European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available online at: www.oapub.org/edu

DOI: 10.46827/ejes.v13i4.6596 Volume 13 | Issue 4 | 2026

WHAT CAN WE LEARN FROM THE 2010 GHANAIAN SENIOR HIGH SCHOOL CHEMISTRY CURRICULUM? AN EVALUATION USING THE CIPP MODEL

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Abstract:
Curriculum evaluation offers educators and stakeholders the fundamental basis for making informed decisions on whether the education provided to its citizens meets its societal needs and whether there is a need for revisions or reforms. As change is an integral part of life, it is imperative that a continuous evaluation of the curriculum be conducted to provide a pathway for making decisions to meet the changes that arise. As Ghana prepares herself to replace the 2010 senior high school (SHS) curriculum, we evaluated the SHS chemistry curriculum, which had been implemented for more than a decade, using the CIPP model. The 2010 SHS chemistry curriculum was organised and structured with components such as rationale, general aims, general objectives, specific objectives, content, teaching and learning processes, and assessment processes. In a mixed methods design, 183 students and seven chemistry teachers were selected through purposive sampling procedures to respond to interviews and questionnaires. Also, observations in the form of field notes were used for data collection. Statistical tools and thematic analysis through open coding and constant comparison were used to make meanings of both quantitative and qualitative datasets. As a result, we report that the context, input, and process of implementation of the SHS chemistry needs to be revised as among teacher professional development to enrich teachers' comprehension of the

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rationale, objectives, instructional process, and the suggested teaching-learning materials and activities for effective implementation of any new curriculum in the years to come.

Keywords: chemistry; curriculum evaluation; context evaluation, input evaluation, and process evaluation

1. Introduction

The senior high school (SHS) chemistry curriculum was introduced in 2010, following the 2008 education reforms. With 50 units organised into sections and grade levels, SHS 1, SHS 2, and SHS 3The rationale for teaching chemistry in the SHS was to help students understand the study of matter and its changes and assist students in appreciating that chemistry is about humans and everything around them (Ministry of Education, 2010). The curriculum was designed around building character and nurturing values, in addition to ensuring seamless progression for all learners and creating clear pathways for academic and career-related programs. There were 12 general aims expected to be achieved with a scope focusing on three key strands: (a) providing enough chemistry for students at that level, (b) for students in their vocational studies, and (c) for those who want to further their education (Ministry of Education, 2010, p ii).

The duration for teaching the chemistry curriculum was 3 years, broken into six periods per week (two periods for practical and four periods for theory) and a period expected to last for 40 minutes (Ministry of Education, 2010). In the first year (SHS 1), students were expected to learn only the theory and practical parts of the curriculum, beginning in the second year (SHS 2). Learners require proficiency in English and basic mathematics concepts, both of which were expected to be acquired from the junior high school (JHS) level. The curriculum also suggested how chemistry teachers can teach the curriculum, which was based on the general objectives containing the skills and behaviours that students needed to demonstrate after being introduced to a section (broad topic). The curriculum is further organised into five columns headed as Units, Specific Objectives, Content, Teaching and Learning Activities, and Evaluation. A detailed description of the way these five columns can be used was provided. The unit consisted of topics that students were to learn under each section, of which teachers were cautioned to teach the units sequentially for students to comprehend the concept easily. The specific objectives outline what the teacher intends students to learn after each unit, while the content is the body of knowledge students learn under each unit. Moreover, the teaching and learning activities are the various activities that engage students actively in the teaching and learning process, whereas evaluation is the exercises and assignments students are presented with either during the lesson or after learning a particular unit. The curriculum also outlined the profile of the dimensions on which assessments would revolve. They include "Knowledge and Understanding (30%), Application of Knowledge (40%), and Practical and Experimental Skills (30%)" (Ministry of Education, 2010, p. viii).

These profile dimensions specify the science process skills expected to be acquired by each learner and form the basis of assessment.

In addition, the chemistry curriculum outlined how both formative and summative assessments should be conducted. It ended with the suggested reference list that the teacher can follow to access information to increase their understanding and support their implementation of the curriculum (Ministry of Education, 2010).

1.1 Empirical studies on the Ghanaian SHS chemistry curriculum

Since its inception in 2010, many chemical educators and researchers have examined some of the content areas and reported that teachers and students have difficulties in teaching and learning chemistry. Among the various parts of the Ghanaian chemistry curriculum, these difficulties include mole concepts (Adu-Gyamfi & Vorsah, 2022; Vorsah & Adu-Gyamfi, 2021), redox reactions and electrochemistry (Adu-Gyamfi & Ampiah, 2019a, 2019b; Adu-Gyamfi et al., 2015, 2018), qualitative analysis (Adu-Gyamfi et al., 2024), hybridisation (Abukari et al., 2022; Marifa et al., 2023; Mawutor & Adu-Gyamfi, 2025) and organic chemistry (Adu-Gyamfi et al., 2012, 2013, 2017; Adu-Gyamfi & Asaki, 2022, 2023; Anim-Eduful & Adu-Gyamfi, 2021, 2022). These studies have focused on either teachers’ or students’ performance or challenges in relation to the curriculum. What appears to be conspicuously missing is evaluating the chemistry curriculum in terms of looking at the context, aims, and objectives of these areas of the curriculum, and the input, that is, the means to achieve these objectives.

Some of these researchers and educators reported that instead of the envisioned correct grasp of concepts, Ghanaian students had misconceptions in some content areas (Abukari et al., 2022; Adu-Gyamfi et al., 2015; Adu-Gyamfi & Ampiah, 2019a, 2019b). Some of the teachers who are charged with the responsibility of enacting the chemistry curriculum also have misconceptions in some content areas (Adu-Gyamfi & Asaki, 2022, 2023; Marifa et al., 2023), while others use weak instructional strategies to teach some topics (Adu-Gyamfi et al., 2018; Vorsah & Adu-Gyamfi, 2021). In most of these works reported on teachers’ and students’ conceptual difficulties in chemistry concepts, however, what has not been addressed is whether the objectives of the curriculum, as well as the specific objectives of those units in the chemistry curriculum, are achieved and/or do not match the cognitive abilities of learners at the SHS level. Could it be that learning resources are not available and that this is the precipitating factor for teachers not using the right instructional materials? Hence, a holistic evaluation of the chemistry curriculum will be the right way to go to inform policy and practice. In assessing the relevance of the Ghanaian curriculum, the curriculum is relevant in instilling values into the students, but it is not relevant in the application of knowledge that employers usually demand of employees in the work environment (Okrah et al., 2020).

Others have looked at which of the topics in the chemistry curriculum is considered difficult (Essiam et al., 2023; Joseph, 2021). For instance, Essiam et al. (2023) investigated the chemistry topics in the Ghanaian SHS curriculum in which students perceived difficulties in learning and their associated reasons for those difficulties and reported that 66.7% of the topics investigated were perceived by the students as being difficult. The reasons the students gave were chemistry teachers' poor teaching techniques, absence of extra tuition, and the lack of practical laboratory work. Their studies found that lessons in chemistry classrooms were more teacher-centred, with little interaction between teachers and students. Similarly, Joseph (2021) found that students indicated redox reactions, electrochemistry and naming of organic compounds as the most difficult topics in the SHS curriculum. The factors that accounted for their perceived difficulties were a lack of practical activities, unavailability of prescribed textbooks, uninteresting lessons, chemistry teachers' instructional strategies, and the failure of available textual materials in use by both teachers and students to meet the requirements of good textbooks.

Another body that has raised concerns on which basis the curriculum needs to be evaluated is the nation's external examination body, the West African Examination Council (WAEC). WAEC has lamented from time to time on students' performance in questions in the various aspects of the chemistry curriculum assessed by the chief examiner for the chemistry paper (WAEC, 2011, 2016, 2018, 2019, 2020). Concerns including students' poor knowledge of concepts related to organic chemistry (WAEC, 2018), mole concept (WAEC, 2021, 2022), periodicity (WAEC, 2020), and chemical bonds (WAEC, 2017), among others, have been raised, although some of the years, some aspects of the chemistry, students are appraised for good performance. If national assessment bodies such as WAEC assess the general learning outcomes of students' complaints, it implies the need to evaluate the chemistry curriculum.

Beyond these challenges, in the context of Ghana, studies have proposed solutions to address these difficulties (Adu-Gyamfi et al., 2020; Adjei et al., 2022; Baah et al., 2020; Sarkodie & Adu-Gyamfi, 2015). For instance, Adjei et al. (2022) investigated the use of collaborative approaches on students' performance in redox reactions and recommended that chemistry teachers in Ghana employ a collaborative learning approach in teaching chemistry to enhance students' learning. Similarly, Adu-Gyamfi et al. (2020), through design-based research, developed a participatory teaching and learning approach, a framework proposed to help in students' conceptual understanding of redox reactions. However, do these empirical studies proposing instructional strategies to use, as well as those proposed by the developers of the chemistry curriculum, provide the required results? Perhaps an appropriate response would be to evaluate the chemistry curriculum.

1.2 Curriculum evaluation

According to Deshpande (n.d.), no curriculum is stable; it must change according to the requirements of its stakeholders, and the stakeholders of the curriculum are teachers, students, parents, examiners, industries, society, and professional bodies. Thus, at some point, these stakeholders may have to contemplate a substantial change in the school curriculum, such as whether to forsake a well-established curriculum in favour of an innovative one. Many teachers depend on informal evaluations, such as casual observation, intuitive reflection, casual conversations with students, and unsystematic study of students' test scores when making these curricular selections. However, the quality of these informal assessments varies greatly: sometimes incisive and perceptive, sometimes shallow and erroneous (Stake, 1967). In the case of Ghana, the National Council for Curriculum and Assessment (NaCCA, 2018) noted that since the enrolment of the chemistry curriculum in 2010, the structure and content of the curriculum have not been consistently evaluated and strategically reviewed to support the development of the type of human resource the country needs. NaCCA agrees with Stakes's assertion that students' performance in external examinations, such as the West African Senior Secondary Certificate Examination (WASSCE), is often what is being looked at, but asserts that such assessment systems do not provide effective examination outcome data for evaluating teaching and learning, to improve the quality of pre-tertiary education. Thus, formal and rigorous evaluations are vital for making excellent curricular selections (Stufflebeam & Shinkfield, 2007).

To this end, a call for evaluation of various curricula, such as the chemistry curriculum, is the right way to go. Curriculum evaluation is instrumental as it aids educators in developing and refining programs to best meet students' learning and developmental needs. Because by evaluating the curriculum, we gather and analyse information from multiple sources to improve students' learning in a sustainable way (Wolf et al., 2006). Such an evaluation will help us address the integral nature of a curriculum. That is, the merit and worth of the 2010 chemistry curriculum for SHS students. Curriculum evaluation should be ongoing endeavours that are particularly focused and systematic under certain circumstances, the results of which will be used to inform decisions, improve curriculum or program quality, and improve student learning (Malin, 2014). Based on the assertions, this study evaluates the Ghanaian SHS chemistry curriculum, which has been implemented for over a decade, with a standard evaluation model that will provide the data for the decision makers to make the right decision regarding the appropriate revisions of the chemistry curriculum for Ghanaian SHS.

1.3 The Context, Input, Process, and Product (CIPP) curriculum evaluation model

Determining the strengths and weaknesses of an existing curriculum can serve as a starting point for curricular change, but achieving that objective requires a model (Raycroft & Flynn, 2020). There are many models for evaluating a curriculum. Glatthorn et al. (2012) identified Tyler's Objective-Centred Model, Scriven's Goal-Free Model, Stufflebeam's Context, Input, Process, and Product Model, Eisner's Connoisseurship Model, Stake's Responsive Model, Bradley's Effectiveness Model, and Eclectic Approach as models that could be used to evaluate a curriculum. Each of these models has its advantages and disadvantages. Stufflebeam (2003) contended that the CIPP model is a decision-focused approach to curriculum evaluation that systematically collects information about a curriculum, identifies strengths and limitations in content or delivery, improves a curriculum's effectiveness, or plans for the future of a curriculum. When making curricular decisions, teachers and curriculum leaders should have access to a wide range of information and data. These data include students' characteristics,

characteristics of the curriculum and its alternatives, outcomes of the curriculum, and costs of delivering the curriculum (Lam, 2017; Stufflebeam, 2004). Thus, the above forms the basis for the choice of the CIPP model for this research. This is because this research investigated the effectiveness of the SHS chemistry curriculum to identify the strengths and weaknesses of the chemistry curriculum and those that are open to improvement (Taş & Duman, 2021) by policymakers and to enable decision makers to be informed appropriately (Glatthorn et al., 2012).

The CIPP model comprises four main components: context, input, process, and product (Glatthorn et al., 2012). This made Bashri et al. (2020) report that the CIPP model is a comprehensive evaluation model that assesses the curriculum based on context, input, process, and product.

- **Context evaluation:** Basaran et al. (2021) explained that context evaluation is the examination of the desired and actual circumstances in relation to the broad themes of the program. Furthermore, the context component evaluates the needs of students and the environment in which they learn (Bashri et al., 2020). To Glatthorn et al. (2012), context evaluation is prudent for the evaluator(s) to identify both the salient aspects of the educational environment that impinge on the field of study and the critical needs of learners. It embraces the use of diverse descriptions and comparisons of properties and draws conclusions leading to the determination of goals in educational programs that relate to the needs of the learner (Tuju et al., 2022). It focuses on providing information on selecting goals and priorities of learning outcomes, as well as providing the relevant data for curriculum planners to consider what the goals should be (Lam, 2017; Stufflebeam, 2004). Thus, assessing whether the aims are suitable, with the objectives used emanating from the aims of the curriculum. It also examines whether the content taught aligns with the aims of the curriculum (Aziz et al., 2018).
- **Input evaluation:** The input phase determines how activities are employed to accomplish the program's stated goals, and the input component evaluates the resources available for teaching and learning (Bashri et al., 2020). It determines and documents sources of support, a solution strategy, a procedural design, a staffing plan, a schedule, and a budget (Lam, 2017; Stufflebeam, 2004).
- **Process evaluation:** Process evaluation focuses on the implementation phase. The process component evaluates how well the curriculum is implemented (Bashri et al., 2020). If the program is under implementation, an evaluation is completed to determine how it affects the activities being performed. It also provides information on the limitations of the current learning design and aids in decision-making challenges as well (Tuju et al., 2022). According to Ornstein and Hunkins (2009), process evaluation addresses implementation decisions that control and manage programs. Targets the monitoring of the implementation of the curriculum. It may be vital for curriculum designers to focus on how a program is implemented after it has been designed. Administrators and program directors can use the data to promptly modify their implementation plans. Another

important reason to carry out a process evaluation is to give curriculum designers the information they can use to evaluate the delivery plan, change the implementation plan, and promptly offer support (Lam, 2017).

- **Product evaluation:** Finally, the product component evaluates the curriculum outcomes (Bashri et al., 2020; Stufflebeam, 2004). According to Imansari and Sutadji (2017), product evaluation relates to the results of the curriculum, collected information, and data on the effects of the curricula on product evaluation, where the program's results will be assessed (Stufflebeam, 2004).

Based on the above evaluation phases, it can be said that to evaluate the chemistry curriculum using the CIPP model, four essential phases, context, input, process, and product, must be considered. The CIPP evaluation techniques have the advantage of providing feedback on the execution of the teaching process and learning outcomes. The output of this feedback serves as a baseline for ongoing process development; the benefit of assessing the context, input, process, and product phases to aid in decision-making (summative role) (Stufflebeam, 2004); and the display of information on accountability (Bashri et al., 2020). Deshpande (n.d.) explained that we may analyse each of these four components of the curricular system with the aid of CIPP models to enable us to make the following decisions based on the various components: (a) on context evaluation, a decision can be made to design/plan a new curriculum; (b) on input evaluation, infrastructure decision for provision of various resources; (c) process evaluation, decision on implementation of curriculum; and (d) product evaluation, decision on the choice of recycling process used to create a product can be made.

Since its birth in 1983 by Stufflebeam, many researchers and educators have used CIPP to evaluate different programs and curricula (Aziz et al., 2018; Bashri et al., 2020; Imansari & Sutadji, 2017; Narod & Narrainsawmy, 2023; Rooholamini et al., 2017). For instance, Bashri et al. (2020) evaluated a biology education curriculum using the CIPP model. In their work, all four phases of CIPP were used. Bashri et al. (2020) found that the curriculum was effective in terms of context, input, process, and product. In this current research, the first three, context, input, and process, were dwelt with. This is because this research looked at the objectives, available resources, and the teaching and learning aspects of the chemistry curriculum. That is, the process of putting it into practice, the contents of the subject, and the structures that were expected to bring change while assisting with instructional resources (Fullan, 1991) were important to any ongoing curriculum revision in the SHS to align with Ghana’s introduction of the standards-based curriculum. To learn something from the 2010 Ghanaian senior high school chemistry curriculum (to inform policy and decision making), we, therefore, looked for answers to the following research questions:

1) In what context was the SHS chemistry curriculum introduced?
2) How was the input guiding SHS chemistry curriculum implementation to achieve the stated curriculum objectives?
3) How was the process by which the SHS chemistry curriculum was implemented?

2. Research Methods

2.1 Research design

In this research, we adapted a convergent parallel mixed methods design to evaluate the 2010 chemistry curriculum for SHS in Ghana. Creswell and Creswell (2018) and Creswell and Plano Clark (2018) described mixed methods as procedures for collecting, analysing, and blending both quantitative and qualitative methods in a single study or a series of studies to understand a research problem, such as the implementation of the 2010 chemistry curriculum in the SHS. In this convergent parallel mixed methods approach, we collected both quantitative and qualitative data separately with the outcomes of none informing the other, then analysed both datasets separately, compared the results from the analysis of both datasets, and interpreted the findings in the light of the literature to generate quality and relevant information to inform policy and decision making in relation to the revision of the SHS chemistry curriculum in line with the standard-based curriculum being implemented by Ghana since the year 2019. First, the implementation of the standard-based curriculum was done in the basic school, and it has now reached the SHS, where chemistry is learnt by students as an elective subject.

2.2 Study area

The study was conducted in two regions of Ghana: The Upper East and Central Regions. The regions were chosen because of disparities in educational facilities. More endowed schools and high-performing schools classified as category A were identified in the Central Region than in the Upper East Region. Geographically, the Central Region was in the southern part of Ghana, and the Upper East Region was in the northern part of Ghana. The Upper East Region has a population of 1,301,226 inhabitants with a land area of 8,842 km^2, a density of 147.3/km^2, and lies between longitude 0° and 1° west, and latitudes 10° 30′N and 11°N (Ghana Statistical Service, 2021). The region shared boundaries with Burkina Faso to the north, Togo to the east, Upper West Region to the west, and the Northeast Region to the south. Administratively, the Upper East Region was divided into 15 assemblies, four municipalities, and 11 districts, which roughly correspond to the main tribal groupings. In terms of education, there were nine tertiary institutions (three universities, four nursing and midwifery training institutions, and two colleges of education), and 37 senior high and technical schools.

The Central Region had a population of 2,859,821. It is bordered by the Ashanti and Eastern Regions to the north, the Western Region to the west, the Greater Accra Region to the east, and the Gulf of Guinea to the south. The region occupies an area of 9,826 km^2 (4.1%) of Ghana’s total land area. Unlike the Upper East Region, the Central Region is divided administratively into 22 assemblies comprising one metropolitan, seven municipalities, and 14 districts. In terms of educational institutions, there were eight tertiary institutions (three universities, three colleges of education, and two accredited nursing and midwifery colleges) and 124 public senior high schools and technical and vocational second-cycle schools.

2.3 Sampling procedure

The participants were selected students and teachers from two regions in Ghana: The Upper East and the Central Regions. A multistage sampling procedure was used to select 217 chemistry students from six science schools, three each in the two regions. However, there was an 84.3% return rate, giving a total of 183 students who participated in the research. That is, there were 43.7% students from the Upper East Region and 56.3% students from the Central Region. Elective chemistry students were selected because the chemistry curriculum was taught only to elective chemistry students in the SHS. Of 183 students, 42.1% attended well-endowed schools, 35.5% attended endowed schools, and 22.4% attended less-endowed schools across the two regions. Again, 63.9% were male and 36.1% were female, with an age range of 11 to 22 years and a mean age of 17.5 years. All students were in the SHS 3, even though we planned to collect data from SHS 2 and SHS 3 students who had experienced the enactment of the 2010 chemistry curriculum in the SHS for more than 1 year. However, at the time of data collection, the SHS 2 students were on vacation due to the double-track system being modelled by the Ghana Education Service. Hence, only the SHS 3 students were present and available to provide responses to the research instruments. Also, the SHS 3 students were an ideal selection for the research as they had had exposure to the chemistry curriculum for at least 2 years and hence, would have been taught more than 90% of the concepts therein.

Twelve chemistry teachers were selected purposely based on teaching experience from the six schools. However, only seven were ready during the period of data collection. The seven teachers had all taught for over 5 years, with one having 28 years of teaching experience in chemistry. Two had bachelor's degrees in science education (chemistry major), one had a Bachelor of Science (applied chemistry), and two had Bachelor of Science (chemistry education), and two had a Master of Philosophy degree in science education (chemistry major).

2.4 Data collection instruments

2.4.1 Chemistry curriculum evaluation questionnaire [CCEQ]

In curriculum evaluation, questionnaires are useful tools that can be used to obtain the reactions of curriculum users, namely, learners, teachers, administrators, parents, and other educational workers concerning various aspects of the prescribed curriculum. Thus, in this research, a self-developed questionnaire, Chemistry Curriculum Evaluation Questionnaire [CCEQ], was used to elicit responses from one of the main users of the curriculum, the students. CCEQ was made up of 24 items organised into two sections: A and B. Section A consisted of only four items, which required a student's gender, age, school type, and level. Section B includes items that focus on the context, input, and process evaluations. In all, there were seven context items (that is, Items 5-10, 22), seven input items (that is, Item 11-15, 20-21), and six process items (that is, Item 16-19, 23-24). Given that the chemistry curriculum was expected to be implemented in the same way across all school types, some of the responses were expected to cut across all school types and again, to allow for compares of how the chemistry curriculum has been implemented across all school types to give a fair evaluation of the chemistry curriculum, closed-ended items were included. The closed-ended items were in the form of five-point Likert scale items. For Items 10–20, the Likert scale items required students to indicate their level of agreement with given statements relating to the context, input, and process evaluation of the chemistry curriculum. The scale range was 1-5, codified as 1=lowest agreement and 5 = highest agreement. Item 20 (input evaluation question) required respondents to indicate the extent to which they considered the contents related to the program relevant to instructional practices and society as a whole, and was codified as 1=least relevant to 5=most relevant. It was also necessary for open-ended questions to be included to enable students to explain and qualify their responses because of variations in the schools. For this reason, Items 21-24 were open-ended ones.

To ensure that the items were valid and reliable, the questionnaire was presented to expert reviewers for reading and critiquing. Thereafter, a pilot study was conducted with 15 students in a school in a different district. The reliability coefficient was 0.78. Typo errors, incorrect wordings, ambiguities, and statements that expressed the same meaning were resolved before the instrument was administered.

2.4.2 Chemistry curriculum evaluation interview schedule [CCEIS]

CCEIS was developed by the researchers and had items relating to the biodata of respondents, the context, input, and process evaluation under which the chemistry curriculum was designed and implemented. It was organised into sections A to D, with section A (biodata) seeking to elicit information on teachers' gender, qualifications (professional and academic), and teaching experiences. This was essential for determining the quality of the teachers implementing the subject. To determine how teachers were veterans of chemistry curriculum implementation and, thus, had the basics and experience to teach the subject. Section B items were based on the context in which the subject was developed. The items sought the needs and aims of chemistry curriculum implementation, relevance of the subject in the job market, adequacy of time, and factors that hinder teaching and learning. It consisted of seven items (5-11). Section C sought to establish the acquisition of input data that guided the implementation of the chemistry curriculum. The items included motivation factors, the contents, skills, and attitudes towards teaching and learning, delivery of instructions, resources available, and problems associated with implementation at this phase. It consists of 12 items (Items 12-23). Finally, Section D sought data on the process of chemistry curriculum implementation. It had items on students' participation, syllabus problems, and teaching and learning evaluation. It comprised six items (Items 24-29). In total, there were 30 items in CCEIS.

To ensure validity and reliability, the responses were audio recorded and played back to ensure their accurate transcription. The transcribed data were sent back to teachers to confirm whether they were a true reflection of their responses. Teachers then made a few changes and inputs before the data were used. In addition, the instrument was given to expert curriculum developers and evaluators to critique. Experts in English, who are also WAEC examiners, and the use of Grammarly software were used to help correct grammatical errors and remove any ambiguity from the questions.

2.5 Data collection procedure

We visited the selected schools and had discussions with the school authorities, where permission was sought to enable us to collect data. Having obtained permission from school authorities, we contacted the chemistry teachers to share the purpose of the research and assured them of confidentiality in how any data will be handled. The teachers were delighted to participate in the study, so they gave us time to meet for the interviews which was mostly during their break periods. While the interviews were conducted, a questionnaire was administered to the students. In some cases, the questionnaire was administered afterwards the interviews were conducted. In all the schools, both instruments were administered on the same day. A maximum of 6 weeks were used in the data collection. Because there was the need to travel over a distance from other regions of Ghana to collect both datasets.

2.6 Data processing and analysis plan

In some instances, analysis was performed using open coding and constant comparisons in relation to the qualitative data from CCEIS. The closed-ended items in CCEQ were coded into quantitative data to aid in the use of descriptive statistical tools for analysis. In this paper, a score in the range 1.0 to 1.4 was considered as lowest agreement, 1.5 to 2.4 was considered low agreement, 2.5 to 3.4 was considered moderate agreement, 3.5 to 4.4 was considered high agreement and 4.5 to 5.0 was considered highest agreement. Also, a mean score of 1.0 to 1.4 was least relevant, 1.5 to 2.4 was less relevant, 2.5 to 3.4 was moderately relevant, 3.5 to 4.4 was relevant, and 4.5 to 5.0 was most relevant. In all, to answer the research questions, frequencies, percentages, means, and standard deviations were used to analyse the quantitative data.

3. Results

Using the CIPP model to evaluate a curriculum, three out of the four areas were examined. These were the context, input, and process evaluation components of CIPP. The research questions were directed towards these areas of the CIPP model. The results from the collected data are presented for these areas. Results based on the datasets obtained from both teachers and students were grouped and merged for presentations and discussions.

3.1 The context of introduction of the SHS chemistry curriculum

Research Question One sought to examine the context in which the chemistry curriculum was implemented in the SHS. The teachers were asked to state the rationale for teaching the chemistry curriculum. This was to tell if the teachers could pinpoint them. It was apparent that some of the teachers did not know the rationale behind teaching the SHS chemistry. Of the seven teachers, four had difficulties pointing out the rationale. For instance, one of the teachers mentioned that

> *"The subject was implemented in schools because it was part of the curriculum."* (Teacher, Joshua)

Another teacher, after checking on the rationale for teaching chemistry using this mobile phone internet mentioned that

> *"It is to enable individuals offering the subject in the SHS level to be able to reason and use chemical knowledge to build explanations, justifications or arguments."* (Teacher, Boni)

Some were confused about the rationale of the SHS chemistry curriculum and the aims and objectives of the curriculum. One of the teachers quizzed,

> *"Rationale? You mean the objectives?"* (Teacher, Nado)

On the part of the objectives, some teachers said they taught the subject based on the aims and objectives indicated in the curriculum. However, they cannot precisely determine their needs and objectives. While Teacher Boni had to check the chemistry curriculum on his phone to enable him to read out the objective, Teacher Joshua attempted to state the objectives. Surprisingly, he provided a definition of chemistry instead of the objectives. An excerpt is:

> *"The objectives are the composition and properties of matter as well as the changes matter undergoes."* (Teacher, Joshua)

Teacher Nado acknowledged that, although he was not familiar with the aims and objectives of the curriculum, he conducted teaching based on what the content demanded. Some of the teachers believed that the subject was taught because various SHS in Ghana implemented it. It was clear from the responses of almost all the teachers that they could not exactly point out the needs and objectives for which the chemistry curriculum was being implemented.

On Items 7 and 8, which were on whether chemistry is related to other subjects and whether it is relevant, all the teachers interviewed indicated that it has a relationship with other subjects and that there was a need to study chemistry. Excerpts are

> *"It is related to integrated science, physics, and biology."* (Teacher, Joshua)

> *"Medicine, pharmacy, physics, biology, …. yea, yes, several sciences related subjects are related to chemistry."* (Teacher, Jafor)

For the need to study chemistry, all the teachers interviewed affirmed the need to study chemistry at the SHS level. An excerpt is:

> *"Yes, there is a need for chemistry to be taught at the SHS level because it is a central science discipline and links with so many areas."* (Teacher, Abigail)

Item 9, which sought teachers' views on whether the chemistry curriculum was relevant to the nation's development, all the teachers interviewed affirmed it was relevant. Five of the seven teachers (71.42%) mentioned some likely areas of the job market in which students who acquired knowledge of chemistry could work. Excerpts are:

> *"Yes, the subject is relevant to national development as it offers a lot of opportunities. For instance, the knowledge in learning the subject provides grounds for individuals to work in institutions such as health services, chemical industries, and petrochemical industries. etc. which will help promote or improve the development of one's nation."* (Teacher, Joycelyn)

> *"Yes, you know students with chemistry knowledge can go to nursing, teaching, and medicine. Yes oh! we can talk about them working as pharmacists. Working in all these areas means that they will contribute to promoting national development. All these areas without a chemical background cannot fit well. That is it."* (Teacher, Nado)

> *"Prepares the fundamentals for such students to fit into areas such as nursing, engineering and those other areas."* (Teacher, Joshua)

Similarly, to the teachers, a greater proportion of the students' suggested that chemistry was essential for Ghanaian society. The results in Table 1 showed that of the 183 students, *26*(*21.7%*) (*M=4.01; Std.=1.119*) highly agreed with the statement on the importance of chemistry to national development. The students also affirmed that chemistry was relevant to the job market under Item 9. Because *25.8%* of the students (*M=3.87, Std.=1.238*) highly agree that knowledge in chemistry is vital for the job market. Hence, the study of chemistry at the SHS is viewed by teachers and students as being of relevance to Ghanaian society and national development.

As part of the context evaluation, students were asked to indicate the level of relevance of various topics in the chemistry curriculum to national development and job opportunities. The results are shown in Figure 1. Across the topics, most students noted that they were relevant. From Figure 1, the chemistry and industry, introduction, states of matter, atomic structure, and chemistry of carbon compounds were rated as most relevant as they rated 70% and above. However, inorganic chemistry and basic biochemistry were the least in terms of most relevant in the perspective of students. Because students rated them most relevant below 60%.

Table 1: Proportion of Students' Level of Agreement to the Context Evaluation (N=183)

No.	Item	LWA		LA		MA		HA		HHA		M	Std.
		n	%	n	%	n	%	n	%	n	%		
5	The time used for learning chemistry is adequate	20	10.9	24	13.1	53	29.0	54	29.5	32	17.5	3.30	1.218
6	The chemistry curriculum is broad and should be divided into three: organic, inorganic and physical chemistry subjects to allow for thorough study	12	6.6	14	7.7	23	12.6	39	21.3	95	51.9	4.10	1.260
7	Chemistry should be integrated with related subjects	30	16.4	13	7.1	30	16.3	63	34.4	47	25.7	2.38	1.392
8	Chemistry is important for Ghanaian society	7	5	6	5.0	23	19.2	26	21.7	58	48.3	4.01	1.119
9	A chemistry course is needful for seeking jobs in the future	9	7.5	5	4.2	27	22.5	31	25.8	48	40.0	3.87	1.258
10	The related subject(s) make(s) the chemistry learning easier	22	12.0	35	19.1	52	28.4	40	21.9	34	18.6	3.16	1.272

Note: LWA = Lowest Agreement, LA = Low Agreement, MA = Moderate Agreement, HA = High Agreement, HHA = Highest Agreement, M = Mean, Std. = Standard Deviation

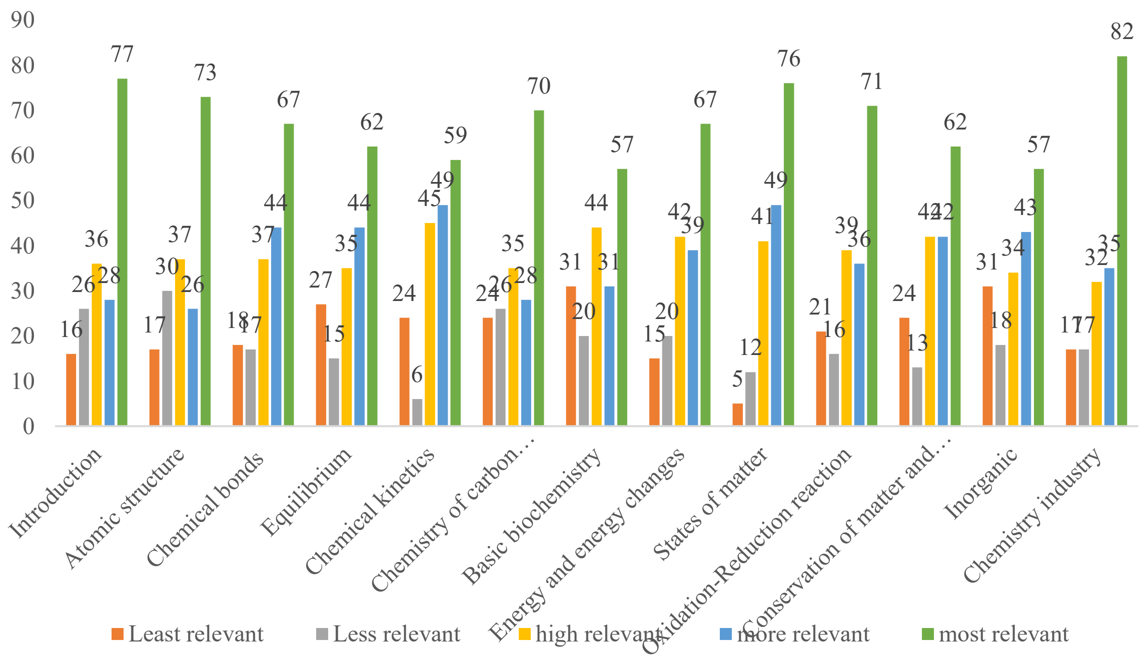

Figure 1: Students Rating of The Level of Relevance of Various Areas of the Chemistry Curriculum (N=183)

On Item 10, which sought adequacy of time for completing the curriculum, the teachers expressed a unanimous concern that the time was inadequate for the completion of the curriculum. An excerpt is:

> *"No, the period for completing the curriculum is inadequate."* (Teacher, Joshua)

For the responses of the students (Item 5 as observed in Table 1), although there were variations in their level of agreement, a greater number of them appeared to agree that adequate time was given for the completion of the curriculum. Because of the 183 students, *29.0%* (*M= 3.30; Std.=1.218*) moderately agreed that the time used for teaching chemistry was adequate. The high standard deviation value suggested heterogeneity in their responses. Consequently, to triangulate this perspective of students, Items 23 and 24, which were open-ended for students to express some of the problems they faced, and how they could be improved, respectively, were explored. The results showed that the time was inadequate for the completion of the content of the chemistry curriculum. This could be observed as a common factor mentioned by students. The excerpts are:

> *"The time for learning chemistry is limited. One will need to cover up with extra classes with some teachers."* (Student, 33, 35)

> *"The time is too small. Hence, we have extra classes here and there even during vacation."* (Student, 118)

Thus, in terms of context evaluation, the adequacy of time for the completion of the SHS chemistry curriculum is problematic, with mixed feeling in the perspective of teachers and students.

Additionally, for context evaluation, the teachers were asked whether chemistry at the SHS level should be integrated with other subjects because it is related to other subjects. Although teachers indicated that it was related to other subjects, they mentioned that it should not be integrated into other subjects. An excerpt is:

> *"… no, its content and structure should be kept as it is and not integrated. Expertise to handle when integrated with an issue."* (Teacher, Joshua)

This perspective of teachers was seconded by their students. Because the results in Table 1 showed that of the 183 students, *7.1%* (*M=2.38, Std.=1.392*) lowly agreed that chemistry should be integrated with other subjects. The high standard deviation suggested that there was high variability in the agreement of students. Consequently, an open-ended Item 24 was used to further examine the possibility of integration of chemistry in other subjects. The broad nature of the chemistry curriculum was a major concern because students felt it should not be integrated. The excerpts are:

> *"It could be laudable to have chemistry integrated but chemistry is very broad."* (Student, 35)

> *"It is quite broad and complex to think of as integrated. Chemistry should be a stand-alone subject with its application seen in other subjects."* (Student, 71)

Nonetheless, the students felt under the context that if the subject is to be studied alone, it should be broken down into its various branches: organic, inorganic, and physical areas to allow for thorough study, rather than its holistic nature in the SHS curriculum. Because *21.3%* of the students (*M=4.10, Std.=1.260*) highly agreed that chemistry should be separated into its broad areas even at the SHS level to ease students' learning. However, there was a high variability in the perspective of students, as there was high standard deviation accompanying the mean of the distribution.

3.2 The input guiding the implementation of the SHS chemistry curriculum

Research Question Two examined the inputs put in place to guide the implementation of the 2010 SHS chemistry curriculum. To address this research question, views were sought using 12 items from CCEIS and five closed-ended items and two open-ended items from CCEQ. The general idea here was to study the materials and human resources available to aid the implementation of the chemistry curriculum.

On Item 11, which sought information on the background characteristics students needed to bring on board to facilitate the implementation of the chemistry curriculum, varied views were shared by the chemistry teachers. Three of the seven teachers (*42.9%*) mentioned that students needed to be able to read and understand as well as do basic mathematical computations. An excerpt is

> *"If the students will learn well in the chemistry program, from the JHS level to SHS, they should be able to read and know some simple mathematics. Because in chemistry, there are concepts you need to explain, and some calculations are also there."* (Teacher, Boni)

This knowledge of language and mathematics is needed for students to reason well. An excerpt is:

> *"… the student should be able to reason and think smart and have a background relating to the subject. Hence, strong basic knowledge in basic language and mathematics is a good starting point."* (Teacher, Joshua)

Also, teachers felt that the prior knowledge the students have should be comprehension and manipulative abilities in science, attained from their previous learning. Five of the seven teachers, *71.4%*, expressed virtually this same idea. An excerpt is

"… at least they should have basic knowledge in understanding and manipulating activities learned in science at the basic level of their education." (Teacher, Joycelyn)

However, the teachers in this study indicated the students they had taught, and most of them lacked these skills.

Teachers indicated that what motivates students to learn the subject is the numerous career opportunities that come with learning chemistry. An excerpt is:

"Learning chemistry at this level is good … because of the career opportunities and the advantages that it offers." (Teacher, Joshua)

Notwithstanding the opportunities associated with learning chemistry in the SHS two of the seven teachers, *28.6%*, believed that some students learn the subject because of the examinations conducted by the examination council, West African Examination Council (WAEC). An excerpt is:

"WAEC examinations are also part of the reasons they learn chemistry, especially those who want to do medicine and other related areas." (Teacher, Joycelyn)

On the part of the students, as observed in Table 2, *24.0%* of the students (*M=3.72, Std.=1.272*) highly agreed that they were self-motivated to learn chemistry in the SHS. In part, students were motivated by the fact that learning chemistry will direct and guide their industrial paths. Because *25.7%* of the students moderately agreed to this perspective (*M=3.31, Std.=1.299*).

When teachers were asked whether the objectives stated in the curriculum could be achieved in 3 years (Item 15), they unanimously indicated no, citing the broad nature of the curriculum, while others cited the current nature of the structure of the educational system at the SHS level. That is, in the current senior high school, students spend more time at home than at school to meet the shift policy of containing the large number of students, which further exacerbates the attainment of the curriculum objectives. The excerpts are:

"No, it wouldn't be possible because there are many objectives to be achieved. The truth is that the curriculum is broad." (Teacher, Joycelyn)

"Oh no! The way students come to school for only a month because of the double track system to manage the large numbers, I don't think that is possible. Have our leaders taught this? Maybe, they themselves do not even want us to achieve the objectives." (Teacher, Abigail)

For the students, it can be observed from Table 2 that *15.8%* of the students (*M=2.87, Std.=1.297*) were of moderate agreement that the time allocated for teaching chemistry in school was inadequate. The high standard deviation around the agreed mean could also suggest that students were heterogeneous, perhaps because of the different status of the schools. Notwithstanding that it was moderate agreement, it meant that most of the students perceived that the time was not sufficient to achieve the objectives of the chemistry curriculum.

In another perspective, the teachers were divided in their opinions on whether the content was clearly stated in the instructions (Item 16). Of the seven teachers interviewed, *71.4%* indicated yes, and *28.6%* indicated no. When probed further, none of them was able to provide specific reasons to substantiate their opinion. That is, it appeared that they did not have knowledge about the alignment of the content of the curriculum to the instructional activities and materials, or they had forgotten. Despite this, all the teachers affirmed that the content matched the abilities of the students (Item 17). The excerpts are:

> *"Yes, the content matches the students' abilities. If you look at the curriculum, we are not expected to go very deep at this level."* (Teacher, Nado)

> *"I think what is in the curriculum now is not too detailed, it is not above their understanding level."* (Teacher, Joshua).

The teachers mentioned that, as part of the knowledge, skills, and attitudes that a teacher needs to implement the curriculum (Item 18), teachers should have studied chemistry as a subject or chemistry-related subject and its pedagogy in their teacher preparation programs in the teacher education universities. An excerpt is:

> *"For knowledge to be able to teach chemistry, then you should have studied chemistry and methods of teaching it in the university."* (Teacher, Joycelyn)

Some of the teachers, *71.4%,* mentioned that a teacher needs to have a positive attitude and be collaborative to learn from others. When probed further, it came to light that the best way to ensure collaboration is to be involved in both formal and informal professional development activities relating to teaching chemistry. The excerpts are:

> *"… an effective teacher should collaborate with other teachers and science colleagues to implement techniques to improve instruction in chemistry. As such, you must have good communication skills, instructional skills, and should also be able to manage time, solve related problems, etc."* (Teacher, Nado)

> *"I think the teacher needs to have a positive attitude and have good knowledge of the subject matter, and this can be achieved when we learn from one another as professionals."* (Teacher, Abigail)

On attitude, *28.6%* of the teachers expressed that they lacked interest in chemistry. Because chemistry is so difficult to transform into certain knowledge for some students who are generally weak academically. An excerpt is:

> *"I like chemistry but the way the students are these days makes me feel bored and uninterested in teaching the subject. One thing, they are weak academically, and another is they don't even want to put in effort."* (Teacher, Joshua)

To compare the chemistry students' population with the population of students in the other subjects (Item 19), all the teachers expressed that there were fewer students offering chemistry than those offering other subjects. Some of the teachers, *57.1%*, mentioned that some students were offering the subject because their programs of study made chemistry a compulsory subject, and that some chose those programs without knowing chemistry was part of the program. An excerpt is:

> *"… comparatively, few students are offering chemistry and those we even have there, most of them are there because of the programs they selected. Some did not; no chemistry was part. An example is the agricultural students doing chemistry."* (Teacher, Boni)

Some of the students acknowledged that they were studying chemistry because it was part of a program they were pursuing. Excerpts are:

> *"It was never a choice but a compulsory one. All science students or those taking science-related programs are supposed to study chemistry in my school."* (Student, 35)

> *"It was never a choice; it was a compulsory elective subject. They say I need it for my university course, but I do not think so."* (Student, 33)

Table 2: Proportion of Students' Level of Agreement to the Input Evaluation (N=183)

No.	Item	LWA		LA		MA		HA		HHA			
		n	%	n	%	n	%	n	%	n	%	M	Std.
11	I motivate myself for learning chemistry	14	7.7	19	10.4	38	20.8	44	24.0	68	37.2	3.73	1.272
12	Learning chemistry direct and guide my path for industries	21	11.5	29	15.8	47	25.7	44	24.0	42	23.0	3.31	1.299
13	I think the time allocated for teaching and learning chemistry is enough	34	18.6	42	23.0	42	23.0	43	23.5	22	12.0	2.87	1.297
14	There are adequate number of teachers for teaching chemistry in this school	36	19.7	23	12.6	34	18.6	50	27.3	40	21.9	3.19	1.426
15	There are enough textbooks to help students	35	19.1	33	18.0	49	26.8	41	22.4	25	13.7	2.93	1.312

	to understand the topics taught.												

Like fewer students offering chemistry in relation to other non-science subjects, fewer teachers are available to teach the subject (Item 20). In some instances, only two chemistry teachers were available to teach chemistry to all the students learning the subject in that school. The maximum number of teachers, as indicated by the teachers interviewed, was four in a school. On the part of the students, *18.6%* of the 183 students (*M=3.19*, *Std.=1.426*) showed moderate agreement that they had an adequate number of teachers teaching chemistry in the schools. Hence, it could be said that there is an inadequate number of human resources needed for the implementation of the SHS chemistry. However, the large side of the standard deviation suggested a high variability in the agreement of the number of teachers teaching in each school.

On Items 21 and 22, which sought the reference materials and other resources available to teachers for the implementation of the 2010 chemistry curriculum, some of the teachers, *57.1%*, listed chemistry GAST and a well-equipped chemistry laboratory as the materials and resources required for teaching chemistry. However, teachers responded to Item 23 that these materials, which are essential for teaching chemistry, were either not there or inadequate. That is, *85.7%* of the teachers expressed that there is an inadequacy in the number of equipment teachers use in implementing the chemistry curriculum. An excerpt is:

> *"Lack of adequate teachers, and again, the laboratory is inadequately equipped in terms of space, apparatus, chemicals, and others. We teachers, at times, find it a bit problematic to push and push the resources. If a teacher is fortunate, they get some resources getting close to the final examinations."* (Teacher, Joshua)

From Table 2, *26.8%* of the students (*M=2.93*, *Std.=1.312*) were of moderate agreement that there were enough textbooks to help them learn the topics for understanding, despite a greater number of them responding otherwise. In addition, the students' responses on the availability of resources and problems of learning chemistry in the SHS showed that there are inadequate material resources in schools for students to learn chemistry. Excerpts are:

> *"Nothing, we are suffering, please help us."* (Student, 43)

> *"Textbooks and a little equipment. Truly, they are not sufficient, and that affects how many times we interact with materials to learn chemistry"* (Student, 057)

3.4 How effective is the process by which the SHS chemistry curriculum was implemented?

3.4.1 Process evaluation

Items under this construct sought to determine how the curriculum was implemented. In total, six items on the teachers and four items on the students were used to answer this research question.

Item 24 was posed to elicit information on how students participated in lesson delivery. Because the chemistry curriculum recommended participatory teaching approaches, which would allow students to participate actively. Various responses were also recorded. Some of the teachers indicated that their students participated well in lesson delivery. Excerpt is:

> *"Students' participation in learning chemistry is good."* (Teacher, Boni)

However, other teachers have indicated that the absence of teaching resources hampers the use of instructional strategies that actively engage their students in instructional participation. An excerpt is:

> *"The way chemistry is abstract, you need materials to always give them something to interact with to keep them actively involved in the lesson, but there is no TLM. Hmmm, there is always a struggle to actively engage students."* (Teacher, Abigail)

On the part of the students, most of them [from moderate to highest, 132(*72.13%)* at (*M= 3.38, Std. = 1.377*) affirmed that they interacted with their teachers during chemistry lessons and that they [from high to highest, 152(*83.06%*)] showed seriousness during chemistry lessons. Most of the students [from highest to lowest, 123(*67.21%*)] also indicated that they took their lessons in the laboratory. It is also worth noting that a significant number, 60(*32.79%*), showed the lowest to low agreement that they took their lessons in the laboratory. Observations of some of the schools revealed that they had laboratories, but the students were taught in their classrooms with little or no participatory approaches.

When the students were asked about the problems they faced, they (52 of the 183) indicated that they hardly took practical lessons, as it was also noticed from 15 of the 183 students that their teachers were very strict and made chemistry lessons boring. Largely, it could be said that chemistry lessons were not taught using the participatory approach.

On finding out the problems encountered during the implementation of the curriculum (Item 25), some (three of the seven) of the teachers stated that students who come to study chemistry in recent times have low cognitive abilities and have difficulties comprehending concepts. An excerpt is:

> *"The students, most of them, are weak academically."* (Teacher, Joycelyn)

Some (two of the seven) indicated that students' attitudes toward learning the subject were a challenge. They indicated that students were never committed to studying the subject. An excerpt is:

> *"The way students show seriousness in learning the subject is not good. Sometimes you give them an assignment, then they will go and put it down until the next day when they have lessons, and they now want to do it. Some come to class to tell you they did not come with their books."* (Teacher, Abigail)

Some of the teachers mentioned absenteeism as a problem, noting that, despite it being boarding schools, too often, students take permission to go home while some come up with excuses to stay away from class, with female students used as the example. An excerpt is:

> *"Most of the students like taking permission home and missing classes. Most of the females come in the name of having their menses and not taking part in lessons. All these affect how they learn the subject."* (Teacher, Nado)

On the part of the students, they indicated an array of issues regarding the problems they faced in learning chemistry, including inadequate textbooks, inadequate laboratory equipment for the practical and difficult nature of the subject, and teachers' inability to make lessons practical, and chemistry as a very difficult subject, among others. Excerpts are:

> *"My teachers were very bad, but now they are okay."* (Student, 003)

> *"Most topics are abstract. It is very difficult to understand topics because they are mostly hypothetical and difficult to visualise. Most information is foreign to the natural environment, and we are forced into memorising numerous chemistry concepts without really understanding."* (Student, 001)

> *"It is difficult to get hold of the theories since we can't literally see anything as to how practical it could be. Chemistry, if the majority were honest, is the challenge in our classes."* (Students, 026)

For Item 26, which sought to determine whether the teaching and learning process was evaluated and perhaps how it was done, all the teachers interviewed indicated yes. While some of the teachers used only formative evaluations, others used summative evaluations, or both. Some of the evaluation forms they used are stated in this excerpt:

"Yes, students are given oral questions to react to at the end of every lesson. Again, they were given a written test in the form of class tests, homework, end-of-semester examinations, etc." (Teacher, Joshua).

Almost half of the students affirmed that they did not receive continuous tests and examinations to equip them with knowledge of chemistry. From Table 3, of the 183 respondents, 77 (*42.08%)* at (M= 2.83, Std. = 1.396) showed the lowest agreement compared with 106 (57.92%).

On Item 27, most of the teachers affirmed yes, but when they were probed further, no specific issues were raised. How the teachers and students cooperated in their lessons was sought using Item 28. It came to bear that the students cooperated well with the teachers for lesson delivery. Although not much information was obtained, the teachers did not explain themselves in detail.

Some of the teachers indicated that they used the lecture method approach to deliver most of the subject's content, arguing that the materials were not available. An excerpt is:

"I have organised my notes into a notebook, and when I go to class, I try to use marker board illustrations and explain to the students. But some of the concepts are abstract, and that always becomes challenging. But I try to explain to students." (Teacher, Boni)

From the teachers' perspective, it was established that besides the lecture, teachers use discussion methods which help elicit students' attention during teaching and learning. Some of the teachers indicated that they read about the content to be delivered and conducted necessary research to buttress whatever they wanted to teach before the delivery day. However, some teachers indicated that they took their students to the laboratory where demonstrations were used to aid their explanation of concepts. However, when it came to the practical part of chemistry, after demonstrations, they allowed their students to practise. The excerpt is:

"I usually take my students to the laboratory.
… Here, you can do demonstrations to help students understand you better. For the practical part, when I demonstrate, it allows the students to do the same." (Teacher, Nado)

Observations of four of the teachers' lessons showed that they practically give notes to students (exposition), focusing on explaining concepts and interacting and guiding students to explain concepts. Hence, students interacting with teaching and learning resources in the laboratory as claimed by the teachers was absent in all the observations we made. From our field notes, everything showed that teachers indeed do much of the laboratory work, practically, when students are in the third year of their 3-year stay, preparing towards final examinations.

Item 30 on the CCEIS sought the teachers' overall view of the effectiveness of the SHS chemistry curriculum, given the context, input, and process of the implemented chemistry curriculum. Of the seven teachers, three rated the chemistry curriculum as ineffective on average, based on the assessment of context, input, and process. In percentage terms, one of the teachers rated the chemistry curriculum 68% ineffective, noting that much more work needs to be done, and that the 32% rating of effectiveness is attributed to the fact that, despite the numerous shortfalls, we are producing graduates using the same curriculum. An excerpt is:

> *"Overall, we are producing people who have passed through this chemistry curriculum. To some extent, I rate this to be approximately 68% ineffective. That is because we just have a whole lot of work to be done."* (Teacher, Joshua)

Boni, another teacher, rated the entire curriculum as 50% effective and lamented that the structure and organisation of the current chemistry curriculum were too broad for this level. That is, there were too many concepts to be covered within a 3-year period in the SHS. His suggestion to improve the curriculum is for the developers to reduce the content expected to be covered in 3 years. An extract from the interview with him is:

> *"If there is something semi-effective, I will go for that one … I see the content as being broad, especially the organic aspect of it, it's broad. The functional groups they need to learn at this level, and I think planners can do better by removing some of them. I do not see the reason why at the SHS, someone will learn something beyond the hydrocarbons, where they will study single, double, and triple bonds and their reactions. To any extent, maybe one or two additions to that, but why will they learn the carboxylic functional groups and carbonyls, such as aldehydes? Is too broad, and for me as a teacher, I do not even like it. So, they can remove some, … if any child develops interest and goes to the university or college, he/she can learn that."*

Table 3: Proportion of Students' Level of Agreement to the Process Evaluation (N=183)

No.	Item	LWA		LA		MA		HA		HHA		M	Std.
		n	%	n	%	n	%	n	%	n	%		
16	There are continuous testing and examinations to equip me on the knowledge of chemistry.	45	24.6	32	17.5	45	24.6	32	17.5	29	15.8	2.83	1.396
17	I interact well with my teacher during lessons on chemistry	23	12.6	28	15.3	43	23.5	35	19.1	54	29.5	3.38	1.377
18	I show a lot of seriousness during chemistry lessons	23	12.6	8	4.4	41	22.4	46	25.1	65	35.5	3.67	1.336
19	We take our lessons in the chemistry laboratory	29	15.8	31	16.9	41	22.4	39	21.3	43	23.5	3.20	1.389

4. Discussion

The finding on context evaluation that the teachers lacked a clear comprehension of the rationale for enacting the SHS chemistry curriculum, where the objectives of the curriculum emanate, is a cause for concern. Because rationale informs the curriculum objectives, both general and specific (Ministry of Education, 2010) and affects how the content will be transmitted by a teacher. It is expected that teachers, as implementers of the curriculum, should visit the rationale as well as the general aims and objectives to guide them in their lesson preparations and delivery, drawing students' attention to this rationale and its objectives. NaCCA, the agency spearheading the reforms in chemistry education, should therefore organise professional development programs, where teachers' knowledge of curriculum rationale, general aims, general objectives, and specific objectives, as well as other front-matter materials, will be enriched, as they enact the content of the chemistry curriculum. Again, the finding that learning SHS chemistry is relevant to the job market and national development, here in our Ghanaian society, is an indicator that the curriculum has not outlived its usefulness. Perhaps minor changes could be made, but abandoning the entire curriculum to go for a new one (Deshpande, n.d.) might not be the best way to go. As Okrah et al. (2020) reported, the Ghanaian SHS chemistry curriculum is relevant in instilling attitude but irrelevant in providing the knowledge that employers need. Hence, curriculum planners and reviewers may review the current SHS curriculum to ensure that this knowledge gap in chemistry education is taken care of. That is, the knowledge obtained from any SHS chemistry curriculum should be applicable in the job market and in addressing societal problems, as a key purpose of education. Moreover, findings on the nature of the chemistry curriculum also call for concern. Because the implementers (the teachers) view that chemistry is broad, notwithstanding its relevance to society. Hence, according to teachers, there is no need to integrate chemistry concepts into other related disciplines, contrary to the learners who think it should be either integrated or broken down into areas for thorough learning.

Moreso, the finding that topics such as introduction to chemistry, atomic structure, chemistry of carbon compounds, states of matter, and chemical industries are highly relevant, however, basic biochemistry, chemical kinetics, and inorganic are less relevant, cannot go unmentioned. That is, researchers and educators in chemistry should therefore reassess the chemistry curriculum vis-à-vis national development needs. Also, curriculum evaluators can begin to examine the impact of each chemistry concept on the cumulative contribution of others to determine whether there is a need to maintain or discard some topics. In view of these findings, it is established that teachers lack comprehension of the rationale and objectives of the SHS chemistry curriculum, the SHS chemistry curriculum is relevant to national development, some of the topics need to be re-examined, and integration and segregation of the curriculum are options available for curriculum planning and decision-makers to consider the context of the SHS chemistry curriculum. These findings are expected to support curriculum planners, developers, educators, and stakeholders in decision-making (Vishnupriyan, 2017).

Under input evaluation, the finding that as part of students' background characteristics, they need to possess basic mathematical knowledge and have learned some basic concepts at the junior high school level, is in line with the expectations of the planners of the SHS chemistry curriculum, who note that for a successful study of the SHS chemistry curriculum, students need basic mathematical knowledge and should learn some concepts from basic science (Ministry of Education, 2010). However, this study established that most students who come to study chemistry lack these basic concepts. This means that a considerable amount of time needs to be taken to take students through basic concepts and some basic mathematics before progress can be made on each topic. This might also be why teachers indicate that the objectives of the curriculum could not be achieved within 3 years. Perhaps NaCCA (now CRDD) did not anticipate this, and so provisions were not made for these emerging issues. If the objectives of the curriculum cannot be achieved within the stipulated time, it implies that its relevance cannot be felt as established in the context of evaluation and will require revision (Taş & Duman, 2021). It could then be proper to say that students' view of curriculum should either be integrated into the other related subjects, or it should be broken down into the areas of inorganic, organic, and physical chemistry, and enough time should be given for second thought by curriculum planners and developers.

It is also worth noting that teachers have the qualifications needed to enact the curriculum and have knowledge of some of the pedagogical approaches to enacting the curriculum. The pedagogical approaches are mostly participatory, which is in line with what the NaCCA requires teachers to use to instruct their lessons. However, teachers barely apply them in chemistry lessons. This implies that the human resources as an input needed for the enactment of the chemistry curriculum are available, only needing some specific professional development in effective contemporary pedagogies. This should be a platform that will ensure continuous professional development to keep teachers' knowledge up to date (Darling-Hammond et al., 2009; Darling-Hammond, 2017). It is possible that this, in part, could help address the finding that teachers had poor attitudes towards the implementation of the curriculum despite their qualifications.

The finding that the population of chemistry students is small compared with other subjects also comes to mind and calls for serious attention to be paid to it. If possible, in the revision of the curriculum, it must be factored into, how to attract a greater number of students. Because learners are the target of the curriculum, chemistry teachers should use their transformation of content knowledge to attract students. It should be noted that we cannot design a curriculum and have no students to implement it. Hence, policymakers should also put measures in place to attract students, in particular the girl child, to chemistry and its education. Thereby contributing to the fulfilment of SDG5 (Gender Equality). Though teachers are seen as professionally qualified, what is also of concern is that fewer teachers are available for enacting the curriculum in schools. We cannot achieve effective chemistry curriculum implementation if those who are to enact it are unavailable.

The finding that the resources available for enacting the curriculum are textbooks and laboratories, cannot be forgotten. Chemistry is a subject with abstract concepts (Johnstone, 2000), and, as such, its instruction needs to lean itself to practical work or activities. Again, both teachers and students need these resources to function well in the enactment of the chemistry curriculum. No curriculum can be implemented effectively if resources are unavailable, not to mention chemistry concepts with three levels of representation (as macroscopic, sub-microscopic, and symbolic levels), which require instructional resources of various kinds to achieve. This shows a lack of or an inadequate number of these resources, which raises a concern regarding how teachers are enacting the curriculum. This calls for a review of the chemistry curriculum by the policy makers. Under process evaluation, the finding that teachers do not use participatory approaches is an affront to what is expected to be done in delivering the SHS chemistry curriculum (Ministry of Education, 2010). Perhaps this could in part explain why the curriculum is not achieving its rationale, thus making it ineffective. This could be one of the reasons the cognitive development level of students in chemistry is low. As it were, the planners of the curriculum of the firm believe that a precipitating teaching and learning approach is required for effective enactment of the SHS chemistry curriculum. This will ensure that the curriculum is tailored to meet students' cognitive development level. In addition, the teachers paid attention to assessments, although they focused more on summative assessments than formative assessments. Tuju et al. (2022) asserted that if limitations in the enactment process are identified, it requires the curriculum planners and developers to change the delivery plan, which could be looked at now. Because the Ghanaian SHS curriculum has been reviewed since 2019. These findings on the shortcomings in the curriculum are also available for decision makers to know the areas to focus on (Lam, 2017; Tuju et al., 2022). The findings address the difficulties in implementation decisions (Ornstein & Hunkins, 2009).

The finding of the overall assessment of the curriculum by the teachers that the chemistry curriculum is, to a greater extent, ineffective cannot go unnoticed. If a curriculum, upon implementation, is not yielding the desired results, a decision could be taken to revise or discard it (Deshpande, n.d.; Glatthorn et. al., 2012). In the case of this curriculum, a revision is more appropriate, as the entire curriculum is not weak. Some areas in the context, such as the relevance of the curriculum to the job market, in the input component, areas such as the teacher's qualification, physical infrastructure, among others, could be maintained.

5. Conclusion and Implications

This research evaluated the 2010 chemistry curriculum used in the SHS, with the CIPP model as the mean evaluation model. This was achieved through an interview of seven chemistry teachers and 183 students responding to a questionnaire. The views of teachers arrived at through open coding and constant comparison were triangulated with perspectives of students in the form of means, standard deviations, and percentages.

Based on the findings of the context evaluation, the SHS chemistry curriculum is relevant to the job market and national development if it is adhered to. However, its weakness is that teachers lack comprehension of the rationale and objectives which will drive its implementation. This research has added to the literature that teachers are a key component of successful implementation of a curriculum, but in their attempt to enact the curriculum, they lack knowledge of the need for teaching and learning chemistry in the SHS to the Ghanaian society. It is, therefore, suggested that curriculum developers, such as NaCCA, should institute continuous professional development on the need of chemistry education in the SHS. In doing so, teachers will have much knowledge and understanding of the rationale and its attendant aims and objectives.

There are inadequate resources (both human and material) for the effective implementation of the SHS curriculum. The teachers in this study had the required qualifications to implement the curriculum, but only a few were available to accomplish the task. Materials resources, such as science laboratories, are not adequately resourced, even in endowed schools, although they appear to be better resourced when compared with less endowed schools. The implication is that the lack of these resources has a cascading effect, as it will affect the process of implementation, and the outcome will be affected, as students will perform poorly in assessments. The Ministry of Education, in collaboration with the development partners, should therefore provide schools with well-equipped chemistry laboratories and support the training of more teachers in the teacher education universities to augment the existing human resources in the implementation process. In addition to immediate intervention, chemistry teachers should make good use of the ultra-modern STEM schools in their catchment areas to make teaching and learning more meaningful to students.

In terms of process evaluation, the curriculum needs to be reviewed to meet contemporary demands in chemistry education. Teachers implementing the curriculum know the right pedagogies to use, but adherence to these pedagogies is problematic. The subject is taught more theoretically than practically. It is suggested that the curriculum be reviewed by the policy makers, emphasising more on the participatory teaching of the subject.

Authorship Contribution Statement

Kenneth Adu-Gyamfi conceptualised the research, developed the methodology, analysed qualitative data, discussed the findings, and wrote the conclusion of the manuscript. He is the corresponding author. Isaiah Atewini Asaki developed the literature review, contributed to the methodology, led data collection, and contributed to data analysis and result presentation. Joyce Delali Mawutor conducted the literature review, piloted research instruments, analysed quantitative data, and proofread the final manuscript.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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