase is directly informed by the initial quantitative outcomes, creating a linked sequence that is especially effective in fields such as education, health, and social sciences (Ivankova et al., 2006). By combining both data types, this design improves the richness, interpretive depth, and practical significance of the study's findings (Plano Clark & Ivankova, 2016).

Mixed-methods research is commonly grounded in a pragmatic paradigm, which prioritises using multiple methods to effectively address research questions instead of adhering to a single philosophical framework. Pragmatism acknowledges both objective and subjective forms of knowledge, enabling researchers to leverage the strengths of quantitative (positivist) and qualitative (constructivist) approaches (Creswell & Plano Clark, 2018). This paradigm encourages flexibility in methodology and supports the integration of diverse data types, allowing for a more comprehensive understanding of complex phenomena (Johnson & Onwuegbuzie, 2004). Within this approach, pragmatism ensures a logical link between the quantitative and qualitative

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phases, guiding the use of each method to serve a practical role in resolving the research problem (Shannon-Baker, 2016).

Pragmatism, with its focus on outcomes and practical problem-solving, facilitates the combination of different types of data to generate more thorough and actionable insights (Morgan, 2007). In essence, mixed-methods research merges qualitative and quantitative approaches to address the limitations inherent in using a single method, provide a more holistic understanding, enhance validity through triangulation, and allow for deeper exploration of complex issues.

A survey is an approach used to gather information from a large population with the aim of describing, exploring, or explaining specific phenomena. This approach was considered suitable for the current study because it provides a cost-effective means of obtaining data on individuals' attitudes, beliefs, and behaviours. Surveys also allow for manageable data collection and involve administering a uniform set of questions, typically through written questionnaires, to many respondents (Mitchell & Jolley, 2004; Fraenkel & Wallen, 2000).

Fraenkel and Wallen (2000) highlighted three main challenges in conducting descriptive surveys. The first challenge involves ensuring that the survey questions are clear, precise, and free from ambiguity. The second challenge is encouraging respondents to provide complete and honest answers. The third challenge relates to obtaining a sufficient number of completed questionnaires to allow for meaningful analysis. In this study, these issues were addressed by using simple and easily understandable language in the questionnaire, requesting respondents to answer truthfully, and following up effectively to ensure the return of completed questionnaires.

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In this study, quantitative data were collected using a questionnaire, while qualitative data were gathered through interviews, observations, and document analysis. This combination of methods provided a comprehensive and in-depth understanding of the research context.

3.2 Population

This study distinguishes between two types of population: the target population and the accessible population. According to Amedahe (2002), the target population comprises the entire set of individuals or cases to which the researcher aims to generalise the study findings; it represents the full group from which the desired information is sought. In contrast, the accessible population refers to the portion of the target population that is available and reachable for the study, serving as the pool from which participants can actually be selected (Amedahe, 2002). Researchers typically draw samples from the accessible population with the intention of generalising the results to the broader target population. Practical considerations such as time constraints and geographic dispersion often necessitate the use of a limited, accessible population. Essentially, the accessible population is a subset of the target population and is also referred to as the study population.

The target population for this study included all chemistry teachers, Heads of Departments (HODs) for science, assistant heads responsible for academics, and students enrolled in elective chemistry courses in Senior High Schools (SHSs) across the Eastern Region of Ghana. Van Dalen (1979) suggests that a sample size of 15–20% of the total population is sufficient to validate a survey study. Accordingly, twenty-one SHSs, representing approximately 30% of the seventy-one schools offering General Science in the region, were selected for the study. The accessible population consisted

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of the chemistry teachers, HODs for science, assistant heads for academics, and elective chemistry students within these selected schools.

3.3 Sampling Technique and Sample

Lawrence (2006) categorises sampling strategies in research into two main types: probability sampling and non-probability (or non-random) sampling. A sample is defined as a smaller portion of a population intended to represent the whole (Wellington, 2003). In this study, the sample was drawn from the accessible population. The twenty-one Senior High Schools included in the research were purposively selected to represent the accessible population. These schools were chosen from various districts and municipalities within the Eastern Region, namely Akuapim North, Akuapim South, New Juaben North, New Juaben South, Nsawam-Adoagyire, Suhum, Upper West Akim, Lower West Akim, Yilo Krobo, and Lower Manya Krobo.

Krejcie and Morgan (1970) assert that the size of a sample is determined by the population size and the acceptable margin of error the researcher is willing to tolerate. They developed a reference table to guide researchers who aim to achieve 95% confidence in estimating what the results would have been if the entire population were surveyed (see Appendix A). Similarly, Kothari (2004) emphasises that the sample should be sufficiently large to provide a confidence interval of the desired precision. These perspectives informed the determination of the sample size for this study. Accordingly, a random sample of 366 Form Three students offering General Science participated in the study. Additionally, 73 chemistry teachers, 21 Heads of Department (Science), and 21 assistant heads for academics from the selected Senior High Schools were purposively included. All participating chemistry teachers and students had used

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the curriculum materials extensively in teaching and learning for a minimum of two years.

3.4 Research Instruments

The study employed multiple instruments to collect data, including observations, interviews, questionnaires, and document analysis.

3.4.1 Observational Schedule

Observation is a research method used for systematically recording individuals' behaviours according to a predefined schedule or set of categories (Bryman, 2016). There are two main types of observation: unstructured and structured. Unstructured observation does not rely on a predetermined schedule; instead, it aims to capture participants' behaviours in a narrative format, providing a descriptive account of their actions (Bryman, 2016). In contrast, structured observation uses predefined categories or schedules to systematically record behaviours, offering an alternative to surveys, which may not always capture the nuances of human behaviour. Structured observation allows researchers to examine interactions, such as those between teachers and students, from a more detailed and systematic perspective, making it particularly valuable in educational research settings.

For this study, a modified version of the Barbados Workshop Observation Instrument, as adapted by Eminah (2007), was employed. The original instrument was developed in 1986 during a workshop at the University of Liverpool, England, and later utilised in a 1987 workshop in Barbados to assess the extent to which students applied process skills in science learning. In the present research, the observation schedule was used to systematically collect data on classroom instructional practices. A copy of the instrument is provided in Appendix B.

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3.4.2 Interview

Interviews are a key method in qualitative research, involving the researcher posing open-ended questions to one or more participants and recording their responses, often using audio devices to ensure accurate transcription (Creswell, 2012). This method is essentially a conversational process in which knowledge is co-constructed through the interaction between the interviewer and interviewee(s) (Brinkmann, 2014). It has become one of the most widely used approaches in the social and human sciences for investigating participants' beliefs, attitudes, and perceptions (Brinkmann, 2018). Interviews are generally classified into three types: structured, unstructured, and semi-structured. Structured interviews involve asking participants a predetermined set of questions without follow-ups, making them quick to administer and straightforward to manage. They are particularly effective when clarifying issues related to literacy or numeracy (Creswell, 2014).

Structured interviews, while efficient, tend to limit participants' responses and are therefore unsuitable when detailed or nuanced information is needed. In contrast, unstructured interviews are informal and flexible, with researchers approaching the discussion without predefined questions or hypotheses (Creswell, 2014). Although they can provide rich, in-depth insights, unstructured interviews are often time-intensive, difficult to manage, and may leave participants uncertain about what to discuss. This approach is particularly useful when exploring areas that are not well understood or when seeking multiple perspectives on a known topic.

The third type, semi-structured interviews, was employed in this study. These interviews are guided by a set of key questions that outline the topics to be explored, while also allowing both the interviewer and interviewee to expand on responses or

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introduce new ideas (Brinkmann, 2018). Semi-structured interviews strike a balance between guidance and flexibility, making them particularly valuable in social science research and exploratory studies where comprehensive, in-depth information is required.

Unlike structured interviews, semi-structured interviews offer flexibility that enables participants to elaborate on or explore issues that are particularly relevant to them. In this study, the interview focused on the challenges associated with implementing the chemistry curriculum in Senior High Schools. The questions were open-ended to allow participants to respond freely and provide detailed insights. An interview guide was used to ensure that key topics were covered and to monitor the discussion, and it is provided in Appendices C and D.

3.4.3 Questionnaire

A questionnaire is a written tool commonly used in survey research, consisting of a set of questions presented to respondents or administered by an interviewer who records the answers (Neuman, 2003). Questionnaire items can be either closed-ended, where respondents select from predetermined options such as “yes” or “no,” or open-ended, allowing participants to provide responses in their own words (Acheampong, 2013). One key advantage of using a questionnaire is its ability to reach a large number of respondents simultaneously, whether distributed by mail or in person (Jack & Norman, 2003).

For this study, a closed-ended questionnaire was employed. During its development, care was taken to ensure that the questions were clear, unbiased, and relevant to the research objectives. The questionnaire contained fifty items in addition to demographic questions. These included ten items on resources, twenty items on instructional

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activities, and ten items on personal capacity-building activities related to chemistry curriculum implementation. Respondents were required to select the option that best reflected their opinions. The questionnaire is provided in Appendices E and F.

3.4.4 Document Analysis

Documents serve as sources of information that help researchers understand the context of a study or the characteristics of its participants. They can be categorized as either printed materials, such as books, test results, or syllabuses, or non-printed materials, including photographs, films, or videos. According to Creswell (2005), documents are further classified into public and private types. Public documents consist of items such as meeting minutes, official memos, books, newspapers, and archival records held in libraries, whereas private documents include personal diaries, journal entries, letters, and private notes. Examining documents provides direct information (McMillan, 2004) that can corroborate or supplement data gathered through interviews or observations. In this study, "documents" specifically refer to written materials collected from the participating schools and teachers.

The documents examined in this study included the chemistry curriculum, which outlines the aims, objectives, content, and recommended teaching and learning strategies; chemistry textbooks, which provide instructional materials and activities for teaching various concepts; and teacher guidebooks, which offer sample lesson plans, suggested teaching strategies, and practical guidance for instructional methods. Additional documents included school timetables, schemes of work, and supplementary reference materials. Analysing these documents was intended to provide insights into the curriculum developers' intentions and to understand how the curriculum could be effectively implemented in practice.

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3.5 Validity of the Main Instruments

Validity refers to the extent to which a research instrument accurately measures what it is intended to measure (Joppe, 2000). To ensure content and face validity, the questionnaire, interview guide, and observation schedules were reviewed by two senior high school chemistry teachers and experts in Science Education at the University of Education, Winneba. Their feedback and recommendations were used to refine and improve the instruments.

3.6 Reliability of the Main Instruments

Reliability refers to the consistency and stability of an instrument's scores over repeated administrations (Creswell, 2005). A reliable instrument produces similar results under consistent conditions. Mugenda and Mugenda (2003) note that a reliability coefficient of 0.7 or higher is considered acceptable, while values below this indicate low reliability. To establish the reliability of the questionnaires for both students and teachers, a pilot study was conducted in four senior high schools in the Eastern Region of Ghana. The pilot involved 60 students and 4 chemistry teachers who were not included in the main study sample. Feedback from the pilot helped identify and modify certain items before the instruments were administered to the actual respondents. The reliability coefficient obtained from the pilot was 0.79. Additionally, the interview and observation guides were tested during the pilot study, and the feedback collected was used to refine these instruments and address any potential issues.

3.7 Data Collection Procedure

The questionnaires were distributed to the respondents, who were given one day to complete them, and the completed questionnaires were collected on the following day. Interviews were conducted with both students and teachers to explore the challenges

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associated with the implementation of the chemistry curriculum. For the assistant heads of academics and the HODs of science, interviews focused on strategies for monitoring curriculum implementation. Additionally, a chemistry lesson was observed in four of the selected schools using a structured observation guide to record classroom instructional practices.

3.8 Data Analysis Procedure

Coding schemes were created to systematically organise the questionnaire responses into meaningful categories for analysis. The quantitative data from the questionnaires were analysed using descriptive statistics, including means, frequencies, and standard deviations, computed with SPSS version 22. Audio-recorded interviews were transcribed and examined thematically, allowing for qualitative analysis of participants' perspectives. Similarly, the data obtained from lesson observations were organized according to pre-determined themes from the observation guide and analysed qualitatively to provide insights into classroom instructional practices.

3.9 Ethical Considerations

Educational research often involves human participants and the institutions in which they learn as the sites for data collection (Wellington, 2000). It is essential to secure official permission from the relevant institutions and obtain consent from individuals whose approval is required before commencing the research (Cohen et al., 2011).

The teachers and headmasters were informed in advance about the purpose of the research. Consent was obtained from the assistant heads for academics, HODs of science, teachers, and students to participate in the study, ensuring that their responses to the research instruments reflected their genuine perspectives. Participants were

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assured of the confidentiality of the information they provided, and no discriminatory actions were taken against students based on their responses.

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CHAPTER FOUR

RESULTS

4.0 Overview

This section of the study elaborates on the results from data gathered. The section contains the descriptive and qualitative analysis of the information for the various research questions. The data obtained from the study were analysed using SPSS for the descriptive analysis. The obtained results have been presented by research question.

4.1 Presentation of the Results by Research Questions

4.2 Research Questions 1: To what extent are the chemistry teachers academically and professionally qualified to teach the subject chemistry?

The demographic background covering gender, age, teaching experience, academic qualification, area of specialization and professional qualification of the teachers involved in the study have been presented in Table 4.1.

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Table 4.1: Demographic Background of the Teachers

Variable	Category	Frequency	Percentage
Gender	Male	70	96
	Female	3	4
Age	21-30years	7	10
	31-40years	25	34
	41-50years	36	49
	Above 51years	5	7
Teaching experience	3-5years	7	10
	6-10years	35	48
	11-15years	12	16
	16-20years	9	12
	Above 20 years	10	14
Academic qualification	1st degree	47	64
	2nd degree	26	36
Area of specialization	chemistry	66	90
	Physics	3	4
	Biology	4	6
Professional qualification	Diploma	6	8
	1st degree	41	56
	2nd degree	9	12
	Other	17	23
	Total	**73**	**100**

Source: Field survey, 2022

From Table 4.1, the results revealed that all the teachers included in the study possess at least a first degree in chemistry or other science-related areas like biology and physics. In the field of chemistry, it is evident that a substantial majority of teachers, specifically 90.4 % possess expertise in this subject. However, 9.6% of the teachers did not specialise in chemistry.

A significant majority (56.2%) of teachers hold a first-degree in professional qualification, and about 12.3% of teachers have pursued second-degree in professional

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qualifications, reflecting a commitment to subject-specific expertise. The remaining teachers have diploma and other professional qualification.

The majority of the teachers (around 76.6%) have between 6 to 20 years of teaching experience, indicating a relatively experienced group. A significant portion (approximately 13.7%) have more than 20 years of teaching experience. A smaller portion (around 9.6%) have less than 6 years of teaching experience.

Summary of findings

The findings revealed that majority of teachers had specialised knowledge in chemistry but there were teachers implementing the chemistry curriculum without requisite academic qualification in chemistry. In addition, majority of the teachers hold professional qualification which indicated a good professional knowledge for their teaching roles. However, there were few teachers with other professional qualifications. Also, the main findings revealed experienced teaching staff, with a significant portion having over six years of experience, while a smaller group consists of teachers with less than six years of experience.

4.3 Research Question 2: What financial, material and infrastructural resources were available for implementing the chemistry curriculum at the classroom level?

This section of the study contains the descriptive analysis of both students and teachers opinion about the resources for chemistry curriculum implementation. Also, findings from physical inspections and document analysis.

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Resources for Chemistry Curriculum Implementation (Students)

The descriptive analysis of students' responses on resources for chemistry curriculum implementation has been presented in Table 4.2.

Table 4.2: Resources for Chemistry Curriculum Implementation (Students)

Statements	SD	D	N	A	SA	Mean	Standard Dev.
The school has a laboratory dedicated for chemistry practical	7 (1.9%)	14 (3.8%)	6 (1.6%)	198 (54.1%)	141 (38.5%)	4.235	.821
The school has adequate equipment, facilities to implemen to the chemistry curriculum.	57 (15.6%)	132 (36.1%)	73 (19.9%)	91 (24.9%)	13 (3.6%)	2.648	1.120
There is easy access to science resources for implementation of the chemistry curriculum.	57 (15.6%)	117 (32%)	92 (25.1%)	86 (23.5%)	14 (3.8%)	2.680	1.110
The school always buys needed materials during examination period	12 (3.3%)	42 (11.5%)	117 (32%)	150 (41%)	45 (12.3%)	3.475	.961
There are textbooks, like GAST chemistry, for SHS which are readily available for teaching and learning chemistry.	24 (6.6%)	106 (29%)	52 (14.2%)	125 (34.2%)	59 (16.1%)	3.243	1.218
The school has a library which is stocked with chemistry reference books	20 (5.5%)	125 (34.2%)	118 (32.2%)	79 (21.6%)	24 (6.6%)	2.896	1.015
The school borrows some chemistry resources from other schools	21 (5.7%)	124 (33.9%)	119 (32.5%)	78 (21.3%)	24 (6.6%)	2.891	1.013
The Ministry of Education and GES regularly supply equipment and materials to the school.	108 (29.5%)	57 (15.6%)	152 (41.5%)	36 (9.8%)	13 (3.6%)	2.424	1.117
Grand mean:3.062							

Source: field survey, 2022

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From Table 4.2, in order to determine students understanding of resources for chemistry curriculum implementation, a Likert scale of 1-5 (where SD represent strongly disagree, D is disagree, N being neutral, A being agree and SA representing strongly agree) was used to rate the items. There were eight (8) items under resources for chemistry curriculum implementation.

The results from the study revealed that majority of the respondents accepted that the school had a laboratory dedicated for chemistry practical. The respondents further indicated that the school always bought needed materials during examination period and there were textbooks, like GAST chemistry, for SHS which were readily available for teaching and learning chemistry.

However, the results revealed that majority of the respondents did not accept that the school had adequate equipment, facilities to implement the chemistry curriculum and easy access to science materials and resources for implementation of the chemistry curriculum. Also, majority of the respondents did not accept that there was timely release of funds to buy required resources and school had a library which was stocked with reference books. Again, the results revealed that majority of the respondents from the study did not accept that the school borrows some chemistry resources from other schools and the Ministry of Education and GES regularly supplied equipment and materials to the school.

Resources for Chemistry Curriculum Implementation (Teachers)

The descriptive analysis of teachers' responses on resources for chemistry curriculum implementation has been presented in Table 4.3.

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Table 4.3: Resources for Chemistry Curriculum Implementation (Teachers)

Statements	D	N	A	SA	Mean	Standard Dev.
The school has a laboratory dedicated for chemistry practical	0	0	46 (63%)	27 (37%)	4.370	.486
The school has adequate equipment, facilities to implement the chemistry curriculum	5 (6.8%)	42(57.5%)	26(35.6%)		3.288	.589
There is easy access to science resources to enable you implement the chemistry curriculum.	16 (21.9%)	29 (39.7%)	28 (38.4%)		2.945	.528
The school always buys needed resources during examination period	8 (11%)	23 (31.5%)	33 (45.2%)	9 (12.3%)	3.589	.847
There are textbooks, like GAST chemistry, for SHS which are readily available for teaching and learning chemistry.	3 (4.1%)	21 (28.8%)	28 (38.4%)	21 (28.8%)	3.877	.971
The school has a library which is stocked with chemistry reference books	5 (6.8%)	25 (34.2%)	37 (50.7%)	6 (8.2%)	3.603	.741
The school borrows some resources from other schools	32 (43.8%)	35 (47.9%)	6 (8.2%)		3.589	.940
The Ministry of Education and GES regularly supply equipment and materials to the school.	23 (31.5%)	50 (68.5%)			2.644	.562
Grand mean:3.488						

Source: Field survey, 2022

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From Table 4.3, in order to determine teachers understanding of resources for chemistry curriculum implementation, a Likert scale of 1-5 (where SD represent strongly disagree, D is disagree, N being not sure, A being agree and SA representing strongly agree) was used to rate the items. There were eight (8) items under resources for chemistry curriculum implementation.

The results from the study revealed that majority of respondents accepted that the school has a laboratory dedicated for chemistry practical and the school always bought needed materials during examination period. Again, majority of the respondents indicated that there were textbooks, like GAST chemistry, for SHS which were readily available for teaching and learning chemistry, the school has a library which was stocked with reference books and the school borrows some chemistry resources from other schools.

However, majority of the respondents from the results did not accept that there was timely release of funds to buy required resources and the school has adequate equipment, facilities to implement the chemistry curriculum. The respondents further did not accept that there was easy access to science resources to implement the chemistry curriculum and the Ministry of Education and GES regularly supplied equipment and materials to the school.

In summary, the results among students and teachers about assessing the resources for teaching and learning of chemistry in schools revealed good linkage in views. The results showed that there were dedicated laboratories for chemistry practical and the schools always bought needed materials during examination period. Additionally, textbooks like GAST chemistry for SHS were easily accessible. However, there were major challenges associated with the adequacy of equipment, facilities and access to

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science materials. Furthermore, there were no regular supply of equipment and materials from the Ministry of Education and GES.

The majority of the teachers indicated that they borrow resources from other schools and the school libraries had chemistry reference books. This was however disagreed by majority of the students.

In the document analysis, the schools involved in the study had chemistry curriculum and textbooks. Some teachers have hard copies and others have soft copies of the chemistry curriculum. Teachers did not have lesson plans as required by the curriculum. The teachers had teaching notes on mostly concepts that learners were assessed on by WAEC. The theory aspect of the elective chemistry were indicated on the timetables but the practical lesson were missing from the timetables. The learners' exercises were mostly on knowledge and comprehension. The learners performed below average for the few items on application of knowledge as seen in their exercises. The items were not aligned with objectives as specified in the chemistry curriculum. Some of the schools had practical books where learners were expected to record their findings in practical as required by the chemistry curriculum. There were schools with no practical books so no record of practical work

During physical inspections, all schools involved in the research had infrastructure dedicated as classrooms, laboratories with some stools. There were limited chemicals and facilities in the schools visited based on the chemistry curriculum content. The schools had libraries with limited chemistry reference books.

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Summary of findings

The findings revealed that there were dedicated laboratories for chemistry practical. Additionally, textbooks like GAST chemistry for SHS were easily accessible. However, there were major challenges associated with the adequacy of equipment and facilities and access to science materials. Furthermore, the school libraries had limited chemistry reference materials, and there were no regular supply of equipment and materials from the Ministry of Education and GES. The teachers had teaching notes on mostly concepts that learners were assessed on by WAEC. The theory aspect of the elective chemistry were indicated on the timetables but the practical lesson were missing from the timetables. The learners' exercises were mostly on knowledge and comprehension.

4.4 Research Question 3: What instructional activities are organised by the teachers during chemistry lessons?

The instructional activities in chemistry curriculum implementation in the schools was captured in the study. This section contains both students and teachers opinions on instructional activities in chemistry curriculum implementation.

Instructional Activities in Chemistry Lessons (Students)

The descriptive analysis of responses of students about instructional activities in chemistry lessons has been presented in Table 4.4

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Table 4.4: Instructional Activities in Chemistry Lessons (students)

Statements	N	R	S	MO	A	Mean	Standard Dev.
There is adequate time for advanced preparation using the required chemistry curriculum resources	20 (5.5%)	125 (34.2%)	118 (32.2%)	79 (21.6%)	24 (6.6%)	2.896	1.015
The learners are involved in the teaching and learning process.	4 (1.1%)	33 (9%)	72 (19.7%)	105 (28.7%)	152 (41.5%)	4.006	1.036
All the concepts are taught as required by the chemistry curriculum	57 (15.6%)	117 (32%)	92 (25.1%)	86 (23.5%)	14 (3.8%)	2.680	1.110
Learners are assessed based on the objectives of the concepts in the chemistry curriculum	44 (12%)	14 (3.8%)	46 (12.6%)	122 (33.3%)	140 (38.3%)	3.820	1.310
Learners are involved in establishing rules and procedures.	88 (24%)	50 (13.7%)	90 (24.6%)	54 (14.8%)	84 (23%)	2.989	1.473
Learners copy notes during the instructional process	4 (1.1%)	26 (7.1%)	79 (21.6%)	98 (26.8%)	159 (43.4%)	4.044	1.017
Learners are assessed before, during and after instruction	56 (15.3%)	50 (13.7%)	84 (23%)	92 (25.1%)	84 (23%)	3.268	1.361
The teacher uses different resources like pictures, videos and realia	115 (31.4%)	86 (23.5%)	111 (30.3%)	36 (9.8%)	18 (4.9%)	2.333	1.160
Learners are regularly examined through exercises, quizzes, assignments and projects.	13 (3.6%)	40 (10.9%)	94 (25.7%)	117 (32%)	102 (27.9%)	3.697	1.097
The teacher facilitates learners' own inquiry.	28 (7.7%)	48 (13.1%)	154 (42.1%)	80 (21.9%)	56 (15.3%)	3.240	1.102
Teacher exposes learners to science equipment during practical	3 (0.8%)	8 (2.2%)	48 (13.1%)	88 (24%)	219 (59.8%)	4.399	.857

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Teacher guides learners on how to write report about experiment.	28 (7.7%)	29 (7.9%)	64 (17.5%)	79 (21.6%)	166 (45.4%)	3.891	1.275
Teacher focuses more on theory than practical in chemistry lessons.	12 (3.3%)	41 (11.2%)	56 (15.3%)	108 (29.5%)	149 (40, 7%)	3.932	1.141
Teacher demonstrates experiments before learners carry out any assigned task.	13 (3.6%)	15 (4.1%)	50 (13.7%)	64 (17.5%)	224 (61.2%)	4.287	1.074
Teacher supervises learners during practical.	5 (1.4%)	0	18 (4.9%)	55 (15%)	288 (78.7%)	4.697	.689
Teacher allows learners to work in groups during practical lessons.	1 (0.3%)	7 (1.9%)	48 (13.1%)	86 (23.5%)	224 (61.2%)	4.434	.811
Teacher gives learners immediate feedback when they need directions to proceed.	1 (0.3%)	6 (1.6%)	22 (6%)	144 (39.3%)	193 (52.7%)	4.426	.705
Teacher organises group work because there is no enough equipment	21 (5.7%)	42 (11.5%)	77 (21%)	79 (21.6%)	147 (40.2%)	3.790	1.244
Teacher denies learners the opportunity to handle every equipment in the laboratory	118 (32.2%)	64 (17.5%)	107 (29.2%)	60 (16.4%)	17 (4.6%)	3.563	1.225
Teacher involves a lab assistant in setting up the practical activities	114 (31.1%)	32 (8.7%)	68 (18.6%)	50 (13.7%)	102 (27.9%)	2.984	1.610
Grand mean:3.152							

Source: Field survey, 2022

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From Table 4.4, in order to determine students understanding of instructional activities in chemistry lessons, a Likert scale of 1-5 (where N=Never, R=rarely, S=sometimes, MO=most often, and A=always) was used to rate the items. There were twenty (20) items under instructional activities in chemistry lessons.

The majority of the respondents as seen in the study accepted that the learners were involved in the teaching and learning process, learners were assessed based on the objectives of the concepts in the chemistry curriculum, learners copy notes during the instructional process and learners were assessed before, during and after instruction. Also, majority of the respondents revealed that learners were regularly examined through exercises, quizzes, assignments and projects, the teacher exposed learners to science equipment during practical, the teacher facilitates learners' own inquiry and teacher guided learners on how to write report about experiment. Again, majority of the respondents' results revealed that teachers focused more on theory than practical in chemistry lessons, teachers demonstrated experiments before learners carried out any assigned tasks, teachers supervised learners during practical and teachers allowed learners to work in groups during practical lessons. The result further indicated that majority respondents agreed that teachers gave learners immediate feedback when they need directions to proceed, teachers organised group work because there is inadequate equipment and teachers denied learners the opportunity to handle every equipment in the laboratory.

However, the results from majority of the respondents did not accept that there was adequate time for advanced preparation using the required chemistry curriculum resources, all the concepts were taught as required by the chemistry curriculum, learners were involved in establishing rules and procedures, the teachers used different resources like pictures, videos and realia, and teachers involved a lab

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assistants in setting up the practical activities.

Instructional Activities in Chemistry Lessons (Teachers)

The descriptive analysis of responses of teachers about instructional activities in chemistry lessons has been presented in Table 4.5.

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Table 4.5: Instructional Activities in Chemistry Lessons (Teachers)

Statements	N	R	S	MO	A	Mean	Standard Dev.
There is adequate time for advanced preparation using the required curriculum resources			46 (63%)	24 (32.9%)	3 (4.1%)	3.411	.573
The learners are involved in the teaching and learning process.			9 (12.3%)	49 (67.1%)	15 (20.5%)	4.082	.571
All the concepts are taught as required by the chemistry curriculum		7 (9.6%)	14 (19.2%)	37 (50.7%)	15 (20.5%)	3.822	.872
Learners are assessed based on the objectives of the concepts in the chemistry curriculum			7 (9.6%)	52 (71.2%)	14 (19.2%)	4.096	.531
Learners are involved in establishing rules and procedures.	9 (12.3%)	7 (9.6%)	33 (45.2%)	21 (28.8%)	3 (4.1%)	3.027	1.027
Learners copy notes during the instructional process			5 (6.8%)	27 (37%)	41 (56.2%)	4.493	.626
Learners are assessed before, during and after instruction			5 (6.8%)	60 (82.2%)	8 (11%)	4.041	.423
The teacher uses different resources like pictures, videos and realia.		8 (11%)	23 (31.5%)	39 (53.4%)	3 (4.1%)	3.507	.748
Learners are regularly examined through exercises, quizzes, assignments and projects.			2 (2.7%)	47 (64.4%)	24 (32.9%)	4.301	.519
The teacher facilitates learners' own inquiry.			46 (63%)	19 (26%)	8 (11%)	3.480	.689
Teacher exposes leaners to science equipment during practical				45 (61.6%)	28 (38.4%)	4.384	.490

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Teacher guides learners on how to write report about experiment.	2 (2.7%)			50 (68.5%)	21 (28.8%)	4.206	.706
Teacher focuses more on theory than practical in Chemistry lessons.			24 (32.9%)	21 (28.8%)	28 (38.4%)	4.055	.848
Teacher demonstrates experiments before learners carry out any assigned task.			6 (8.2%)	29 (39.7%)	38 (52.1%)	4.438	.645
Teacher supervises learners during practical.			9 (12.3%)	23 (31.5%)	41 (56.2%)	4.438	.707
Teacher allows learners to work in groups during practical lessons.			13 (17.8%)	31 (42.5%)	29 (39.7%)	4.219	.731
Teacher gives learners immediate feedback when they need directions to proceed.			2 (2.7%)	46 (63%)	25 (34.2%)	4.315	.524
Teacher organises group Work during lessons in class	9 (12.3%)	0	30 (41.1%)	13 (17.8%)	21 (28.8%)	3.507	1.260
Teacher denies learners the opportunity to handle every equipment in the laboratory			23 (31.5%)	26 (35.6%)	24 (32.9%)	4.014	.808
Teacher involves lab assistant in setting up the practical activities			31 (42.5%)	26 (35.6%)	16 (21.9%)	3.795	.781
Grand mean: 3.982							

Source: Field survey, 2022

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From Table 4.5, in order to determine teachers understanding of instructional activities in chemistry lessons, a Likert scale of 1-5 (where N=Never, R=rarely, S=sometimes, MO=most often, and A=always) was used to rate the items. There were twenty (20) items under instructional activities in Chemistry lessons.

The results from the majority of the respondents accepted that learners were involved in the teaching and learning process, teachers supervised learners during practical, teachers allowed learners to work in groups during practical lessons and teachers gave learners immediate feedback when they need directions to proceed. Also, results of the majority of the respondents indicated that teachers denied learners the opportunity to handle every equipment in the laboratory, learners were assessed based on the objectives of the concepts in the chemistry curriculum, learners copy notes during the instructional process, learners were assessed before, during and after instruction and teachers exposed learners to science equipment during practical. Again, results of the majority of the respondents indicated that learners were regularly examined through exercises, quizzes, assignments and projects, teachers guided learners on how to write report about experiment, teachers focused more on theory than practical in chemistry lessons and teacher demonstrated experiments before learners carried out any assigned tasks.

However, the results of the majority of the respondents did not accept that the teacher used different resources like pictures, videos and realia. Learners were involved in establishing rules and procedures, the teachers facilitated learners' own inquiry and adequate time for advanced preparation using the required chemistry curriculum resources. Also, results of the majority of the respondents did not accept that teacher organised group work because there is inadequate equipment, all the concepts were

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taught as required by the chemistry curriculum and teachers involved a lab assistant in setting up the practical activities.

The results from the lesson observation guide have been presented using the lesson observation guide

The lesson observed was Hybridization.

Objective: The teacher did not share the objectives with students.

Lesson Introduction: The teacher introduced the topic based on students' relevant previous knowledge and captured their attention.

Lesson Presentation: The teacher took the central role in presenting the subject matter, providing explanations and examples.

Core Points: Throughout the lesson, the teacher emphasized core points making it easier for students to identify the most important concepts.

Use of Teaching and Learning Resources: The teacher did not use any teaching and learning resources.

Mastery of Subject Knowledge: The teacher provided accurate and comprehensive explanations to the students.

Mastery of Pedagogical Knowledge: The strategy used was not effective pedagogical skills in ensuring active student participation and better understanding of concept

Assessment of Student Learning: The teacher used question and answer method to assess the lesson.

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Management of the Learning Environment: Maintaining order and discipline in the classroom was essential, with the teacher responsible for setting and enforcing rules and expectations.

Student Participation: Student participation was limited. Most interactions were initiated by the teacher during questions and answers sessions.

Use of Language: The communication was good. The teacher used clear language and avoided jargons.

Use of Whiteboard: A whiteboard was often used to illustrate key points, diagrams and enhanced the clarity of the presentation.

Pace of the Lesson: The teacher controlled the pace, ensuring that the lesson progressed smoothly and that students could follow the content.

Lesson Closure: The lesson concluded with a recap of key points and what students could expect in the next session.

The lesson observed was States of Matter.

Objective: The teacher did not share the objectives with students.

Lesson Introduction: The teacher introduced the topic based on students' relevant previous knowledge

Lesson Presentation: The teacher presented the subject matter by providing explanations.

Core Points: The teacher summarised the main ideas in the lesson.

Use of Teaching and Learning Resources: The teacher did not use any teaching and learning resources.

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Mastery of Subject Knowledge: The teacher provided comprehensive explanations to the students.

Mastery of Pedagogical Knowledge: The strategy used was not effective pedagogical skills in ensuring active student participation and better understanding of concept

Assessment of Student Learning: The teacher used question and answer method to assess the lesson.

Management of the Learning Environment: The teacher ensured discipline in the class during the instructional process.

Student Participation: Student participation was limited. Most interactions were initiated by the teacher during questions and answers sessions.

Use of Language: The teacher communicated effectively using clear language.

Use of Whiteboard: A whiteboard was often used to illustrate key points and diagrams.

Pace of the Lesson: The teacher controlled the pace, ensuring that the lesson progressed smoothly and that students could follow the content.

Lesson Closure: The lesson concluded with a recap of key points and what students could expect in the next session.

Another lesson observed in a different school was on Alkanes

Objective: The teacher did share objectives with students

Lesson Introduction: The teacher introduced the lesson and explained the relevance of the concept.

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Lesson presentation: The teacher performed the task or explained the concept, offering step-by-step clear explanations and using the models. Students attentively watched and took notes. They had the opportunity to ask questions as they observed.

Use of Teaching and Learning Resources: The teacher incorporated models to make the concept more tangible for students.

Mastery of Subject Knowledge: The teacher had better understand of the subject matter and effectively solved any questions or concerns related to the concept.

Mastery of Pedagogical Knowledge: The students were not actively engaged in performing tasks to improve understanding. The teacher only demonstrated how alkanes were formed using models.

Assessment of Student Learning: The teacher assessed student learning through questions.

Management of the Learning Environment: The teacher ensured that the classroom was conducive and safe for learning.

Student Participation: The approach was primarily teacher-centred. The students participated in the lesson through questions and answers.

Use of Language: Effective communication was key, as the teacher used clear and concise language to explain the concept

Lesson Closure: The lesson ended with a summary of what was learned

One laboratory practical lesson was observed on Volumetric analysis

Objective: The objective of this laboratory practical lesson was shared with students.

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Lesson Introduction: The question was read to the students.

Lesson Presentation: The teacher formed groups of five members each. Each group was provided with the equipment and materials necessary to conduct their experiment. The students carried out the titration and got the end point.

Core Points: The teacher wrote the relevant key ideas on whiteboard.

Use of Teaching and Learning Resources: Given the limited equipment, the teacher provided guidance on how to use available resources effectively.

Mastery of Subject Knowledge: The teacher possesses up-to date knowledge on the scientific concept being explored.

Mastery of Pedagogical Knowledge: The teacher facilitated the practical session, ensured that groups were on right track, addressed questions, and guided the learning process effectively.

Assessment of Student Learning: Students worked cooperatively to carry out the task.

Management of the Learning Environment: The teacher ensured that the laboratory setup was safe and conducive for group work. Attention was given to maintaining safety protocols while allowing students to collaborate effectively.

Student Participation: Students worked collaboratively in groups to follow instructions and conducted experiments and made decisions collectively.

Use of Language: The teacher encouraged clear and respectful communication between group members and provided guidance when needed.

Use of Whiteboard: The whiteboard was used for a brief explanation of experimental procedures and key points.

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Pace of the Lesson: There was sufficient time for the practical group work and determination of the end point.

Lesson Closure: The lesson ended with students cleaning their work areas and they were asked to present their reports the following day.

Summary of the findings

The findings among students and teachers about instructional activities organised by teachers during chemistry lessons revealed that there were involvement of learners in the instructional process and teachers supervised practical sessions where learners worked in groups but learners did not get opportunity to handle all laboratory equipment. Learners were assessed before, during and after instruction and immediate feedback were provided by teachers. Also, learners were exposed to a range of assessment methods, from exercises to projects and aligning assessments with curriculum objectives. In addition, teachers guided learners in writing experiment reports and demonstrated experiments prior to learners' execution. There were noted emphasis on theory lessons over practical lessons in the chemistry lessons and learners copy notes during the instructional process.

The findings also revealed that inadequate time for advanced preparation using the required chemistry curriculum resources, teachers did not use different resources like pictures, videos and realia, and learners were not involved in establishing rules and procedures during the instructional process. In addition, the teachers did not facilitate learners' own inquiry and group work during theory lessons. Also, all the concepts were not taught as required by the chemistry curriculum and teachers did not involve laboratory assistants in setting up the practical activities.

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The findings indicated that lessons observed were typical teacher-centred. The focus of the lessons were on the transmission of knowledge from the teacher to the students, with limited opportunities for students' active participation in the learning process. Evaluations were teacher-driven, and the pace of the lessons were determined by the teacher. The lessons did not foster interactive learning environment that accommodates diverse learning styles and promotes critical thinking. In the observed practical lesson, the development of the process skills was hampered due to the limited equipment. Every student did not get opportunity to manipulate the equipment, collect data and carried out his/her experiment.

4.5 Research Question 4: What monitoring strategies were designed to enhance the classroom implementation of the chemistry programme?

The analysis of responses of HODs science and assistant heads in-charge of academics about monitoring strategies in chemistry curriculum implementation are presented:

The fifteen assistant heads responsible for academics indicated that lesson observations in the classroom for chemistry teachers were conducted once per semester. The other six assistant heads do not take part in classroom observations. The lesson observations were conducted by the HODs science. These observations were used to assess the instructional methods, management of classroom activities, and the effectiveness of classroom assessment, assessing student engagement levels and knowledge of subject matter by the teacher.

The officers in-charge of the classroom observations indicated that teachers observed were provided with feedback using a structured rubric that assessed various aspects of teaching, such as instructional delivery, classroom management, student engagement, assessment strategies and subject matter knowledge

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The twenty-one HODs science indicated that performance of students in internal examinations and WASSCE were normally discussed during departmental meetings. The teachers normally strategized based on the difficulties identified and planned relevant intervention to address the concern. All the assistant heads responsible for academics analysed and led the discussions on students' performance after semester results and WAEC results during staff meetings. Teachers were invited to express their ideas on the students' performance and the way forward.

HODs science indicated that there were no officials from the Ministry of Education or NaCCA who visited the selected schools to check the effectiveness of the chemistry curriculum implementation. The assistant heads responsible for academics also pointed out the same views.

Summary of the findings

The findings revealed that majority of the assistant heads for academics and a few HODs science conducted lesson observations once in the semester. The observation focused on instructional methods, management of classroom activities, and the effectiveness of classroom assessment, assessing student engagement levels and knowledge of subject matter by the teacher. Then feedback provided for the teachers who were observed in the classrooms implementing the chemistry curriculum.

Also, the findings revealed that the assistant heads for academics and HODs science normally analysed semester and WASSCE performance of students' and planned strategies to address problems identified.

Furthermore, the findings revealed that no official from MOE or NaCCA visited the selected schools to ensure compliance of the chemistry teachers with the curriculum prescriptions.

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4.6 Research Question 5: What personnel capacity-enhancing activities were organised for the teachers?

The descriptive analysis of responses of teachers about personnel capacity-enhancing activities in chemistry curriculum implementation are presented in Table 4.6.

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Table 4.6: Personnel Capacity-Enhancing Activities in Chemistry Curriculum Implementation

Statements	N	R	S	MO	A	Mean	Standard Dev.
There is in-service training on the chemistry related areas for teachers	10 (13.7%)	32 (43.8%)	31 (42.5%)			2.288	.697
The teacher undertakes upgrading course in chemistry education	2 (2.7%)	18 (24.7%)	31 (42.5%)	19 (26%)	3 (4.1%)	3.041	.889
The teacher undertakes observational visits to other schools on chemistry issues.	20 (27.4%)	18 (24.7%)	32 (43.8%)	3 (4.1%)		2.247	.910
There is peer observation as part of the formal school arrangement.	5 (6.8%)	17 (23.3%)	38 (52.1%)	10 (13.7%)	3 (4.1%)	2.849	.892
There is individual teacher or team research on chemistry issues of interest at the school	8 (11%)	7 (9.6%)	48 (65.8%)	10 (13.7%)		2.822	.805
There is professional development sessions in the school where teachers share innovative ideas related to teaching and learning of chemistry concepts.	13 (17.8%)	38 (52.1%)	22 (30.1%)			2.123 .	.686
The teacher participates in network of chemistry social media platform to share ideas on chemistry related issues	5 (6.8%)	14 (19.2%)	31 (42.5%)	23 (31.5%)		2.986	.890
The teacher receives incentive for taking part in professional development activities that take place outside regular school hours.	20 (27.4%)	31 (42.5%)	20 (27.4%)	2 (2.7%)		2.055	.815
The professional development sessions conflict with the work schedule of the teacher.	21 (28.8%)	3 (4.1%)	44 (60.3%)	5 (6.8%)		2.452	.987
The teacher personally pays for professional development outside the school.	10 (13.7%)	7 (9.6%)	16 (21.9%)	20 (27.4%)	20 (27.4%)	3.452	1.354
Grand mean: 2.632							

Source: Field survey, 2022

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From Table 4.6, in order to determine teachers understanding of personnel capacity-enhancing activities in chemistry curriculum implementation, a Likert scale of 1-5 (where N=Never, R=rarely, S=sometimes, MO=most often, and A=always) was used to rate the items. There were ten (10) items under personnel capacity-enhancing activities in chemistry curriculum implementation.

The results of the majority of the respondents accepted that the teachers undertook upgrading course in chemistry education, the teachers personally paid for professional development outside the school, there was peer observation as part of the formal school arrangement, there was individual teachers or team research on chemistry issues of interest at the school and the teachers participated in network of chemistry social media platform to share ideas on chemistry related issues.

However, the results of the study from majority of the respondents did not accept that the teachers undertook observational visits to other schools on chemistry issues, there was professional development sessions in the school where teachers share innovative ideas related to teaching and learning of chemistry concepts. Again, the results from majority of the respondents did not accept that the teacher received incentive for taking part in professional development activities that take place outside regular school hours, the professional development sessions conflicted with the work schedule of the teachers and there was in-service training on the chemistry related areas for teachers.

Summary of the findings

The findings revealed that the teachers undertook upgrading course in chemistry education and personally paid for professional development outside the school. Also, teachers indicated that there were peer observation as part of the formal school arrangement and individual teachers or team research on chemistry issues of interest at

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the schools. The findings further indicated that the teachers participated in network of chemistry social media platform to share ideas on chemistry related issues.

However, findings revealed that the teachers never undertook observational visits to other schools on chemistry issues and there were no professional development sessions in the schools where teachers share innovative ideas related to teaching and learning of chemistry concepts. Again, findings also revealed that the teachers did not receive incentive for taking part in professional development activities that take place outside regular school hours. In addition, the professional development sessions conflicted with the work schedule of the teachers and teachers did not attend in-service training on the chemistry related areas.

4.7 Research Question 6: In the view of the teachers and students, what are the challenges to the effective classroom implementation of the chemistry curriculum? Teachers' views on the challenges of the effective classroom implementation of the SHS chemistry curriculum from the interview responses have been put into thematic areas and analysed accordingly.

Overloaded Chemistry Content

Sixty-three (86%) of the interviewees were of the view that the chemistry curriculum was overloaded with too many content information. Teaching all the content effectively to achieve the learning objectives was difficult and also limited learners' opportunity to develop critical thinking. Teachers sometimes rushed through the instructional process to enable them complete the curriculum. This may have led to learners not fully understanding the concepts and skills taught. This made implementation of the chemistry curriculum difficult.

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Large Class Sizes

In the views of sixty (82%) interviewees, the classes were large which made teaching and learning of chemistry difficult. They pointed out that it was extremely difficult to give individual attention during teaching and learning of concepts in chemistry. Learners sometimes find it challenging to understand chemistry concepts when they do not have access to individualised attention and support. Learners with different learning styles were not always considered.

Eight (11%) interviewees claimed that large class size posed problem in terms of providing adequate laboratory space, equipment and materials for every learner to conduct experiments. This resulted in some learners being unable to participate in certain activities or having to share equipment. It was difficult to complete experiments in a timely manner. This usually led to inadequate time for follow-up discussions.

Inadequate Chemistry Teachers

Thirty six (49%) of the interviewees also raised concern about the need for highly qualified and required number of chemistry teachers to handle learners in the instructional process. Science teachers including that of chemistry seemed to be in short supply. The chemistry teachers teach many classes in the week. They claimed the need to encourage teachers to work in the sciences including chemistry should be intensified across at all levels.

Inadequate Instructional Resources

Forty (55%) interviewees expressed concern regarding inadequate resources such as laboratory equipment and chemicals. In the absence of right and adequate tools and materials, it was difficult to create engaging and effective lesson plans especially activity-oriented lessons. The physical conditions in some chemistry laboratories were

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not suitable for effective teaching and learning process. In the words of twenty-two (30%) interviewees, the laboratories in the schools were not equipped with fittings that can be used for practical activities. There were laboratories without proper sinks and fumes. Some laboratories have serious renovation need. Four (5%) of the interviewees indicated that inadequate instructional resources limit the use of a variety of teaching and learning methods. There was no information technology equipment to assist in teaching and learning of chemistry.

Inadequate Practical Activities

Sixty- seven (92%) interviewees were of the views that hands-on chemistry education seems to be in short supply in the senior high schools. They indicated that they were eager to conduct lots of activities in chemistry instruction to encourage active learners' involvement in the lessons. However, shortage of equipment and materials negatively affect their ability to organize practical activities. The interviewees indicated that it was necessary to make lessons learned centred to promote acquisition of scientific skills. This can be done mostly with adequate practical activities.

In classes where chemistry was being taught, too much of it seems limited to lectures based on textbooks. The relevance of experiments comes from observing those variations in experimental results and relate it to those indicated by theory. It seems that chemistry instruction was based on imparting knowledge and the learners use the knowledge to answer some pre-defined questions. Learners are expected to use chemistry knowledge to answer their own questions.

Insufficient Number of Periods on the Timetable

Forty- two (48%) of the interviewees claimed the insufficient number of periods limited the amount of time teachers have to cover all the necessary topics. The teachers were

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often forced to rush through important concepts due to the limited amount of time available. Practice and review of concepts does not occur regularly. This made the situation difficult for learners to understand and apply the concepts. The lessons allocated to teaching and learning of chemistry do have theory and laboratory practical indicated on the timetable. This made the teachers to use their own discretion on when to teach theory and organise laboratory practical. Classroom timetables were fixed.

However, a lot of events were conducted inside or outside the schools. This reduced the time for learners to study chemistry.

Six (8%) of the teachers expressed worry about the arrangement of subjects on the timetable negatively affect teaching and learning of chemistry. Learners cannot concentrate on chemistry lessons taught after sports lessons. They look exhausted and lose their attention. Nine (12%) interviewees also pointed out that in some cases, learners have to learn Mathematics followed by chemistry. Learners become tired and do not want to study anymore.

Pressure of External Examination like WASSCE

Sixty (82%) of the interviewees conceded that passing WASSCE was one key reason for using particular strategy in the instructional process. The national examinations emphasize on scores. There was increase in the level of competition among senior high schools in relation to the WASSCE. Interviewees pointed out that they taught in a way that assisted learners pass at least the minimum level. This helped the learners to further their studies. The life skills were not assessed in the examinations.

Inadequate Infrastructure

In the views of fifty-six (77%) respondents, laboratory experiments and hands-on activities were essential components of chemistry curriculum implementation. Many

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schools, however, lack well-equipped laboratories and materials for undertaking practical work, restricting students' hands-on experience and understanding of scientific principles.

In the words of three (4%) respondents, fume cupboards and safety equipment were essential in chemistry laboratories. However, some schools lack these which can lead to unsafe working circumstances that threaten both students and staff.

In the views of three (4%) respondents, some schools have infrastructure for teaching and learning of chemistry, however the facilities were not well-maintained. This can threaten students and teachers' lives and diminish the usefulness of the facilities.

A total of two (3%) indicated that poor lighting and ventilation in classrooms can have a negative impact on both teachers' and students' health and well-being. Poor lighting can cause eye strain and headaches, while poor ventilation might cause respiratory difficulties and decreased concentration.

Insufficient In-service Training

Forty-six (63%) of the interviewees claimed that the issue of required support needed for implementing the chemistry curriculum was not readily available. There was no regular tailored in-service training on chemistry concepts. There was no in-service training on how to carry out some experiments as indicated in the chemistry curriculum. Participation in in-service training was not compulsory for chemistry teachers. Some chemistry teachers do not have up-to-date knowledge and skills when delivering chemistry lessons.

Twenty-one (29%) of chemistry teachers stated that they would like to participate in an in-service training program on difficult chemistry concepts like redox reactions and organic reactions.

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Inadequate Chemistry Textbooks

Eighteen (25%) of the interviewees said most textbooks in their schools were not adequate. Learners shared textbooks and others bought their own textbooks. It was difficult to ensure whether learners were learning the most up-to-date and accurate information. Without current textbooks, learners may be studying outdated or incorrect information. This may cause misunderstandings and affect learners' ability to learn and apply new concepts

Five (7%) interviewees indicated that some textbooks did not cover all of the required topics on the chemistry curriculum. As a result, learners do not get the required knowledge for future learning.

Other four (5%) of the interviewees said inadequate current textbooks made it difficult for learners to access the resources they need to learn effectively. Learners sometimes do not appreciate the relevance of the subject matter to their lives or the world around them.

Inadequate Funding to Buy needed Items

Fifty-one (70%) of the interviewees claimed there were inadequate funding to buy the necessary equipment and materials. Teachers were not able to provide effectively learning experience required in the implementation of the chemistry curriculum. This generally limited learners' understanding of chemistry concepts and reduced their interest in pursuing science-related fields.

Three (4%) of the interviewees said the learners have limited opportunities for experimentation as a result of non-availability of fund. Hands-on experimentation was critical component of teaching chemistry.

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Seventeen (23%) of the interviewees claimed that they did not have access to the resources for effective implementation of the chemistry curriculum. This sometimes made them frustrated which have impacted on their job satisfaction and morale.

Inadequate Teachers' Remuneration

Forty (55%) of the interviewees expressed reservations about teacher remuneration which hampered the ability to attract and maintain qualified chemistry teachers. Experienced teachers sometimes leave the profession to seek employment elsewhere. This resulted in the loss of valuable knowledge and expertise in the classroom. Some chemistry teachers often leave their teaching position in search of better-paying opportunities, leaving their learners with inconsistent instruction and disrupted learning experiences. Without adequate compensation, teachers find it difficult to pursue professional development opportunities which can limit their ability to improve their teaching skills and provide effective instruction to learners.

Another seventeen (23%) interviewees stated that inadequate remuneration led to reduced motivation among teachers. When teachers felt they were not being adequately compensated in the teaching profession, they become demotivated which affected implementation of the chemistry curriculum. When teachers felt undervalued and underpaid, it impacted adversely on their overall job satisfaction and morale. This affected learner learning experiences negatively.

Inadequate Qualified Chemistry Technicians

Forty-four (60%) of the interviewees stated that laboratory technicians were inadequate in many schools. In some schools, one laboratory technician was responsible for preparing practical set up for chemistry, physics and biology. In other schools, there were no technicians and the chemistry teachers carried out the additional

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workload. Inadequate maintenance of equipment as a result of inadequate qualified chemistry technicians. This led to potential safety hazards and decreased effectiveness of laboratory experiments.

Lack of Sponsorship for Further Studies

In the words of fifty-three (73%) interviewees, the chemistry teachers further their education using loans from banks. Teachers who have taught over a decade in their schools did not get any financial assistance when the decided to further their education. It was extremely difficult for many chemistry teachers to get study leave to further their education from the government. When teachers were unable to continue their studies in chemistry due to a lack of sponsorship, they sometimes pursued other careers or relocated to other countries where sponsorship for chemistry education was available. This resulted in a brain drain in chemistry and a shortage of qualified chemistry teachers. Chemistry teachers may not be able to provide their learners with the most up-to-date information and techniques.

Students' Lack of Interest and Motivation

Twelve (16%) of the interviewees claimed that learners' behaviour including laziness, and truancy were among factors that impeded the implementation of chemistry curriculum. The learners were not interested in doing assignments by themselves but would rather copy from friends who had done the assignments. Sometimes, the teachers gave a take-home message relevant to the lesson and ask them to think about it and come back to discuss this again in the next lesson, but it seems this strategy was not working properly. Some learners come back to the next lesson with nothing

Two (3%) of the interviewees said some learners cannot apply what they had learnt previously and teachers spent hours to teach the concepts for better understanding. The

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readiness of some of the learners were questionable. Learners with low learning ability who got frustrated were also seen as an issue. Learners who cannot concentrate for a whole lesson was also raised.

Three (4%) of the interviewees indicated the learners just want to finish senior high school and get a job in order to get money to buy smart phones and other gadgets. Learners want to have a lot of money to heighten their social status. Learners think they could earn a living without any high academic qualification.

Two (3%) of the interviewees claimed some learners did not like to think and solve challenging tasks. The learners answer easy tasks assigned by the teachers very well. However, learners struggle to deal with tasks that required creativity and logical reasoning

Issue of School Organisation and Management

Six (8%) of the interviewees were engaged in administrative works which sometimes shift their focus from planning teaching activities to doing administrative duties. They carried out duties such as typing formal letters to parents to collect money in order to conduct certain school activities and purchasing schools' equipment. The teachers sometimes were engaged in extra-curriculum activities like sports and games, singing competition which affected mandatory lesson periods. The teachers then compelled learners to have an extra class in order to prepare them for an exam.

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Students' views on the challenges of the effective classroom implementation of the SHS chemistry curriculum from the focus group interview responses have been put into thematic areas and analysed accordingly.

Inadequate Educational Materials

Inadequate educational materials were one of the issues that hampered chemistry curriculum implementation. The one hundred and seventy-five (96%) respondents stressed on the fact that educational materials in their schools were inadequate. Inadequate educational materials, according to the learners, had a detrimental impact on the teaching and the students' comprehension. When learners do not have access to the appropriate materials, they may not understand the subject being taught, which can lead to poor examination results.

Inadequate Practical Lessons

Practical lessons aid learners' comprehension of abstract concepts. One hundred eighty-three (100%) of the respondents indicated that practical sessions were not held on a regular basis at the schools. In some schools, practical lessons began in the second year. Other schools began their practical lessons in the third year. Some learners stated that the majority of the practical work was outlined in a textbook and they simply followed the step-by-step guidelines in the textbook. Students may not have enough opportunities to experiment and learn new scientific facts. It was difficult to apply chemistry concepts to real-world problems and learning of critical abilities by learners.

Too much Chemistry Curriculum Content

The chemistry curriculum contained too much information for students to study for the three years. One hundred and five (57%) of the respondents claimed that the teachers were obliged to speed through topics when there were too much concept to teach. The

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teachers were sometimes pushed to prioritize certain topics above others, resulting in an uneven distribution of time and effort. Students sometimes merely scrape the surface of a concept, missing out on the potential to completely comprehend it.

A total of seventy- five (41%) respondents said that students were presented with an excessive amount of knowledge and struggle to remember what they have learned. Learners may become obsessed with memorizing concepts rather than developing long-term abilities. It may be difficult to make changes to accommodate individual learners or respond to changes in the learning environment because the chemistry curriculum was overloaded with content. As a result, teaching and learning practices that do not satisfy the requirements of all learners may emerge.

Inadequate Infrastructure

One hundred and forty-nine (81%) respondents claimed there were no well-equipped laboratories to conduct experiments and learn practical skills. This limited the scope and quality of experiments which reduced the effectiveness of the chemistry curriculum implementation. A total of two (1%) respondents pointed that insufficient classroom space made it harder for learners to learn properly. Large class sizes in tiny classrooms made the setting noisy and crowded which made it difficult for students to concentrate and learn.

Inadequate Current Chemistry Textbooks

Respondents of fifty-five (30%) students stressed that the scarcity of updated textbooks can make it difficult for students to have access to the information they require to learn properly. This might be especially problematic for students who live in remote regions or who do not have access to the internet. Textbooks may not cover all of the required

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topics or may not offer up-to-date information on the concepts. As a result, students may overlook critical information and be unprepared for future learning.

Ineffective Teaching Methods

Chemistry teachers must not only impart knowledge to students, but also plan chemistry classes differently. The respondents of one hundred and twenty (66%) students reported that they were overwhelmed by the teacher-centred approaches used to teach the chemistry concepts. This situation was more for final year students who were prepared in exam-oriented classroom drills. Students were pressured to memorize an excessive number of facts to prepare students for WASSCE. Some teachers, especially those with long term teaching experiences were strongly attached to their preferred teaching strategy and resist change. They feel unhappy to implement it and were still attached to the same old teaching style.

Influence of External Examinations like WASSCE

Respondents of one hundred and seventy (93%) reported that external examinations like WASSCE put a lot of pressure on both teachers and students. This pressure can emerge in a variety of ways, with both positive and negative consequences for learning outcomes. External examination was one of the difficulties faced by students. This was particularly challenging in chemistry education where students must be able to apply their knowledge in real-world circumstances and think critically about complicated scientific challenges. The stress of external exams might lead to students prioritizing test preparation over other vital parts of learning such as hands-on experimentation, inquiry-based learning, and student-led projects. This can limit students' chances of pursuing their own interests and engaging in creative problem-solving, both of which are required for success in chemistry and science related areas.

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Insufficient Time to cover Chemistry Curriculum

A total of one hundred and fifty (82%) respondents expressed worry about insufficient time to study and understand the chemistry concepts in the curriculum. The teachers also struggled with not having enough time to cover chemistry curriculum. Teachers were unable to go into more depth on specific topics or provide more hands-on learning opportunities as a result. It was impossible to cover all of the necessary chemistry content in the few hours per week. School holidays and co-curricular activities such as sports and games, debates also reduced the instructional time.

Inadequate Funding to Buy needed Items

One hundred and thirty (71%) respondents indicated that schools cannot afford to buy chemicals and lab equipment due to insufficient funds. Chemistry requires practical work to reinforce theoretical concepts and without the necessary equipment and supplies, practical sessions were limited. The respondents sometimes were unable to acquire adequate hands-on laboratory experiences. The shortage of hands-on experience resulted in reduced interest in certain concepts in chemistry.

Large Class Sizes

In the views of one hundred and forty (77%) respondents, the large number of learners in the class was problematic because the teachers found it difficult to control them. It was difficult for a teacher to give each learner individual attention. Learners have unanswered questions of the class. Students in a large class find it difficult to actively engage in the learning process, ask questions, and participate in discussions. This can result in improper understanding of concepts. It was difficult to assess each student's comprehension of the concept. Resources like lab equipment and materials were not sufficient for the students. Marking and grading of exercises, homework and examinations took significant amount of time and effort.

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Insufficient Trained Chemistry Teachers

The respondents numbered seventy (38%) expressed concern that there were shortage of chemistry teachers which accounted for fewer qualified teachers to teach chemistry content. Teachers were overloaded with lessons to be taught in chemistry. The teachers were trying hard to cover the work that was supposed to be done in each form. Many chemistry teachers may leave the profession due to the difficulties of teaching chemistry, resulting in a shortage of experienced chemistry teachers.

Inadequate Qualified Chemistry Laboratory Technicians

The scarcity of qualified chemistry laboratory technicians in teaching and learning chemistry was a source of concern. Respondents of one hundred and ten (60%) reported that laboratory technicians play an important role in chemistry teaching and learning because they were in charge of preparing laboratory experiments and ensuring that they were carried out safely and accurately. Inadequate chemistry laboratory technicians required chemistry teachers to spend more time preparing and setting up experiments, which may take away from valuable instructional time. Furthermore, chemistry teachers may be less able to provide students with individualised support during experiments, limiting students' opportunities to learn through hands-on exploration. Due to a lack of trained professionals to guide them, students may be unable to conduct experiments safely. This can have a negative impact on their understanding and appreciation of chemistry, leading to a decrease interest in science-related careers. A lack of laboratory technicians can increase the risk of accidents or incidents in the laboratory, raising safety concerns for students and teachers.

No Meaningful Link between Chemistry Content and Industries

According to sixty-seven (37%) respondents, one of the challenges associated with chemistry curriculum implementation was no productive links between industries and

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chemistry content. Chemistry has a lot of real-world application so students need to see how it relates to the world around them. However, without links to local industries or businesses, it can be difficult to provide students with real-world examples of how chemistry is used in the workplace. This can make it harder to engage students and help them understand the relevance of the concept. Students may not see the value in learning about chemistry if they do not see the practical applications of scientific concepts and discoveries.

Ineffective Assessment Techniques

Sixty (33%) said assessments that only test students' knowledge of concepts but usually fail to assess important skills such as critical thinking, problem solving, and communication. Individual differences in learning styles, abilities, and needs were not taken into account in assessments designed to be uniform across all students in a class. Such tests may not accurately assess what students have learned or their potential for future learning. Timed tests put students under pressure to perform quickly, which may not reflect their true understanding of a concept. Some tests require students to answer a large number of questions quickly. These types of tests can be stressful for students and may not accurately assess their knowledge of the concepts.

Inadequate Chemistry Teachers' Remuneration

Fifty-five (30%) interviewees indicated that chemistry teachers who were underpaid became demotivated to give their all in the classroom. This could lead to poor teaching quality, which could have a negative impact on student learning outcomes. It could disrupt the flow of teaching and learning, leaving students without the necessary foundation for future studies. The challenge can limit opportunities for professional development for chemistry teachers to stay current with the latest developments for effective instructional process. The issue of inadequate teacher compensation also

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account for difficulty in recruiting adequate qualified chemistry teachers. This is especially problematic in rural and underserved areas.

Inadequate ICT tools

Ninety-five (52%) claimed students have limited access to ICT tools. The vast amount of information available on various chemistry topics on the internet cannot be studied. This can lead to inadequate scientific knowledge. Students said multimedia presentations, simulations, and virtual laboratories were examples of ICT tools that can make chemistry teaching and learning more interactive and engaging. ICT tools can help teachers assess student learning and progress by providing valuable data to inform their instruction.

Summary of findings

The findings of challenges of chemistry curriculum implementation identified by both teachers and students involved in the study were overloaded chemistry content, large class sizes, inadequate chemistry teachers, inadequate instructional resources, inadequate practical activities and insufficient number of periods on the timetable. Again, they pointed other challenges such as pressure of external examination like WASSCE, inadequate infrastructure, insufficient in-service training, inadequate chemistry textbooks, inadequate funding to buy needed item, inadequate teachers' remuneration and Inadequate qualified chemistry technicians.

The teachers indicated other challenges that were not mentioned by the students. The challenges include lack of sponsorship for further studies, students' lack of interest and motivation and Issue of school organisation and management. On the other hand, the students involved in the study also revealed other challenges that were not mentioned by the teachers. The challenges include ineffective teaching method, no meaningful link

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between chemistry content and industries, ineffective assessment techniques and inadequate ICT tools.

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CHAPTER FIVE

DISCUSSION

5.0 Overview

This chapter presents a detailed analysis of the findings from the study. The results are organised thematically, with each theme corresponding directly to a particular research objective or question, allowing for a structured and coherent examination of the data.

5.1 The extent to which the chemistry teachers were academically and professionally qualified to teach the subject chemistry

The findings indicated that while most teachers possessed specialised knowledge in chemistry, some were delivering the chemistry curriculum without the necessary qualifications in the subject. Ensuring that only adequately qualified teachers handle chemistry instruction is essential for achieving the desired educational outcomes. This aligns with Van Heijden et al. (2015), who emphasised that teachers are key participants and agents of change in the educational process. Clearly, teachers play a pivotal role, as they are directly responsible for implementing educational reforms. Consequently, overlooking the significant influence teachers have on reform initiatives may negatively affect the overall success of curriculum implementation (Fullan, 2007).

Furthermore, most teachers possessed professional qualifications, reflecting a strong foundation of professional knowledge relevant to their teaching responsibilities. This finding aligns with Darling-Hammond (2006), who argued that pedagogical knowledge should be central to teacher education programs and emphasised the need to cultivate teachers' expertise in instruction, assessment, and understanding student learning. However, a few teachers held only diplomas or other lower-level professional certifications. This contrasts with the perspective of Seweje and Jegede (2005), who

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asserted that a teacher's effectiveness is not determined solely by academic credentials but rather by the exceptional pedagogical skills they have developed.

The findings also showed that the teaching staff were largely experienced, with a considerable number having more than six years of teaching experience, while a smaller segment had less than six years. This observation is consistent with Wang and Cheng (2005), who noted that among the various factors influencing curriculum implementation, a teacher's qualifications and experience—shaped by their training and skills—are likely the most critical determinants.

5.2 The financial, material and infrastructural resources available for implementing the chemistry curriculum

From the perspectives of both students and teachers, the study's findings offered important insights into the accessibility and adequacy of resources and facilities for teaching and learning chemistry in senior high schools.

The findings from both students and teachers regarding the assessment of resources for teaching and learning chemistry revealed a strong alignment in their perspectives. The study indicated that schools had dedicated laboratories for chemistry practical, and textbooks such as *GAST Chemistry for SHS* were generally accessible. However, several challenges were identified, including insufficient equipment and facilities, limited access to science materials, delays in funding for resource procurement, and the need to borrow resources from other schools. Additionally, school libraries contained few chemistry reference materials, and there was no consistent provision of equipment and materials from the Ministry of Education and the Ghana Education Service. These observations contrast with Yidana and Aboagye (2018), who emphasised that adequate and appropriate resources—including facilities, equipment, and supplies—are essential

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for effective curriculum implementation. Similarly, Carless (1997) highlighted that one of the reasons the original piloting of the Target-Oriented Curriculum in Hong Kong was unsuccessful was the lack of teaching resources; teachers were not provided with sufficient instructional materials or non-contact time to adequately prepare their lessons.

Similarly, Makunja (2016) reported that teachers in Morogoro Municipality, Tanzania, struggled to implement curriculum reforms due to a lack of adequate teaching and learning resources. However, the mere provision of resources does not guarantee their effectiveness; if resources do not align with the principles of the intended change, they may be perceived as irrelevant. This aligns with Ottevanger (2001), who argued that high-quality curriculum materials can serve as valuable support for teachers during the initial stages of implementation, helping them to plan and conduct learner-centred lessons effectively. Likewise, research in Botswana by Thijs (1999) found that well-designed curriculum materials could help teachers overcome initial apprehensions and motivate them to experiment with learner-centred teaching methods, providing new strategies to enhance student engagement in lessons.

The document analysis revealed that all the schools involved in the study had the chemistry curriculum and textbooks available, with some teachers possessing hard copies while others used digital versions. Students primarily relied on textbooks as their main source of the curriculum. However, teachers did not consistently prepare lesson plans as prescribed by the curriculum; instead, they relied on teaching notes that focused mainly on topics assessed by the West African Examinations Council (WAEC). While theoretical aspects of elective chemistry were included in the timetables, practical lessons were often absent. Students' exercises mainly targeted knowledge and

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comprehension, and their performance on application-based tasks was generally below average, indicating a misalignment between the exercises and the curriculum objectives. All schools had infrastructure such as classrooms and laboratories, but the availability of chemicals and other resources necessary for practical lessons was limited. Some schools provided practical books for students to record their experimental findings, as required by the curriculum, while others did not, resulting in no formal record of practical work. Overall, the chemistry curriculum prescriptions were not consistently implemented across the schools.

This situation does not align with the CRDD (2010) chemistry curriculum, which stipulates that teachers should carefully sample objectives within units and sections to design assessments that accurately reflect the relative importance of the skills taught in class. Teachers are also expected to assign tasks and exercises that challenge students to apply their knowledge to real-world problems, fostering problem-solving abilities and promoting positive scientific attitudes. Inadequate resources can negatively impact student learning, as Asare (2010) noted that the effective use of educational resources enhances learning outcomes by both stimulating and motivating students. Kankam (2013) further emphasized that science laboratory resources can be classified as human or material. Human resources include personnel such as teachers, laboratory technologists, assistants, and students, while material resources encompass tools and equipment available to support teaching and learning, such as textbooks, computers, thermometers, fire extinguishers, first aid kits, ovens, incubators, chalkboards, models, televisions, radios, and other electronic devices.

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5.3 The instructional activities that were organised by the teacher during chemistry lessons

The purpose of this research question was to investigate the instructional activities organized by teachers during chemistry lessons. Data were collected through questionnaires administered to both students and teachers. The findings revealed the nature of teaching and learning practices employed in the implementation of the chemistry curriculum. Students were actively involved in the instructional process, and teachers supervised practical sessions where learners worked collaboratively in groups. However, students did not have the opportunity to handle all laboratory equipment themselves. Assessment occurred before, during, and after instruction, with teachers providing immediate feedback to support student learning.

Students were exposed to a variety of assessment methods, including exercises and project-based tasks. Additionally, teachers guided learners in writing laboratory reports and demonstrated experiments before students conducted them. However, there was a noticeable emphasis on theoretical instruction over practical lessons, with students primarily copying notes during class. This practice does not align with Loughran et al. (2007), who argued that pedagogical content knowledge (PCK) extends beyond simply delivering subject content and that meaningful student learning involves more than rote memorization of facts. Similarly, Schwarz and Passmore (2017) highlighted the critical role of teachers' content knowledge in helping students understand connections between scientific concepts. They emphasized that teachers must be able to identify and communicate the underlying principles that link different scientific ideas and recommended that teacher education and professional development programs focus on enhancing educators' ability to integrate and connect these concepts effectively.

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The findings further indicated that teachers had insufficient time for thorough preparation using the required chemistry curriculum resources. Various instructional materials, such as pictures, videos, and realia, were underutilized, and students were not actively involved in establishing classroom rules or procedures. Additionally, teachers did not promote student-led inquiry or collaborative group work during lessons. Not all curriculum concepts were covered, and laboratory assistants were not engaged in preparing practical activities. This situation contrasts with Michael (2006), who noted that globally, teacher-centred approaches are increasingly being replaced by learner-centred methods, which position students at the heart of the learning process and encourage full engagement. Such approaches are considered effective in improving student performance and offer measurable outcomes. The findings also support Ajayi and Fakokunde (2020), who identified inadequate instructional materials as a significant challenge, highlighting that the lack of access to models, specimens, and audio-visual aids reduces student interest and motivation in learning.

The lessons observed were predominantly teacher-centred, focusing on the transmission of knowledge from teacher to students with minimal opportunities for active student engagement. Assessments were largely controlled by the teacher, and the pace of instruction was determined by the teacher rather than the learners. The lessons did not promote an interactive learning environment that accommodates diverse learning styles or fosters critical thinking. In practical sessions, the development of students' process skills was limited due to insufficient laboratory equipment, preventing every student from manipulating materials, collecting data, or conducting experiments individually. As a result, the chemistry curriculum was not fully implemented. This aligns with Eminah (1993), who argued that when a curriculum is not executed as prescribed, teachers often perceive it as ineffective, primarily because

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the recommended procedures were not followed. According to the CRDD (2010) chemistry curriculum, teaching and learning activities should maximize student participation, emphasizing participatory methods over rote learning and drill-oriented approaches.

In line with best practices, the cognitive, affective, and psychomotor domains of knowledge should be emphasized in instructional activities wherever appropriate. Lessons should ideally begin with practical problems linked to previous lessons or new, untaught information, allowing students to analyse the problem, propose solutions, and evaluate the viability of these solutions. Such an approach is intended to cultivate students' analytical thinking and practical problem-solving skills. When designing assessment procedures for the chemistry curriculum, it is important to select specific objectives that allow evaluation of a representative subset of syllabus goals, with each objective serving as a criterion for student achievement. However, the implementation of the chemistry curriculum in the observed classrooms did not align with the prescriptions outlined in the CRDD (2010) chemistry curriculum. This contrasts with the findings of Omiko (2015), who reported that hands-on experiences foster students' spirit of inquiry and enable them to acquire scientific skills and develop the proper attitudes for handling scientific tools and materials.

These findings align with the research of Lee (2003), who critically evaluated the junior secondary science curriculum reform in Hong Kong. The reformed curriculum differed from its predecessor by emphasizing scientific investigation as a unifying theme and highlighting the practical relevance of science in everyday life. A key feature of the new curriculum was the inclusion of investigations designed to help students integrate conceptual understanding with practical skills, particularly in open-ended contexts.

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However, the implementation of this investigative approach varied significantly among teachers. As a result, student outcomes showed improvement primarily in less complex process skills, while their attitudes toward science and the curriculum declined. These results were largely attributed to inconsistencies between the curriculum planners' intentions, the design of the curriculum, and actual classroom practices.

5.4 The Monitoring Strategy to enhance Classroom Implementation of the Chemistry Curriculum

This section of the study aimed to examine the monitoring strategies employed to enhance teachers' classroom implementation of the chemistry curriculum. Findings indicated that most assistant heads for academics, along with a few heads of science departments (HODs), conducted lesson observations only once per semester. These observations primarily focused on instructional methods, classroom management, assessment effectiveness, student engagement, and teachers' subject knowledge. Feedback was provided to teachers following these observations. This approach contrasts with the findings of Bibik (2017), Grischenko (2016), and Sima (2006), who emphasised that sufficient, comprehensive, and continuous monitoring is crucial for the successful implementation of any educational program. Monitoring plays a key role in guiding the implementation of educational policies, objectives, and plans. Additionally, Marriott and Goyder (2009) highlighted that effective monitoring is an essential element of learning activities and contributes to the long-term success of educational endeavours. The assistant heads for academics and HODs of science also analysed semester and WASSCE student performance and used the results to develop strategies for addressing identified challenges.

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The findings indicated that no officials from the Ministry of Education (MOE) or the National Council for Curriculum and Assessment (NaCCA) visited the selected schools to verify that chemistry teachers were adhering to the curriculum prescriptions. This contrasts with the view of Fegan and Field (2009), who argued that monitoring systems in education serve as tools to assess the effectiveness and quality of educational programs and to provide stakeholders with relevant information.

5.5 Personnel Capacity-enhancing Activities to enhance Classroom Implementation of the Chemistry Curriculum

This section of the study focused on examining personnel capacity-enhancing activities aimed at improving teachers' classroom implementation of the chemistry curriculum. The findings showed that teachers participated in upgrading courses in chemistry education and often personally funded professional development activities outside their schools. Additionally, teachers reported that peer observation was incorporated into formal school arrangements, and that individual or team-based research on chemistry-related topics was conducted within the schools. The study also found that teachers engaged with online networks and social media platforms dedicated to chemistry to exchange ideas and share best practices. These findings are consistent with research suggesting that effective professional development programs should address teachers' specific needs. When professional development activities are designed around teachers' real-life contexts, they are generally more impactful (Harris et al., 2006; Bayar, 2014).

However, the findings revealed that teachers did not undertake observational visits to other schools to learn about chemistry teaching practices, and there were no school-based professional development sessions where teachers could share innovative strategies for teaching and learning chemistry concepts. Moreover, teachers did not

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receive incentives for participating in professional development activities conducted outside regular school hours, and such sessions often conflicted with their work schedules. Teachers also did not attend in-service training related to chemistry. These findings contrast with Nishimura (2014), who emphasised that school-based professional development is crucial for improving teachers' instructional practices. When effectively implemented, such programs help teachers identify essential resources and strategies tailored to the needs of their learners through problem-solving activities focused on real classroom challenges. Additionally, research suggests that PD programmes should reflect the specific context of each school, as linking PD activities to school needs allows teachers to see the direct relevance of the training to their own classroom situations (Sandholtz & Scribner, 2006; Starkey et al., 2009).

5.6 Challenges affecting effective classroom implementation of the SHS Chemistry Curriculum

This section of the study focused on identifying factors that influence the implementation of the chemistry curriculum by teachers and students. Overall, both teachers and students reported several challenges affecting curriculum delivery, including a heavy chemistry syllabus, large class sizes, a shortage of qualified chemistry teachers, limited instructional resources, insufficient practical activities, and a lack of adequate teaching periods in the timetable. Additional challenges highlighted by participants included the pressure of external examinations such as WASSCE, inadequate infrastructure, a shortage of chemistry textbooks, limited funding for necessary materials, low teacher remuneration, and a scarcity of qualified chemistry laboratory technicians.

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Teachers reported additional challenges not mentioned by students, including a lack of sponsorship for further studies, insufficient in-service training, students' low interest and motivation, and issues related to school organisation and management. Conversely, students highlighted other obstacles that teachers did not mention, such as ineffective teaching methods, a lack of meaningful connections between chemistry content and industry applications, ineffective assessment techniques, and inadequate ICT tools. These findings align with numerous studies in the literature, which identify various factors that hinder the effective implementation of the chemistry curriculum. Research indicates that low levels of curriculum implementation can be attributed to unqualified or insufficient numbers of chemistry teachers, limited subject knowledge, lack of laboratories, large class sizes, an overly extensive curriculum, poorly prepared science textbooks, inadequate teaching equipment and materials, low teacher motivation, inappropriate instructional methods, insufficient in-service training, and a lack of practical activities (Uzoechi, 2006; Ugwu, 2008; Ayodele, 2009; Ejidike & Oyelana, 2015).

These findings are consistent with the study by Wambua and Waweru (2019), which investigated challenges affecting the implementation of the Competency-Based Curriculum (CBC) in public primary schools in Machakos County. Their study revealed that teachers were not adequately prepared for CBC implementation and that schools faced shortages of staff, inadequate infrastructure, and insufficient teaching and learning resources. Similarly, the findings align with Musaiwa (2020), who examined the challenges of implementing the new senior secondary school chemistry curriculum in Mulanje District, Malawi. The study found that most schools lacked sufficient teaching and learning materials, including chemistry textbooks and mobile laboratories, with only a few schools adequately resourced. In terms of human resources, most

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schools experienced a shortage of chemistry teachers, although some had an adequate number.

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CHAPTER SIX

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, SUGGESTIONS FOR FURTHER STUDIES AND CONTRIBUTIONS OF THE STUDY TO SCIENCE EDUCATION

6.0 Overview

This chapter provides a comprehensive overview, presenting a summary of the findings, the conclusions drawn from the study, recommendations based on the results, and suggestions for future research.

6.1 Summary of Major Findings

- The findings indicated that most teachers possessed specialised knowledge in chemistry; however, some were delivering the chemistry curriculum without the necessary academic qualifications in the subject. In addition, the majority of teachers held professional qualifications, reflecting a strong foundation of professional knowledge relevant to their teaching responsibilities, although a few lacked such qualifications. The study also revealed that the teaching staff were largely experienced, with a significant number having more than six years of teaching experience, while a smaller proportion had less than six years
- A survey conducted among students and teachers assessed the availability of resources for teaching and learning chemistry in schools. The findings indicated that schools had dedicated laboratories for chemistry practical sessions, and textbooks such as GAST Chemistry for SHS were generally accessible. However, significant challenges were reported, including insufficient equipment and facilities and limited access to science materials.

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School libraries contained few chemistry reference materials, and there was no consistent provision of equipment and materials from the Ministry of Education and the Ghana Education Service (GES). Document analysis further revealed that teachers primarily relied on teaching notes covering topics assessed by WAEC. While theoretical aspects of elective chemistry were included in the timetables, practical lessons were often omitted. Additionally, student exercises focused mainly on knowledge and comprehension skills.

- The study examined the instructional activities organised by teachers during chemistry lessons. The findings showed that students were actively involved in the learning process, and teachers supervised practical sessions in which learners worked collaboratively in groups. However, students did not have the opportunity to handle all laboratory equipment individually. Assessment was conducted before, during, and after instruction, with teachers providing immediate feedback. Learners were exposed to a variety of assessment methods, including exercises and projects, which were generally aligned with curriculum objectives. Teachers also guided students in writing laboratory reports and demonstrated experiments before students carried them out. Despite these efforts, there was a noticeable emphasis on theoretical lessons over practical activities, and students primarily copied notes during instruction.
- The findings also revealed that inadequate time for advanced preparation using the required chemistry curriculum resources, teachers did not use different resources like pictures, videos and realia, and learners were not involved in establishing rules and procedures during the instructional process.

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In addition, the teachers did not facilitate learners' own inquiry and group work during lessons. Also, all the concepts were not taught as required by the chemistry curriculum and teachers did not involve laboratory assistants in setting up the practical activities.

The lessons observed were predominantly teacher-centred, with the primary focus on transmitting knowledge from the teacher to the students and limited opportunities for active student participation. Assessments were largely controlled by the teacher, and the pace of instruction was determined by the teacher rather than the learners. The lessons did not create an interactive learning environment that accommodated diverse learning styles or promoted critical thinking. In practical sessions, the development of students' process skills was constrained by insufficient laboratory equipment, preventing all students from manipulating materials, collecting data, or conducting experiments individually.

- The survey revealed that most assistant heads for academics, along with a few heads of science departments (HODs), conducted lesson observations only once per semester. These observations focused on instructional methods, classroom management, the effectiveness of assessments, student engagement, and teachers' subject knowledge, followed by feedback to the observed teachers. Additionally, the assistant heads and HODs regularly analysed students' semester and WASSCE performance and developed strategies to address identified challenges. However, the study also found that no officials from the Ministry of Education (MOE) or the National Council for Curriculum and Assessment (NaCCA) visited the selected schools to monitor teachers' compliance with the chemistry curriculum prescriptions.

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- The survey revealed that teachers participated in upgrading courses in chemistry education and often funded professional development activities outside their schools. Teachers also reported that peer observation was part of formal school arrangements, and that individual or team research on chemistry-related topics was conducted within the schools. Additionally, teachers engaged with online networks and social media platforms focused on chemistry to exchange ideas and share best practices.

  However, the findings also indicated several limitations in professional development. Teachers did not undertake observational visits to other schools to learn about chemistry teaching practices, and there were no school-based sessions for sharing innovative teaching and learning strategies. Furthermore, teachers did not receive incentives for participating in professional development activities outside regular school hours, and such sessions often conflicted with their work schedules. Participation in in-service training on chemistry-related topics was also limited.

- The study identified several challenges affecting the implementation of the chemistry curriculum, as reported by both teachers and students. These included a heavy chemistry syllabus, large class sizes, a shortage of chemistry teachers, limited instructional resources, insufficient practical activities, and an inadequate number of teaching periods in the timetable. Additional challenges highlighted were the pressure of external examinations such as WASSCE, inadequate infrastructure, a shortage of chemistry textbooks, limited funding for necessary materials, low teacher remuneration, and a lack of qualified chemistry laboratory technicians.

  Teachers reported additional challenges not mentioned by students, including

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limited sponsorship for further studies, insufficient in-service training, low student interest and motivation, and issues related to school organization and management. Conversely, students highlighted other obstacles that teachers did not mention, such as ineffective teaching methods, a lack of meaningful connections between chemistry content and industry applications, ineffective assessment techniques, and inadequate ICT tools.

6.2 Conclusions

The primary objective of the study was to assess the extent to which chemistry teachers possessed the academic and professional qualifications necessary to teach the subject. The findings indicated that most teachers responsible for implementing the chemistry curriculum held the required academic and professional credentials. However, a few teachers lacked the necessary qualifications, which could limit their content knowledge and pedagogical skills, potentially hindering effective curriculum implementation.

The second objective of the study was to assess the availability of financial, material, and infrastructural resources necessary for implementing the chemistry curriculum at the classroom level. The findings revealed that most schools had laboratories, copies of the chemistry curriculum, and accessible textbooks. However, there were significant gaps in essential resources, including laboratory equipment, facilities, and teaching materials. Overall, the available resources were insufficient to support the effective implementation of the chemistry curriculum.

The third objective of the study was to examine the instructional activities organized by teachers during chemistry lessons. Findings revealed that students, particularly in their third year, participated in practical lessons using the limited available resources under teacher supervision; however, the development of process skills was constrained.

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The observed theory lessons were predominantly teacher-centred, focusing on the transmission of knowledge from teacher to students, with minimal opportunities for active student engagement. Assessments were largely teacher-driven, and overall, teachers did not fully adhere to the prescribed chemistry curriculum during lesson implementation.

Additionally, the study sought to examine the monitoring strategies implemented to enhance classroom delivery of the chemistry curriculum. The findings showed that most assistant heads for academics, along with a few heads of science departments (HODs), conducted lesson observations only once per semester. These observations focused on teaching methods, classroom management, the effectiveness of assessments, student engagement, and teachers' subject knowledge, with feedback subsequently provided to the observed teachers. The assistant heads and HODs also analysed students' semester and WASSCE performance and developed strategies to address identified challenges. However, the study revealed that no officials from the Ministry of Education (MOE) or the National Council for Curriculum and Assessment (NaCCA) visited the selected schools to monitor teachers' compliance with the prescribed chemistry curriculum.

Furthermore, the study aimed to examine personnel capacity-enhancing activities organized for teachers. Findings indicated that teachers participated in activities to support their professional growth, including upgrading courses in chemistry education, peer observations of chemistry lessons, conducting research on chemistry-related topics, and engaging with online networks and social media platforms to share ideas on chemistry issues. However, the study also revealed several limitations: teachers did not receive incentives for participating in professional development activities, they did not

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attend in-service training in chemistry-related areas, and professional development sessions often conflicted with their work schedules.

Additionally, the study aimed to explore teachers' and students' perspectives on the challenges affecting the effective classroom implementation of the chemistry curriculum. Participants identified several obstacles, including an overloaded chemistry syllabus, large class sizes, a shortage of chemistry teachers, inadequate instructional resources, limited practical activities, insufficient teaching periods in the timetable, the pressure of external examinations such as WASSCE, inadequate infrastructure, and insufficient in-service training, among others. These challenges were found to have a significant negative impact on the effective delivery of the chemistry curriculum in the schools.

6.3 Recommendations

Based on the research findings, the following recommendations are proposed:

Senior High Schools (SHSs) should collaborate with the government and relevant stakeholders to establish well-equipped chemistry laboratories that include adequate chemicals and essential facilities such as water, electricity, first aid supplies, and fire safety equipment. These provisions are critical for ensuring safe and effective laboratory work, allowing students to engage in practical experiments that reinforce their understanding of chemistry concepts.

Furthermore, SHSs should partner with providers of specialized educational software to access virtual simulation tools in chemistry at affordable rates. Such virtual simulations can act as alternatives when physical laboratories are unavailable or lack specific chemicals. These digital tools enable students to perform experiments virtually,

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observe chemical reactions, and analyse data, providing valuable hands-on experience in a safe and controlled environment.

SHSs should ensure that the GES assigns additional laboratory assistants to support chemistry teachers in organising practical sessions. These assistants can handle equipment setup, organise materials, and manage the overall execution of experiments, reducing the workload on teachers and allowing them to focus on facilitating effective learning.

SHSs should also allocate dedicated time slots within the school timetable for practical activities. This would enable teachers to engage students in hands-on experiments regularly, providing learners with more opportunities to use laboratory equipment, observe chemical phenomena, and deepen their understanding of chemistry concepts.

Moreover, SHSs should ensure that both teachers and students have access to adequate and appropriate chemistry textbooks. Comprehensive, well-structured textbooks not only guide the coverage of the curriculum but also serve as reference materials for teachers and resources that enhance students' comprehension of the subject.

SHSs should provide professional development opportunities, including in-service training, workshops, and seminars, to ensure that teachers remain updated on modern teaching methods, technological advancements, and subject knowledge necessary for effective chemistry curriculum implementation.

SHSs should also allocate specific time within the school timetable for professional development activities. This would allow chemistry teachers to share insights on the curriculum prescriptions and discuss strategies for translating these guidelines into classroom practice.

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In addition, heads of science departments (HODs), in consultation with school leadership, should develop quality indicators for monitoring chemistry curriculum implementation, using the curriculum prescriptions as a reference. HODs and school leadership should also establish systematic monitoring mechanisms to evaluate the implementation process, providing feedback to teachers to address weaknesses and improve instructional effectiveness.

Chemistry teachers should implement project-based learning strategies and organise chemistry competitions to enhance students' motivation and active participation. Such initiatives would encourage students to explore chemistry concepts through hands-on activities, research, and problem-solving, leading to a deeper understanding of the subject and improving overall teaching and learning outcomes.

Teachers should also develop innovative chemistry teaching aids to improve instructional effectiveness. Tools such as visual models, interactive demonstrations, and tactile materials can help students grasp complex concepts, promote active engagement, and support a deeper comprehension of chemistry topics.

Furthermore, chemistry teachers should demonstrate the real-life relevance of chemistry by contextualising lessons within everyday situations. Student visits to industries where chemistry concepts are applied can stimulate interest and foster a positive attitude toward the subject.

In collaboration with curriculum developers, chemistry teachers should work to streamline the overloaded chemistry curriculum by refining objectives, categorising content according to complexity, and emphasising practical applications. These

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measures will help create an engaging, effective, and learner-centred chemistry curriculum aligned with best practices.

6.4 Suggestion for further studies

Based on the findings of this study, the following areas are recommended for future research:

a. Conduct a study to evaluate the impact of teacher training programs on the quality of SHS chemistry curriculum implementation.
b. Undertake a survey to examine the relationship between SHS chemistry curriculum implementation and students' academic performance in chemistry.
c. Investigate the alignment between teachers' beliefs about chemistry education and their classroom instructional practices.
d. Examine the role of technology in enhancing the delivery of the SHS chemistry curriculum and promoting student engagement.
e. Explore the influence of different learning styles on the implementation of the SHS chemistry curriculum.
f. Investigate strategies to increase student participation and engagement in SHS chemistry lessons.
g. Conduct a comparative analysis of chemistry curriculum implementation in rural versus urban SHSs.
h. Evaluate the effectiveness of various assessment methods in measuring learning outcomes in the SHS chemistry curriculum.
i. Explore the impact of socioeconomic factors on the implementation of the SHS chemistry curriculum and student performance.
j. Investigate the benefits of collaborative planning and teaching among SHS chemistry teachers.

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k. Examine how parental involvement influences students' interest and achievement in the SHS chemistry curriculum.
l. Explore how teachers adapt the SHS chemistry curriculum to meet the specific learning needs of their students.
m. Investigate the integration of local culture and context into the SHS chemistry curriculum to enhance relevance and student engagement.
n. Assess the impact of ongoing professional development on teachers' capacity to implement the SHS chemistry curriculum effectively.

6.5 Contributions of the study to Science Education

This study enhances current knowledge regarding human resource capacity in secondary school chemistry education and provides context-specific data that can guide teacher education policies, staffing strategies, and future research on chemistry curriculum implementation. The findings highlight significant gaps in teacher deployment policies and underscore the importance of enforcing stricter qualification requirements and providing targeted professional development to ensure effective delivery of the chemistry curriculum in the classroom.

The study highlights a notable gap between the theoretical and practical components of chemistry education in schools. It points to insufficient laboratory equipment, limited reference materials, and the absence of well-structured practical lessons, all of which impede effective teaching and learning of chemistry. Instruction in the observed schools was largely teacher-centred, restricting student engagement, critical thinking, and the development of essential scientific process skills.

Lessons primarily involved one-way knowledge transmission, with minimal student interaction and limited consideration of diverse learning styles. Practical sessions were

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largely ineffective due to inadequate equipment, preventing students from gaining hands-on experience and conducting meaningful experiments. These findings emphasise the urgent need to adopt more learner-centred pedagogies and to improve resource availability to support active, inquiry-based chemistry education.

The study found that instructional supervision in chemistry teaching is limited in both scope and frequency, and is mainly conducted by school-level administrators rather than external educational authorities. The lack of oversight from national bodies such as the Ministry of Education (MOE) and the National Council for Curriculum and Assessment (NaCCA) reveals a significant gap in maintaining consistent chemistry curriculum implementation and accountability. These findings underscore the need for stronger external monitoring systems and more regular, structured support to ensure the curriculum is implemented effectively.

The findings indicate that teachers show a strong personal commitment to professional development through self-funded courses, peer observations, and engagement in online professional networks. However, there is a lack of structured, school-based professional development programmes and limited inter-school collaboration. Systemic challenges, including the absence of incentives, scheduling conflicts, and restricted access to in-service training, further hinder sustained and collaborative professional learning. These observations highlight the need for more supportive, coordinated, and policy-driven professional development frameworks to enhance teacher growth and effectiveness.

The study provides a comprehensive identification of the challenges affecting effective chemistry curriculum implementation from the perspectives of both teachers and students. It offers new insights by highlighting both shared and unique concerns: common challenges include content overload, insufficient resources, large class sizes,

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and limited instructional time, while teachers additionally stressed systemic and professional issues such as lack of sponsorship, inadequate in-service training, and organizational constraints. Conversely, students emphasised pedagogical shortcomings, limited relevance to real-world applications, and insufficient integration of ICT tools. This dual-perspective analysis deepens the understanding of barriers to successful chemistry curriculum implementation and underscores the need for targeted interventions that address both institutional and learner-focused challenges.

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APPENDICES

APPENDIX A

TABLE FOR DETERMINING THE RANDOM SAMPLE SIZE

POPULATION	RANDOM SAMPLE
10	10
15	14
20	19
25	24
30	28
35	32
40	36
45	40
50	44
55	48
60	52
65	56
70	59
75	63
80	66
85	70
90	73
95	76
100	80
110	86

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120	92
130	97
140	103
150	108
160	113
170	118
180	123
190	127
200	132
210	136
220	140
230	144
240	148
250	152
260	155
270	159
280	162
290	165
300	169
320	175
340	181
360	186
380	191
400	196
420	201

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440	205
460	210
480	214
500	217
550	226
600	234
650	242
700	248
750	254
800	260
850	265
900	269
950	274
1,000	278
1,100	285
1,200	291
1,300	297
1,400	302
1,500	306
1,600	310
1,700	313
1,800	317
1,900	320
2,000	322
2,200	327

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2,400	331
2,600	335
2,800	338
3,000	341
3,500	346
4,000	351
4,500	354
5,000	357
6,000	361
7,000	364
8,000	367
9,000	368
10,000	370
15,000	375
20,000	377
30,000	379
40,000	380
50,000	381
75,000	382
1,000,000	384

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APPENDIX B

Observation Guide

It is highly appreciated that you have accepted to participate in this research. The information will be used for academic research purposes only. An observation guide will be used to observe and write done a set of activities or behaviours that occur in the instructional process. It will involve direct observation which means observing without interacting with the objects or people under study in the setting.

School Code: ……...

Teacher Code: …… ..

Topic ……..

Date: ……

Objective:

Lesson Introduction:

Lesson presentation:

Use of Teaching and Learning Resources:

Mastery of Subject Knowledge:

Mastery of Pedagogical Knowledge:

Assessment of Student Learning:

Management of the Learning Environment:

Student Participation:

Use of Language:

Lesson Closure:

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APPENDIX C

INTERVIEW SCHEDULE FOR CHEMISTRY TEACHERS AND STUDENTS

Thank you for agreeing to participate in this interview. The responses in this interview will be used for academic research purposes only. There are no right or wrong answers to the question. With your permission, responses will be audio recorded. All responses will be kept confidential. This means that only your de-identified interview responses will be used in the research work.

In your view(s), what are the challenges associated with chemistry curriculum implementation in this school?

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APPENDIX D

INTERVIEW GUIDE - ASSISTANT HEADS FOR ACADEMICS AND HODs SCIENCE

Thank you for agreeing to participate in this interview. The responses in this interview will be used for academic research purposes only. There are no right or wrong answers to the question.. With your permission, responses will be audio recorded. All responses will be kept confidential. This means that only your de-identified interview responses will be used in the research work.

1. How frequently do you conduct lessons observations for chemistry teachers, and what specific aspects do you focus on during these observations?

2. Can you describe the process use to provide feedback to teachers after lesson observations?

3. How do you utilise student performance data to monitor the effectiveness of the chemistry curriculum implementation?

4. Do you get officials from Ministry of Education and (NaCCA) to visit the school to check on chemistry curriculum implementation?

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APPENDIX E

QUESTIONNAIRE FOR TEACHERS'

Dear Respondent,

The study is purely for academic purposes. You are not required to write your name and the school. Any information received will be kept confidential. Kindly read through each of the items carefully and indicate your opinion as honestly as possible. For any further enquiry, contact the researcher on mobile number: 0243355360. Thank you very much for your time and participation.

General instruction

Please tick [√] the appropriate bracket or column or fill in the blank spaces where necessary.

Section A: Background Information

Sex:

Male [ ] Female [ ]

Age:

Below 21yrs [ ] 21-30 yrs [ ] 31-40yrs [ ]

41-50yrs [ ] Above 51yrs [ ]

1. How long have you been teaching Chemistry in senior high school?

3-5yrs [ ] 6-10yrs [ ] 11-15yrs [ ]

16-20yrs [ ] Above 20yrs [ ]

2. What is your highest academic qualification?

(a) Diploma [ ] (b) 1st Degree [ ]

(c) 2nd Degree [ ] (d) Any other, specify …….

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3. What is your area of specialization?

(a) Biology (b) Chemistry

(c) Physics (d) Any other, specify ……

4. What is your highest professional qualification?

(a) Diploma [ ] (b) 1st Degree [ ]

(c) 2nd Degree [ ] (d) Any other, specify ……

Please tick (√) inside the box that corresponds to your choice of response. There is no "right" or "wrong" responses. Be sure to respond to all items. If you change your mind about your response to an item, just cross it out and tick another.

Section B: Resources for Chemistry Curriculum Implementation

Serial No.	Item Description	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
1.	The school has laboratory dedicated for chemistry practical					
2.	The school has adequate equipment, facilities to implement the chemistry curriculum					
3.	There is easy access to science resources to enable you implement the chemistry curriculum.					
4.	The school always buys needed resources during examination period					
5.	There are textbooks, like GAST chemistry, for SHS which are readily available for teaching and learning chemistry.					
6.	The school has a library which is stocked with reference books					

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7.	The school borrows some resources from other schools					
8.	The Ministry of Education and GES regularly supply equipment and materials to the school.					

Section C: Instructional Activities in Chemistry Lessons

Serial no.	Item Description	Always	Most often	Some times	Rarely	Never
1	There is adequate time for advanced preparation using the required curriculum resources					
2	The learners are involved in the teaching and learning process.					
3	All the concepts are taught as required by the chemistry curriculum					
4	Learners are assessed based on the objectives of the concepts in the chemistry curriculum					
5	Learners are involved in establishing rules and procedures.					
6	Learners copy notes during the instructional process					
7	Learners are assessed before, during and after instruction					
8	The teacher uses different resources like pictures, videos and realia.					
9	Learners are regularly examined through exercises, quizzes, assignments and projects.					
10	The teacher facilitates learners' own inquiry.					

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Section C: Instructional Activities in Chemistry Curriculum Implementation

Serial No.	Item Description	Always	Most often	Some Times	Rarely	Never
11	Teacher exposes leaners to Science equipment during practical					
12	Teacher guides learners on how to write report about experiment.					
13	Teacher links practical to theory for learners to appreciate and understand the concept.					
14	Teacher demonstrates experiments before learners carry out any assigned task.					
15	Teacher supervises learners during practical.					
16	Teacher allows learners to work in groups during practical lessons.					
17	Teacher gives learners immediate feedback when they need directions to proceed.					
18	Teacher organises group work because there isn't enough equipment.					
19	Teacher denies learners the opportunity to handle every equipment in the laboratory					
20	Teacher involves lab assistant in setting up the practical activities					

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Section D: Personnel Capacity-enhancing Activities in Chemistry Curriculum Implementation

Serial No.	Item Description	Always	Most often	Some times	Rarely	Never
1	There is in-service training on the chemistry related areas for teachers					
2	The teacher undertakes upgrading course in chemistry education					
3	The teacher undertakes observational visits to other schools on chemistry issues.					
4	There is peer observation as part of the formal school arrangement.					
5	There is individual teacher or team research on chemistry issues of interest at the school					
6	There is professional development sessions in the school where teachers share innovative ideas related to teaching and learning of chemistry concepts					
7	The teacher participates in network of chemistry social media platform to share ideas on chemistry related issues					
8	The teacher receives incentive for taking part in professional development activities that take place outside regular school hours.					
9	The professional development sessions conflict with the work schedule of the teacher.					
10	The teacher personally pays for professional development outside the school.					

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APPENDIX F

STUDENTS' QUESTIONNAIRE

Dear Respondent,

The study is purely for academic purposes. You are not required to write your name and the school. Any information received will be kept confidential. Kindly read through each of the items carefully and indicate your opinion as honestly as possible. For any further enquiry, contact the researcher on mobile number: 0243355360. Thank you very much for your time and participation.

General instruction

Please tick [√] the appropriate bracket or column. Be sure to respond to all items. If you change your mind about your response to an item, just cross it out and tick another.

Section A: Background Information

Sex:

Male [ ] Female [ ]

Age:

Below 13yrs [ ] 13-15yrs [ ] Above 16yrs [ ]

2. Which area of science do you like best?

(a) Biology (b) Chemistry

(c) Physics (d) Any other, specify ……

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Please tick (√) inside the box that corresponds to your choice of response. There is no "right" or "wrong" responses. Be sure to respond to all items. If you change your mind about your response to an item, just cross it out and tick another.

Section B: Resources for Chemistry Curriculum Implementation

Serial No.	Item Description	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
1.	The school has laboratory dedicated for chemistry practical					
2.	The school has adequate equipment, facilities to implement the chemistry curriculum					
3.	There is easy access to science materials and resources for implementation of the chemistry curriculum.					
4.	The school always buys needed materials during examination period					
5.	There are textbooks, like GAST chemistry, for SHS which are readily available for teaching and learning chemistry.					
6.	The school has a library which is stocked with reference books					
7.	The school borrows some chemistry resources from other schools					
8.	The Ministry of Education and GES regularly supply equipment and materials to the school.					

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Section: C Instructional Activities in Chemistry Lessons

Serial No.	Item Description	Always	Most often	Some Times	Rarely	Never
1	There is adequate time for advanced preparation using the required chemistry curriculum resources					
2	The learners are involved in the teaching and learning process.					
3	All the concepts are taught as required by the chemistry curriculum					
4	Learners are assessed based on the objectives of the concepts in the chemistry curriculum					
5	Learners are involved in establishing rules and procedures.					
6	Learners copy notes during the instructional process					
7	Learners are assessed before, during and after instruction					
8	The teacher uses different resources like pictures, videos and realia					
9	Learners are regularly examined through exercises, quizzes, assignments and projects.					
10	The teacher facilitates learners' own inquiry.					

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Section C: Instructional Activities in Chemistry Lessons

Serial No.	Item Description	Always	Most often	Some times	Rarely	Never
11	Teacher exposes learners to Science equipment during practical					
12	Teacher guides learners on how to write report about experiment.					
13	Teacher links practical to theory for learners to appreciate and understand the chemistry concept.					
14	Teacher demonstrates experiments before learners carry out any assigned task.					
15	Teacher supervises learners during practical.					
16	Teacher allows learners to work in groups during practical lessons.					
17	Teacher gives learners immediate feedback when they need directions to proceed.					
18	Teacher organises group work because there is no enough equipment.					
19	Teacher denies learners the opportunity to handle every equipment in the laboratory					
20	Teacher involves a lab assistant in setting up the practical activities					