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Perspectives of Schools Heads on Science and Mathematics Teachers' Continuous Professional Development in Ghana

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Abstract
This study investigated the perspectives of heads of Senior High Schools (SHSs) on the participation of Science and Mathematics teachers in Continuous Professional Development (CPD) in Ghana. It was guided by objectives that examined available CPD opportunities and their perceived influence on teaching using a convergent parallel mixed-methods design. Data from 157 Heads of SHSs, collected via a questionnaire and an interview schedule, were analyzed using descriptive statistics and thematic analysis. Heads of SHSs viewed CPD as crucial for instructional improvement, identifying general initiatives, subject-specific workshops (GAST, SMASE-WESCA), ICT training and content mastery as vital for enhancing pedagogy, subject knowledge and digital literacy. CPD was also seen to promote student-centred instruction, classroom delivery and formative assessment. The study highlights the evolving needs of STEM instruction and CPD's role in bridging pedagogical gaps, emphasizing inclusive, context-sensitive and practice-oriented frameworks with structured policies and follow-ups.

Keywords: Continuous Professional Development; SHSs; Mathematics; Science Teachers.

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Introduction

Continuous Professional Development (CPD) is recognized as a critical tool for enhancing teachers' professional competencies, ensuring that they remain updated with evolving pedagogical trends and subject knowledge. In many education systems worldwide, CPD is systematically implemented to address teaching challenges and improve learning outcomes (Nkundabakura et al., 2024; Nyaaba et al., 2023; Abreh, 2018; Rossiter et al., 2023). Countries, such as Finland and Singapore, have well-structured CPD frameworks that emphasize collaborative learning, instructional coaching and subject-specific training (OECD, 2019). In contrast, in many developing nations, including Ghana, CPD provision is often inconsistent, lacks clear structures and is sometimes misaligned with teachers' needs (Abakah, 2023; Salifu et al., 2024; Kumi-Korsah, 2021).

Heads of Senior High Schools (SHSs) play a crucial role in facilitating and overseeing CPD initiatives within their schools (Rahman et al., 2024). Their perceptions influence the extent to which CPD is prioritized and effectively implemented, and so their perspectives facilitate discourses leading to advantageous

engagement (Ellis, 2025; Ewulley et al., 2023). Research suggests that CPD opportunities for teachers in Ghana, including those in Science and Mathematics, are often sporadic and lack a structured framework (Frimpong, 2018). Kumi-Korsah (2021) found that teachers in Ghanaian pre-tertiary institutions viewed CPD as formal, but it was revealed that training sessions organized by schools and education authorities were infrequent.

These sessions, though valuable, are largely teacher-passive and heavily content-focused, limiting their impact on broader instructional strategies and pedagogical skills. Similarly, Abreh (2018) reported that while CPD opportunities existed for Science and Mathematics in Ghanaian secondary schools, there was no standardized scheme guiding their provision. Some schools offered periodic, subject-based training while others lacked a structured CPD framework, resulting in inconsistencies in professional development experiences among teachers.

While Kumi-Korsah (2021) and Abreh (2018) examined CPD through the lenses of teachers and department heads, the views of Heads of SHSs remain under explored. Given their roles in resource allocation, curriculum oversight and instructional supervision, understanding their perspectives is critical to improving CPD in Science and Mathematics education. Moreover, Ghana's socio-cultural and linguistic diversity underscores the need for socially responsive and pedagogically competent teachers that CPD provides (Anlimachie et al., 2025).

Globally, CPD is regarded as vital for enhancing teaching quality, promoting instructional innovation (Ambon et al., 2024; Petar, 2024) and improving student outcomes (Nyaaba et al., 2023). High-performing systems design CPD to build both subject knowledge and teaching competencies, equipping teachers to meet evolving educational demands (Darling-Hammond et al., 2017). However, in Ghana, the perceived effectiveness of CPD, particularly from the perspective of Heads of SHSs, remains insufficiently studied. Kumi-Korsah (2021) noted that while CPD in Ghana aims to enhance content knowledge and pedagogy, it often lacks interactivity and has limited influence on teacher creativity and efficacy. Similarly, Abreh (2018) found that although HODs believed CPD helped in syllabus completion and curriculum alignment, its overall impact was limited by the absence of continuous and structured support. Heads of SHSs, however, oversee CPD from a broader institutional perspective, with implications for school-wide instructional quality, student engagement and academic performance (Bendtsen et al., 2022).

Although existing studies have shed light on CPD from the viewpoint of teachers and HODs, the strategic insights of Heads of SHSs, who manage CPD planning, funding and evaluation, remain largely unexplored. This study addressed that gap by examining their perceptions of CPD availability, accessibility and effectiveness in enhancing Science and Mathematics teaching. By integrating their perspectives, the study contributes to efforts aimed at designing more structured, continuous and productive CPD programs that align with both teacher needs and national educational priorities.

Literature Review

This section reviews the theoretical and empirical literature relevant to the study. It begins with the theoretical underpinnings. It proceeds to discuss existing empirical studies on CPD, with a focus on Science and Mathematics teachers in the Ghanaian senior high school context.

Theoretical framework

This study is guided by the Transformative Learning Theory, developed by Mezirow (1978, 1997), which emphasizes that adult learning is most effective when it leads to fundamental changes in thinking, beliefs and behaviour (Mezirow, 2018). The theory emphasizes critical reflection and experiential learning as key processes in promoting deep, lasting professional growth. Transformative Learning Theory relates to this study as it explains how heads of SHSs, as adult learners, critically reflect on and interpret CPD opportunities available to Science and Mathematics teachers. In relation to this study, the theory provides a lens to underscore the perspectives of heads of Ghanaian SHSs on CPD opportunities for Science and Mathematics teachers for improved teaching and learning experience. It also supports an analysis of how Heads of SHSs perceive the role of CPD initiatives, challenge existing practices, promote innovative strategies, and improve teaching

effectiveness (Ghamrawi et al., 2024; Liu, 2015; Meijer et al., 2017; Namaganda, 2020; Nyaaba et al., 2023).

Empirical studies

CPD) remains a crucial mechanism for enhancing teacher quality and improving educational outcomes. In Ghana, multiple studies (Abonyi et al., 2020; Abreh et al., 2018; Abakah et al., 2022; Amponsah et al., 2023; Kumi-Korsah, 2021) have explored the scope, implementation and outcomes of CPD initiatives; however, their findings vary depending on the context, target population and methodology. Kumi-Korsah (2021), using an exploratory-sequential mixed methods approach, reported that CPD for pre-tertiary teachers was largely formal, irregular and passive, lacking consistency and long-term planning. While teachers showed gains in content knowledge and technical skills, improvements in instructional effectiveness were limited. Similarly, Abakah et al. (2022) found that CPD engagement was sporadic and poorly aligned with teachers' developmental needs in key areas such as ICT, inclusive education and research. Their study also identified systemic challenges, including weak CPD structures and insufficient school-level support, which hinder the overall effect of these programs.

Assefa and Zenebe (2024) reported that public primary school leaders in Ethiopia viewed CPD as effective for enhancing leadership capacity, benefiting from varied formats, such as workshops and specialized training. This contrasts with findings in Ghana, where contextual factors, such as educational level and policy frameworks, influence CPD outcomes. Osei-Owusu (2022), studying 97 senior high schools in Ghana, found that structured CPD positively impacted teachers' professional knowledge and student performance. Similarly, Nyaaba et al. (2023) demonstrated that CPD enhances students' engagement, satisfaction and achievement by improving teaching strategies.

Despite positive perceptions, Abreh (2018) found that CPD structures for Science and Mathematics teachers in Ghana were weak, with low participation and poor organization. Abonyi et al. (2020) cited limited resources and administrative support as key barriers to applying knowledge of CPD. Amponsah et al. (2023) identified motivation, career growth and coping strategies as factors influencing CPD participation whereas Salifu et al. (2024) highlighted systemic issues, including poor policy implementation and inadequate funding. Collectively, these studies reveal significant contradictions. While some suggest that CPD is beneficial when well-structured and responsive (e.g., Osei-Owusu, 2022; Nyaaba et al., 2023), others argue that its implementation remains ineffective, mainly due to structural, contextual or institutional weaknesses (e.g., Kumi-Korsah, 2021; Abakah et al., 2022; Abreh, 2018).

There is a notable gap in research on the CPD experiences of Science and Mathematics teachers in SHSs, despite their key role in STEM education and high-performance demands. Most studies focused on basic school teachers (Abakah et al., 2022; Abonyi et al., 2020), general pre-tertiary settings (Kumi-Korsah, 2021) or the link between CPD and students' outcomes without subject-specific analysis (Osei-Owusu, 2022). Few examined CPD from the perspective of Heads of SHSs, who play a vital role in resource allocation, supervision and instructional leadership. Their views are essential for understanding the implementation of CPD, which is expected to inform the overall outcomes of schooling activities but remains under explored. This study fills this gap by investigating the perceptions of the heads of SHSs of CPD participation for science and mathematics teachers and how these influence teaching in Ghanaian senior high schools.

Methodology

This section outlines the research design, population and sampling, data collection instruments, analysis techniques and ethical considerations that guided the study.

Design

This study employed a convergent parallel mixed methods design, which involves the simultaneous collection and analysis of both quantitative and qualitative data to provide a comprehensive understanding of the research problem (Creswell & Poth, 2016; Takona, 2024). This design was appropriate because it allowed for the integration of broad, generalizable trends from quantitative data with in-depth insights from qualitative responses, thereby enhancing the validity and richness of the findings.

Population and Sampling

The target population comprised Heads of SHSs in Ghana, drawn from 875 SHSs across the ten administrative regions. A sample of 170 SHSs was selected using a proportional stratified sampling technique, based on region and number of schools per region. From each selected school, the head was targeted, resulting in 170 participants. Questionnaire sheets were distributed to the heads of these schools, out of which 157 were duly completed and returned, yielding a response rate of 92.4%. For the qualitative phase, purposive sampling was used to select some Heads of SHSs based on experience and willingness to be interviewed. The number of qualitative participants was guided by the principle of data saturation (Fugard & Potts, 2015). In all, ten heads of SHSs were interviewed.

Data Collection Instruments

The study employed two main instruments: a structured closed and open-ended questionnaire and an interview schedule. These tools targeted Heads of SHSs, focusing on their perceptions of CPD opportunities for Science and Mathematics teachers and the perceived influence of these programs on instructional practices. The questionnaire included both closed and open-ended items, allowing for quantitative responses as well as elaboration. The interview schedule facilitated in-depth exploration of participants' contextual experiences and insights.

Validity and Reliability

To enhance the validity and reliability, both instruments were pilot-tested in four Senior High Schools in Cape Coast, for clarity, consistency and precision. For the qualitative strand, trustworthiness was ensured through member checking, external audits and triangulation in line with Creswell and Creswell's (2022) recommendations. These strategies strengthened the credibility, dependability and confirmability of the findings by minimizing bias and enhancing interpretive rigour (Frey, 2018).

Data Collection Procedure

Data was collected by 31 trained personnel, comprising 28 from the Centre for Research into Education and Development (CERED) and three from the GES Headquarters. The team underwent a one-day intensive training session, focusing on the content and administration of each instrument, ethical data collection practices and strategies for efficient regional deployment. The data collection process was carried out concurrently across all ten regions. Each regional team was equipped with introductory letters from the GES Headquarters to facilitate school access. Respondents were given 35 to 45 minutes to complete the questionnaire.

Data Analysis

Data collected from the structured open-ended instruments was coded and entered into the Statistical Package for the Social Sciences (SPSS, version 26) for analysis. Descriptive statistical techniques, specifically frequencies and percentages, were employed to analyse the demographic profile of respondents and the quantitative data, providing insights into the Heads of SHSs' perceptions of CPD opportunities and their influence on Science and Mathematics teaching. For the qualitative data, thematic analysis was conducted to identify, analyse and report recurring patterns and themes. This approach enabled a deeper understanding of the contextual and experiential perspectives of Heads of SHSs, complementing the quantitative findings and enriching the overall interpretation of the results.

Ethical Consideration

The study adhered to strict ethical standards throughout its design and implementation. Ethical clearance and authorization for data collection were obtained from the Ghana Education Service Headquarters. Introductory letters were presented at each school to inform and assure stakeholders of the legitimacy and purpose of the research. During training, data collectors were sensitized to ethical principles, including voluntary participation, informed consent, confidentiality and data protection. Participation in the study was entirely voluntary and respondents were assured of anonymity. Schools used in the pilot test were excluded from the main study to prevent bias.

Results and Findings

This section presents the study's findings, guided by research questions.

Profile of Respondents

The study surveyed 157 Heads of SHSs comprising 97 males (61.8%) and 60 females (38.2%), indicating that gender distribution

skewed towards males (see Table 1). Most respondents (86.6%) were aged 51–60 while smaller proportions fell within the 41–50 (8.2%) and 31–40 (4.5%) age brackets; only one respondent was over 60. Regarding leadership experience, 85.4% had served as heads for over a year. Similarly, 71.3% had spent more than a year at their current schools.

Table 1: Profile of Heads of Senior High Schools

Variable	Subscale	N	%
Gender	Male	97	61.8
	Female	60	38.2
Age (in years)	31-40	7	4.5
	41-50	13	8.2
	51-60	136	86.6
	Over 60	1	0.6
Years of Experience as Head of a Secondary School	Less than one year	8	5.1
	One year	15	9.6
	More than one year	134	85.4
Years as Head of Present School	Less than one year	14	8.9
	One year	31	19.7
	More than one year	112	71.3
Highest Academic Qualification	Diploma	1	0.6
	BSc	10	6.4
	BA	16	10.2
	Bed	29	18.5
	Med	63	40.1
	MPhil in Education	11	7
	MPhil (Other Fields)	4	2.5
	MSc	4	2.5
	PhD	3	1.9
	MA	12	7.6
	EMPA	2	1.3
	MBA	2	1.3
Professional Qualification	Dip.Ed	31	19.7
	PGDE	4	2.5
	B.Ed	47	29.9
	M.Ed	58	36.9
	DL(HC)	1	0.6
	'A' 3 Year Post-Secondary/CERT A	7	4.5
	Dip/M.Ed	2	1.3
	MPhil	4	2.5
	PGCE/M.Ed	2	1.3
	MSc in Education	1	0.6

Regarding academic qualifications, a bigger portion held an MEd (40.1%), followed by BEd (18.5%), MPhil (7.0%), MA (7.6%), MSc (2.5%) and PhD (1.9%). Additionally, 10.2% held a BA, and 6.4% a BSc. For professional qualifications, the most common were MEd (36.9%), BEd (29.9%), and Diploma in Education (19.7%), with a few holding PGDE (2.5%), MPhil (2.5%), and PGCE/MEd (1.3%). These results indicate that the Heads of SHSs are vastly experienced and well-qualified, making them credible sources of insight into CPD participation among Science and Mathematics teachers.

Research Question 1: What CPD opportunities are available to Science and Mathematics teachers in Senior High Schools (SHSs) in Ghana?

The first research question examined the perspectives of SHS heads on CPD opportunities that science and mathematics teachers had been exposed to. The results in Table 2 provide insights into the CPD programs that Science and Mathematics teachers in SHSs have been exposed to, as perceived by Heads of SHSs. The findings indicate that the most common CPD activity is general CPD training and workshops, such as annual workshops, departmental training, staff development programs and subject association workshops, which accounted for 25.5% of responses. This suggests that structured training programs remain the primary means through which teachers receive professional development.

Table 2: CPD Opportunities Available to Science and Mathematics Teachers

CPD Programme	Frequency (n)	Percent (%)
General CPD Training & Workshops (e.g., Annual Workshops, Departmental Training, Staff Development, Subject Association Workshops, Training Programmes)	40	25.5
Science Teachers' Workshops (e.g., GAST, SEIP, SMASE-WESCA)	23	14.6
Teaching Methodology (e.g., Innovative Teaching Strategies, Handling Difficult Topics, Investigative Science Teaching)	18	11.5
In-Service Training (e.g., INSET, SEIP In-Service Training, ICT-Based Training)	12	7.6
Content Knowledge Development (e.g., Syllabus Analysis, Lesson Planning, Science & Maths Content)	10	6.4
Pedagogical Skills Enhancement (e.g., Practical Science Teaching, Concept Teaching, Teaching Ethics)	8	5.1
Science & Mathematics Technology Training (e.g., ITEC, SEIP, I-Box, Electronics)	8	5.1
Professional Development Conferences (e.g., GAST Conference, SEIP Conferences, Conference Marking)	6	3.8
Specialized Science & Mathematics Programmes (e.g., Biology, Physics, Chemistry, Mathematics)	6	3.8
School-Based CPD (e.g., School-Based INSET, Science & Math Training Under SEIP)	6	3.8
SEIP-Sponsored CPD Programmes	5	3.2
Science Resource Centre Training (e.g., Science Resource Centre Workshops)	4	2.5
ICT and Digital Learning Training (e.g., ICT in Education)	3	1.9
None / Not Applicable	8	5.1
Total	**157**	**100**

Subject-specific CPD activities, particularly workshops organised by professional bodies such as GAST, SEIP and SMASE-WESCA, were reported by 14.6% of respondents. This highlights the role of these associations in enhancing teachers' content knowledge and instructional practice. Methodology-focused CPD, including innovative strategies and investigative teaching, was cited by 11.5%, indicating a strong emphasis on pedagogical improvement. Some respondents (7.6%) mentioned in-service training programs such as INSET and SEIP while CPD focused on content development (6.4%) and pedagogical skills (5.1%), suggesting continued support for professional growth. Technology-related CPD, including ITEC, SEIP, I-Box and Electronics, was reported by 5.1%, reflecting efforts to integrate digital tools into Science and Mathematics education. Other forms of CPD included conferences and subject-specific training, each cited by 3.8%.

Notably, 5.1% of respondents indicated no exposure to CPD, suggesting gaps in access. While the findings reflect a variety of CPD opportunities focused on workshops, association-led training, and pedagogy, they also point to the need for broader access, particularly in technology integration and subject-specific content development.

To further explore Heads of SHSs' perspectives on CPD programs, 10 Heads of SHSs were interviewed regarding the types of CPD initiatives teachers have been exposed to and their perceived effectiveness. The findings from these interviews provide deeper insights into CPD opportunities that science and mathematics teachers have been exposed to while reaffirming the quantitative results.

Most Heads of SHSs acknowledged that their teachers had participated in general CPD training and workshops, including annual workshops, departmental training and subject association meetings. HT1 stated, "Our teachers regularly attend general CPD workshops and these have significantly improved their teaching skills and methodologies." Similarly, HT2 noted, "Subject association workshops offer a platform for our teachers to engage with other professionals, helping them stay updated on new teaching trends." These insights align with the survey results, where 25.5% of the respondents identified general CPD training as their primary professional development activity.

Several Heads of SHSs emphasized the importance of science-specific CPD programs such as the Ghana Association of Science Teachers (GAST) and SEIP workshops. HT3 commented, "Science-focused CPD training has helped our teachers develop effective strategies for handling complex topics."Likewise, HT4 stated, "Programs like SEIP and SMASE-WESCA equip our teachers with practical teaching methods, making Science and Mathematics more engaging for students."These perspectives correspond with the 14.6% of respondents who reported participating in Science teachers' workshops.

Integrating technology and digital learning tools in CPD was another theme that emerged from the interviews. HT5 remarked, "ICT-based training has introduced our teachers to digital tools that enhance interactive learning in Science and Mathematics." HT6 added, "Teachers who have attended I-Box and Electronics training sessions now use more technology-driven approaches in their lessons." These findings resonate with the survey data, where Science and Mathematics Technology Training and ICT in Education collectively accounted for 7% of CPD participation.

Some Heads of SHSs also emphasized the importance of in-service training and content knowledge development in enhancing instructional quality. HT7 observed, "INSET programs have been crucial in deepening teachers' content knowledge and refining their lesson planning." Similarly, HT8 noted, "Workshops on syllabus analysis and investigative Science teaching have helped teachers structure their lessons more effectively." These responses align with the 7.6% and 6.4% of teachers who reported exposure to in-service training and content knowledge development, respectively.

Despite the benefits, some Heads of SHSs expressed concerns about the limited accessibility and application of CPD programs. HT9 mentioned, "While CPD training is beneficial, not all teachers get the opportunity to participate, and some struggle to implement what they learn." Additionally, HT10 stated, "There are teachers who have not engaged in CPD at all, and this affects the overall effect on instructional quality." This observation reflects the 5.1% of survey respondents who indicated they had not participated in any CPD program.

The interview findings strongly affirm the quantitative results, demonstrating that CPD programs have improved the pedagogical practices, subject content knowledge and digital technology integration of Science and Mathematics teachers. Heads of SHSs recognized that CPD workshops, subject-specific training and ICT-based learning are crucial in enhancing instructional quality. However, challenges, such as limited participation, inconsistent application of acquired skills and lack of universal access to CPD opportunities remain concerns. These findings suggest that while CPD is widely beneficial, greater efforts are needed to ensure equal access and effective implementation to maximize its influence on teaching and learning.

The interview findings in Table 3 offer detailed insights into Heads of SHSs' perceptions of CPD programs for Science and Mathematics teachers, complementing the quantitative data.

A significant proportion of Heads (25.5%) noted teacher participation in general CPD workshops, which, as HT1 and HT2 emphasized, refine teaching strategies and foster professional networking through teacher associations.

These workshops provide platforms for exchanging pedagogical ideas and innovations, contributing to continuous instructional improvement (Abakah et al., 2022). This aligns with Abakah et al.'(s (2022) that workshops are predominant CPD activities among Ghanaian basic school teachers and with Kumi-Korsah (2021), who observed that formal CPD initiatives mainly involve workshops, seminars, and advanced education programs.

Subject-specific CPD programs—such as those by the Ghana Association of Science Teachers (GAST), Secondary Education Improvement Project (SEIP) and SMASE-WESCA—were identified as crucial for equipping teachers with specialized competencies. HT3 and HT4 described these programs as vital in clarifying complex scientific concepts and boosting pedagogical confidence. This corroborates the 14.6% of Heads reporting participation in science-specific CPD, emphasizing the tailored nature of these initiatives. The integration of technology through ICT-focused CPD emerged as a key theme. Heads acknowledged that such sessions introduced teachers to digital tools, enhancing classroom interactivity and engagement. Quantitatively, 7% of teachers reported involvement in tech-based CPDs. HT5 and HT6 highlighted training on tools like the I-Box and electronics, facilitating the adoption of dynamic, resource-rich instructional strategies. These findings underscore the critical role of CPD in aligning teaching with 21st-century digital demands.

In-service training (INSET) and content mastery sessions were also valued for improving lesson planning and curriculum alignment. HT7 and HT8 noted that these programs assist teachers in unpacking syllabi and planning inquiry-based lessons, reflecting the 7.6% and 6.4% participation rates in INSET and content-specific CPDs, respectively, highlighting the importance of continuous subject enrichment for teachers.

However, the interviews revealed challenges, including HT9 and HT10, that pointed to disparities in CPD access and difficulties in applying learned knowledge, indicating limited funding, inadequate follow-up, and lack of motivation. This shows the necessity for more inclusive, sustainable CPD frameworks that promote equitable access and provide ongoing mentorship (Abreh, 2025).

Research Question 2: What is the perceived influence of CPD programs on science and mathematics teaching in Ghana's SHSs?

The second research question examined the perceived influence of CPD programs on the instructional practices of science and mathematics teachers by heads of SHSs.

Table 3: Influence of CPD Programs on Science and Mathematics Teaching

Items in the Questionnaire	Frequency (n)	Percent (%)
Improved teaching skills, methodologies, and pedagogical competencies	35	22.3
Enhanced lesson delivery, lesson planning, and classroom management	15	9.6
Increased teacher confidence and professional growth	12	7.6
Greater use of innovative and student-centered teaching strategies	11	7.0
Improved assessment strategies and ability to address student needs	10	6.4
Enhanced ability to handle challenging topics and subject content	9	5.7
Increased engagement with students, fostering interactive learning	8	5.1
Use of technology and teaching-learning materials (TLMs) in instruction	7	4.5
Strengthened ability to conduct practical and hands-on lessons	6	3.8
Enhanced student performance and learning outcomes	6	3.8
Better time management, punctuality, and commitment to teaching	5	3.2
Application of new strategies from CPD training	5	3.2
Increased content knowledge and subject mastery	4	2.5
Shift from theoretical to practical teaching approaches	4	2.5
Improved collaboration and peer-learning among teachers	3	1.9
More effective use of assessment tools and exam preparation	3	1.9
Strengthened student motivation and interest in Science and Mathematics	3	1.9
CPD had no significant impact or not applicable	6	3.8
Total	**157**	**100**

As shown in Table 3, 22.3% of Heads reported improvements in teaching skills, methodologies and pedagogical competencies as the most significant influence. This suggests that CPD

enhances instructional techniques, supporting more effective teaching and learning.

Additionally, 9.6% of Heads highlighted improvements in lesson delivery, planning and classroom management, pointing to CPD's role in refining instructional organization. Teacher confidence and professional growth (7.6%) and adopting innovative, student-centred strategies (7%) further underscored its bearing on teaching quality. CPD was also credited with enhancing assessment practices and responsiveness to student needs (6.4%), as well as improving subject-matter delivery (5.7%) and promoting interactive learning (5.1%). Technology use and TLM integration (4.5%), practical instruction (3.8%), better student outcomes (3.8%) and improved time management (3.2%) were noted as additional benefits. Only 3.8% of Heads saw no noteworthy impression. Overall, the results reflect the broad benefits of CPD, although areas such as collaboration, assessment tools, and student motivation (each at 1.9%) remain underdeveloped.

Ten heads of SHSs were interviewed to gain deeper insights into the influence of CPD programs on Science and Mathematics teachers. Their perspectives aligned mainly with the quantitative findings. The responses revealed that CPD programs have significantly enhanced teachers' instructional practices, professional confidence and student engagement.

Several Heads of SHSs emphasized the transformative effect of CPD on teachers' pedagogical skills. For instance, HT1 stated, "The CPD sessions have improved our teachers' ability to structure lessons effectively and use appropriate methodologies. Their lesson planning and classroom management have become more refined." Correspondingly, HT2 observed, "There has been a noticeable improvement in how teachers handle complex subject content. They now employ better strategies to break down difficult topics for students." These views reinforce the quantitative findings, where 22.3% of respondents identified improved teaching skills, methodologies and pedagogical competencies while 9.6% highlighted enhanced lesson delivery and classroom management.

Moreover, Heads of SHSs noted that CPD programs have bolstered teachers' professional confidence and growth. HT3 remarked, "I have seen a significant boost in teachers' confidence levels. They are more proactive and their interactions with students have improved." This observation aligns with the 7.6% of Heads of SHSs in the survey who identified increased teacher confidence and professional growth as a key outcome of CPD. Similarly, HT4 added, "Teachers now use a variety of student-centered strategies, including group discussions and inquiry-based learning, making lessons more engaging." This affirms the quantitative result where 7% of respondents acknowledged greater use of innovative and student-centered teaching approaches.

Technology integration was another theme that emerged during the interviews. HT5 explained, "With CPD training, our teachers have started incorporating technology in their lessons. Some now use projectors and simulations to enhance understanding." Likewise, HT6 stated, "The use of teaching-learning materials (TLMs) has become more common, and students are responding positively." These perspectives support the quantitative results, where 4.5% of the Heads of SHSs recognized CPD's role in increasing the use of technology and TLMs in instruction.

The interviewees also pointed to the role of CPD in fostering student engagement and interactive learning. HT7 commented, "Our teachers have become more interactive in the classroom. They encourage discussions and ask thought-provoking questions, which keep students engaged." This aligns with the survey findings, where 5.1% of respondents noted increased student engagement. Additionally, HT8 remarked, "Teachers are now implementing more effective assessment strategies, ensuring that students' needs are adequately addressed." This mirrors the 6.4% of Heads of SHSs in the survey who highlighted improved assessment strategies and responsiveness to student needs.

Despite the overall positive impression, a few Heads of SHSs noted areas for improvement. HT9 stated, "While CPD is beneficial, not all teachers are equally committed to applying the new strategies. Some still rely on traditional methods." This reflects the 3.8% of Heads of SHSs in the survey who indicated that CPD had

no unique bearing or was not applicable. Furthermore, HT10 suggested,"CPD training should emphasize collaboration among teachers. Peer-learning opportunities could further enhance the impact of these programs."

This highlights the need for strengthening professional learning communities, as seen in the 1.9% of respondents who mentioned improved collaboration and peer-learning. The interview findings affirm the quantitative results, reinforcing the notion that CPD programs positively influence Science and Mathematics teachers' pedagogical competencies, confidence and engagement with students. The responses indicate that CPD fosters improved lesson planning, interactive learning and technology integration. However, the interviews also highlighted the need for stronger peer collaboration and differentiated CPD approaches to ensure broader effectiveness. These findings suggest that while CPD has had a notable effect, further enhancements could maximize its effectiveness, particularly in promoting collaboration and ensuring uniform adoption of new instructional strategies.

The second research question examined the perceived influence of CPD programs on Science and Mathematics teachers' instructional practices, drawing on both qualitative narratives and quantitative data for a comprehensive understanding. A central theme was the enhancement of pedagogical competence. Heads of SHSs reported that CPD enabled teachers to structure lessons effectively, adopt appropriate methodologies and better deliver complex content. Quantitatively, 22.3% observed improved teaching skills and 9.6% noted enhanced classroom delivery and management—findings consistent with research positioning CPD as pivotal to improving STEM instructional quality (Desimone, 2009; Kennedy, 2016).

Teacher confidence and professional initiative also emerged as key outcomes, with 7.6% of Heads citing growth in these areas. This reflects the developmental function of CPD beyond technical skill enhancement, in line with literature that links sustained professional development to increased teacher agency and instructional leadership (Avalos, 2011; Opfer & Pedder, 2011). Another significant outcome was the adoption of student-centred approaches. Heads cited greater use of group work and inquiry-based learning, supported by 7% of responses, aligning with the broader push for active learning in STEM education (Garet et al., 2001; Vescio et al., 2008).

Technology integration was noted by 4.5% of Heads, who observed growing use of digital tools and TLMs in instruction. Though modest, this shift reflects alignment with the TPACK framework, which promotes integrating content, pedagogy, and technology (Koehler & Mishra, 2009). Enhanced students' engagement was also highlighted, with 5.1% of responses acknowledging interactive strategies that improved classroom participation, echoing studies linking CPD to improved student-teacher dynamics and motivation (Timperley et al., 2007; Borko, 2004). Assessment practices also showed improvement. About 6.4% of the Heads reported more responsive, learner-aligned assessment methods—an outcome that resonates with research emphasizing the value of formative assessment in advancing learning (Black & Wiliam, 2009; Naila & Mirwan, 2022).

The findings reflect the influence of Wenger's (2009) social theory of learning, which views learning as participatory, rooted in identity, community and practice. CPD, as reported by Heads, enabled teachers to engage in meaningful and collaborative practices, signaling a shift in professional identity (Allen et al., 2021). These developments align with Mezirow's Transformative Learning Theory (1978, 1997), emphasizing critical reflection as a pathway to change assumptions and behaviors. The adoption, use of technology and improved assessment illustrates both social learning processes (Wenger, 2009) and internal transformation (Mezirow, 2018). Teachers, through CPD, became active participants in communities of practice while also engaging in reflective and experiential learning that led to lasting pedagogical change (Friedman, 2023; Wenger, 2009; Mezirow, 2018).

Nonetheless, some Heads (3.8%) reported minimal influence, citing inconsistent teacher commitment—echoing concerns in the literature about the limitations of CPD when follow-up, support, and contextual alignment are lacking (Ono & Ferreira, 2010; Kennedy, 2014). A qualitative call for increased peer learning further highlighted the need for CPD formats that promote collaboration, pointing to the importance of professional learning

communities (PLCs) in sustaining change (Allen et al., 2020; Christensen, 2025).

Conclusions and Recommendations

This section presents concise conclusions and recommendations based on the perspectives of Senior High School heads regarding Continuous Professional Development (CPD) for Science and Mathematics teachers in Ghana.

Regarding the CPD opportunities available to Science and Mathematics teachers in SHSs, the study concludes that while a variety of programs exist, including general workshops, subject-specific training and methodology-based sessions, access to these opportunities remains uneven across schools, with some teachers having limited or no exposure to CPD activities. Therefore, the Ghana Education Service (GES) and Ministry of Education (MoE) should develop an inclusive national CPD framework that ensures equitable access for all Science and Mathematics teachers, particularly in under-served regions. Emphasis should be placed on specialized content knowledge and digital pedagogy to strengthen teachers' professional competencies.

In relation to the perceived influence of CPD on teaching practices, CPD programs are viewed as instrumental in improving pedagogical skills, instructional strategies and classroom management. They also enhance teacher confidence and promote innovation in lesson delivery. Nonetheless, their overall impact is sometimes constrained by inconsistent participation and inadequate follow-up support. To maximize CPD effectiveness, the GES and MoE should strengthen monitoring and evaluation mechanisms to ensure consistent quality and practical application of training outcomes. Heads of Senior High Schools should cultivate a culture of continuous professional learning through peer mentoring, collaborative professional learning communities, and regular in-school support sessions.

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